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Operating Experience

with Nuclear Power Stations in Member States



2021 edition

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OPERATING EXPERIENCE
WITH NUCLEAR POWER STATIONS
IN MEMBER STATES (2021 EDITION)

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FOREWORD

This report is the fifty second 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 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 2021 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 2020.

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 have been added to illustrate global operational statistics up to and including 2020.

The data that form the basis of this publication are a direct output from the IAEA's Power Reactor Information System (PRIS), the database which 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) allows 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 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. In order to avoid confusion, refer to the definitions in Section 2.

As of 31 December 2020, there were 442 operational nuclear power reactors worldwide, with a total capacity of 392.6 GW(e). Overall, nuclear power capacity since 2011 has shown a gradual growth trend, including some 23.7 GW(e) of new capacity added by the connection of new units to the grid or upgrades to existing reactors.

In 2020, though, total global capacity increased by some 0.5 GW(e) compared with 2019. During the year, 448 operational power reactors contributed to the 2020 results and statistics.

In 2020, five new pressurized water reactors (PWR) were connected to the grid, resulting in an additional 5.5 GW(e) of nuclear power capacity. Over 36% of this new capacity was added in Asia and included two reactor units in China at Fuqing-5 (1000 MW(e)) and Tianwan-5 (1000 MW(e)). Over 44% of new capacity in 2020, over 2.4 GW(e), was added by two countries with no previous nuclear power operating

experience – Belarusian 1 (1110 MW(e)) in Belarus and Barakah-1 (1345 MW(e)) in the United Arab Emirates. In Russia, Leningrad 2-2 was connected to the grid in October 2020 with a total capacity of 1066MW(e).

As of 31 December 2020, 52 reactors were under construction in 19 countries with a total of capacity of 54.4 GW(e). Installed nuclear power capacity under construction has largely remained steady in recent years, except for continuous growth in Asia, where a total of 58.5 GW(e) operational capacity (64 reactors) has been connected to the grid since 2005. In 2020, the construction of four PWR reactors began, with three reactors in China (Sanaocun-1 (1117 MW(e)), Taipingling-2 (1116 MW(e)) and Zhangzhou-2 (1126 MW(e)) and one reactor in Turkey (Akkuyu-2 (1114 MW(e)).

Six reactors with a total capacity of 5165 MW(e) were permanently shut down globally. Some 37% of the capacity loss resulting from permanent shutdowns came from two reactors in France, Fessenheim-1 and Fessenheim-2, each unit with capacity of 880 MW(e). Another 30.9% came from shutdowns of Duane Arnold-1(601 MW(e)) and Indian Point-2 (998 MW(e)) in the United States. Leningrad-2 (925 MW(e)) in Russia shut down in November 2020 and Ringhals-1 (881 MW(e)) in Sweden shut down on the last day of the year. Overall, 5.2 GW(e) of nuclear power capacity was removed during 2020.

This publication also catalogues the use of nuclear power reactors for non-electrical applications, including district heating, industrial process heat delivery and water desalination. In 2020, 64 nuclear power reactors in 10 countries applied 3396.4 GWh of electrical equivalent heat to support non-electric applications of nuclear energy. Over 92% of the non-electric applications were utilized in Europe, generating 1999.4 GWh of electrical equivalent of heat to support district heating and 1231.7 GWh for process heating by 56 reactors. The remaining 8% was utilized by 8 reactors in Asia to generate 34.7 GWh of electrical equivalent of heat to support desalination and 130.6 GWh to support process heating.

Information and data received by the IAEA through 1 June 2021 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 correspondents. 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. 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 [h]

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 4 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 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 where 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 10 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, respectively.

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, whatever 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 CO_2 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 D_2O 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
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.
NBEPC	NEW BRUNSWICK ELECTRIC POWER COMMISSION
NDNP	FUJIAN NINGDE NUCLEAR POWER COMPANY, LTD.
NEK	NUKLERANA ELEKTRARNA KRŠKO
NEXTERA	NEXTERA ENERGY RESOURCES, LLC
NNEGC	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. Nuclear power reactors operating experience years
2. Lifetime energy availability factors up to 2020
3. Reactors with high availability factors for years 1985–2020
4. Average energy availability factors for years 1985–2020
5. Number of reactors in operation (as of 31 December 2020)
6. Number of reactors by age (as of 31 December 2020)

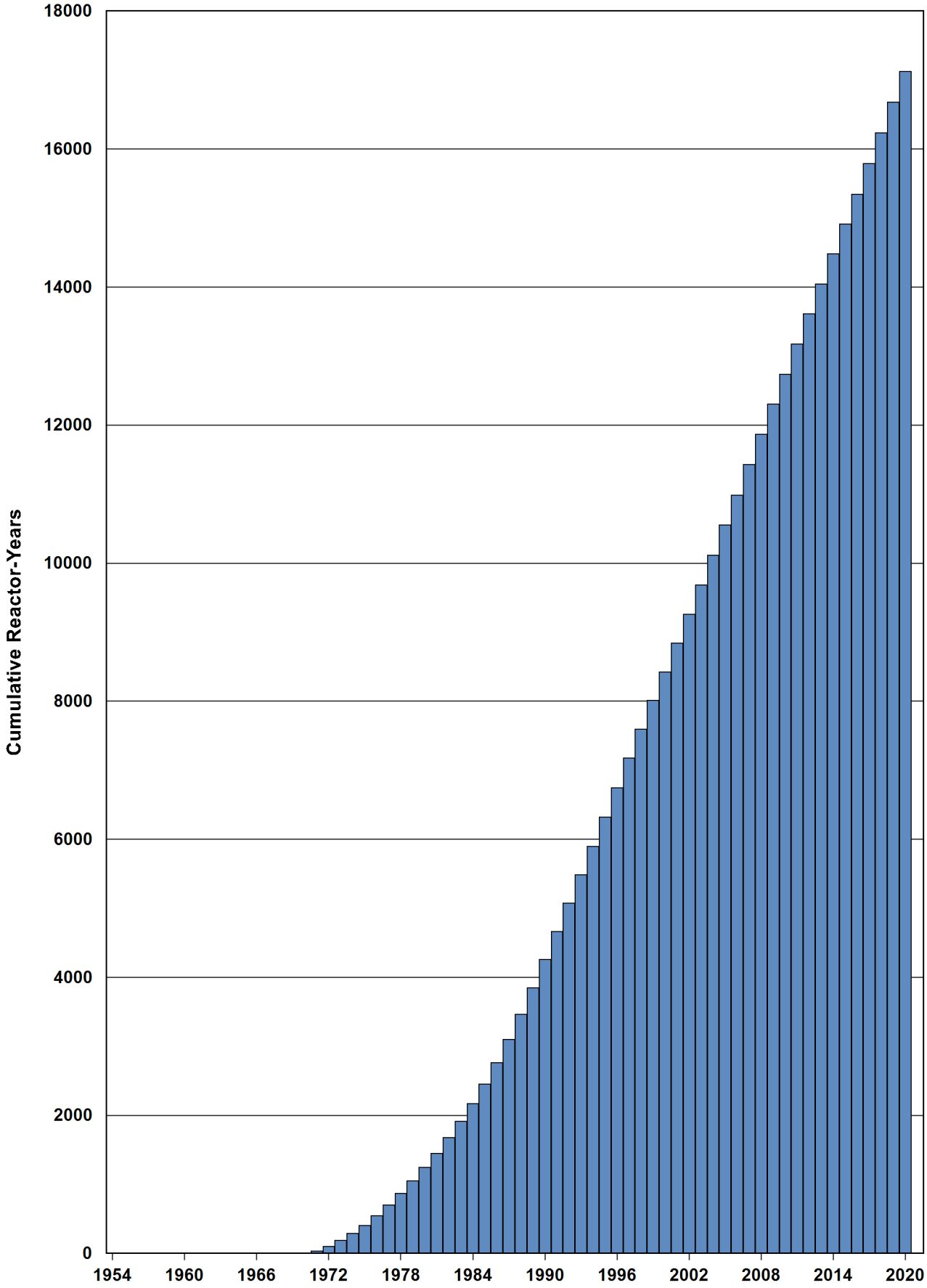


Figure 1 — Nuclear Power Reactors Operating Experience

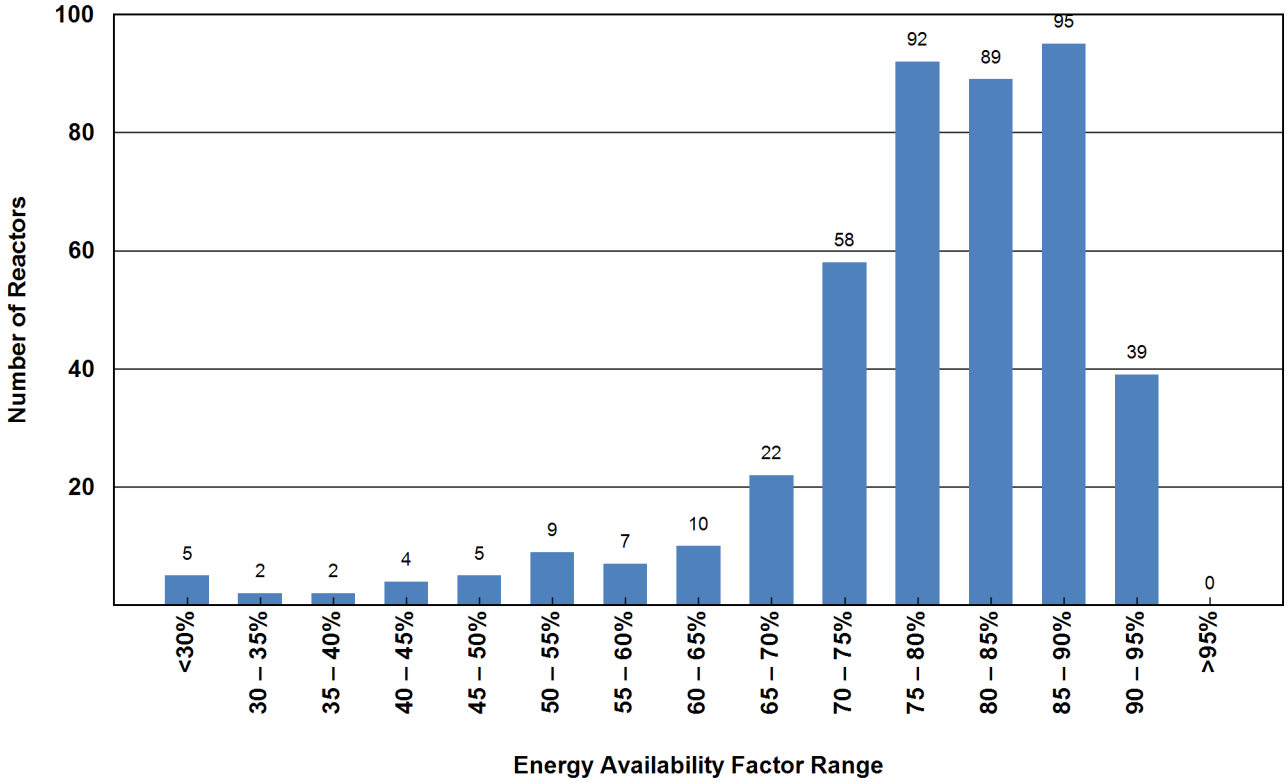


Figure 2 — Lifetime Energy Availability Factors up to 2020

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

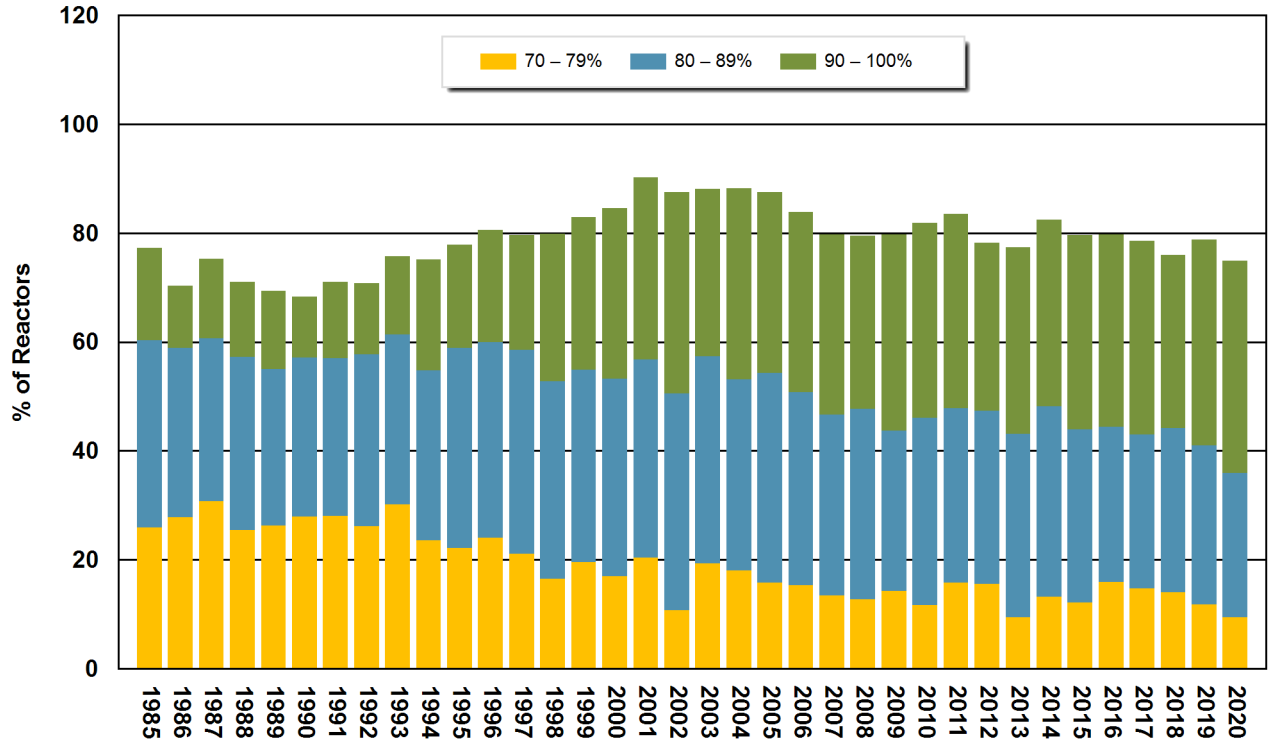


Figure 3 — Reactors with High Availability Factors

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

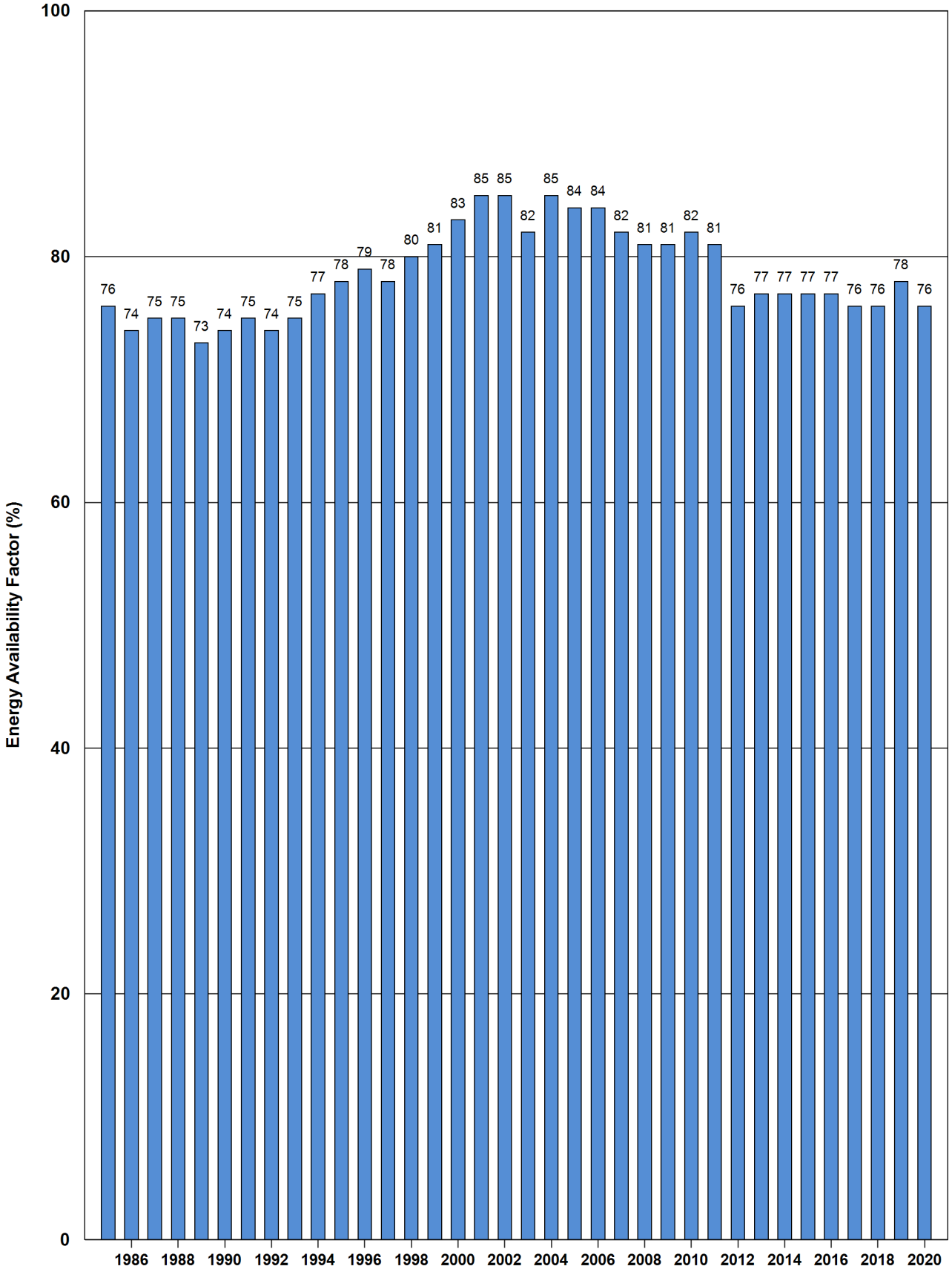


Figure 4 — Average Energy Availability Factors

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

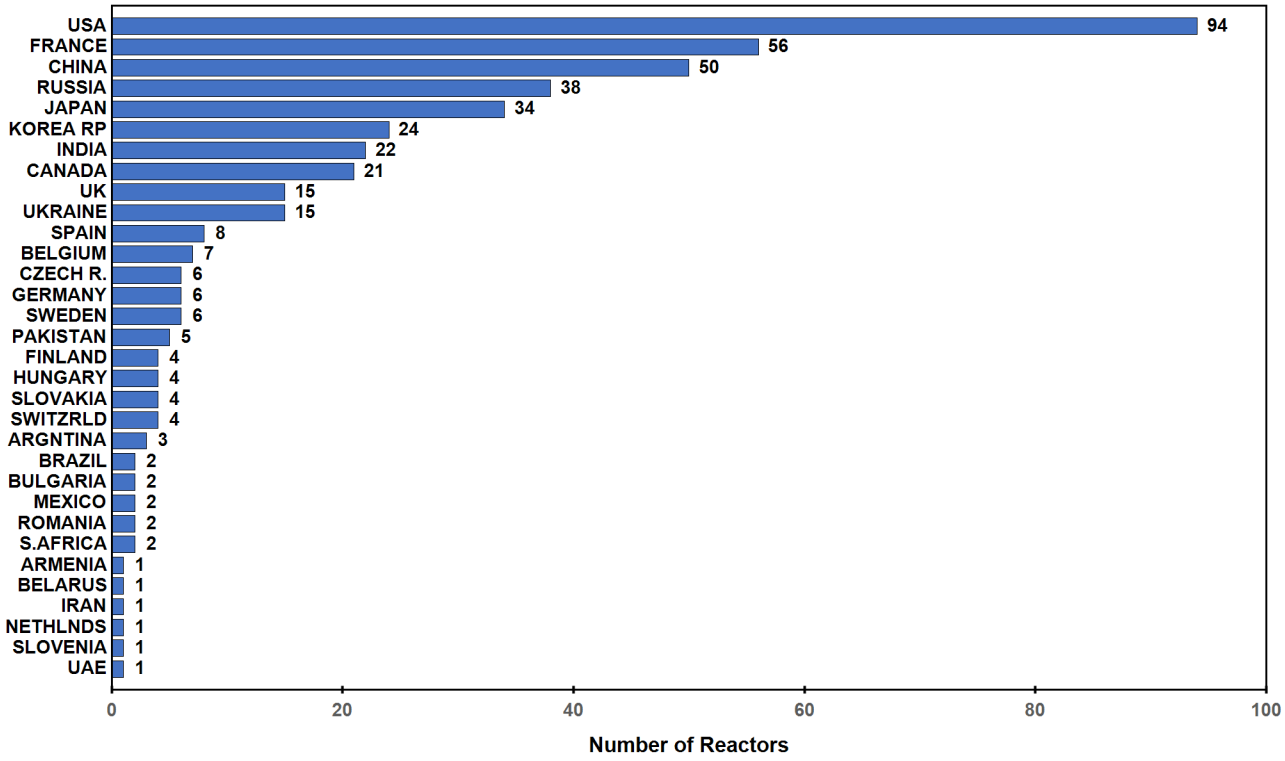


Figure 5 — Number of Reactors in Operation (as of 31 December 2020)

Note: There were 442 reactors in operation in Taiwan, China.

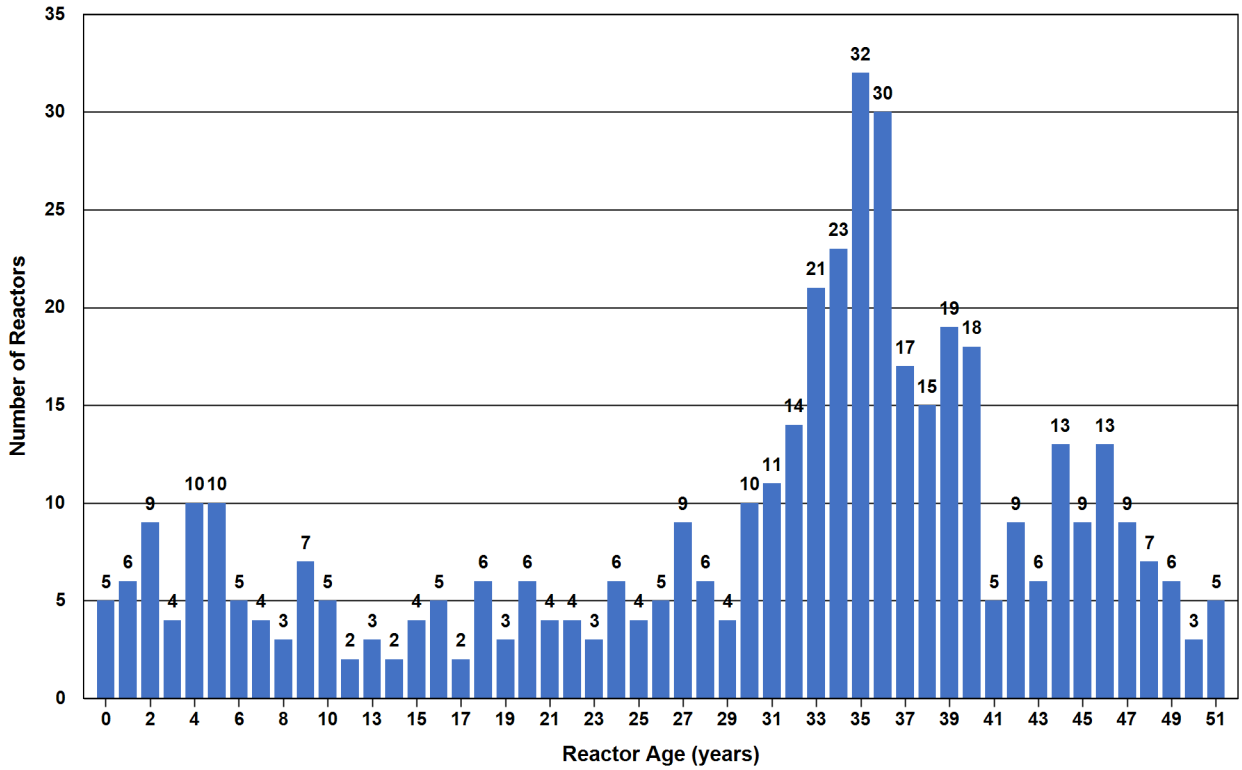


Figure 6 — Number of Reactors by Age (as of 31 December 2020)

5. OPERATING DATA SHEETS ON INDIVIDUAL NUCLEAR POWER STATIONS UNITS

COUNTRY	NUMBER OF REACTORS IN OPERATION IN 2020
ARGENTINA	3
ARMENIA	1
BELARUS	1
BELGIUM	7
BRAZIL	2
BULGARIA	2
CANADA	19
CHINA	50
CZECH REPUBLIC	6
FINLAND	4
FRANCE	56
GERMANY	6
HUNGARY	4
INDIA	22
IRAN, ISLAMIC REPUBLIC OF	1
JAPAN	33
KOREA, REPUBLIC OF	24
MEXICO	2
NETHERLANDS	1
PAKISTAN	5
ROMANIA	2
RUSSIAN FEDERATION	38
SLOVAKIA	4
SLOVENIA	1
SOUTH AFRICA	2
SPAIN	7
SWEDEN	6
SWITZERLAND	4
UKRAINE	15
UNITED ARAB EMIRATES	1
UNITED KINGDOM	15
UNITED STATES OF AMERICA	94
TOTAL REACTORS*	**442**

* The total includes 4 reactors in Taiwan, China.

2020 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	:	1968-06-01
Grid Date	:	1974-03-19
Commercial Date	:	1974-06-24
Age at end of year	:	46 years

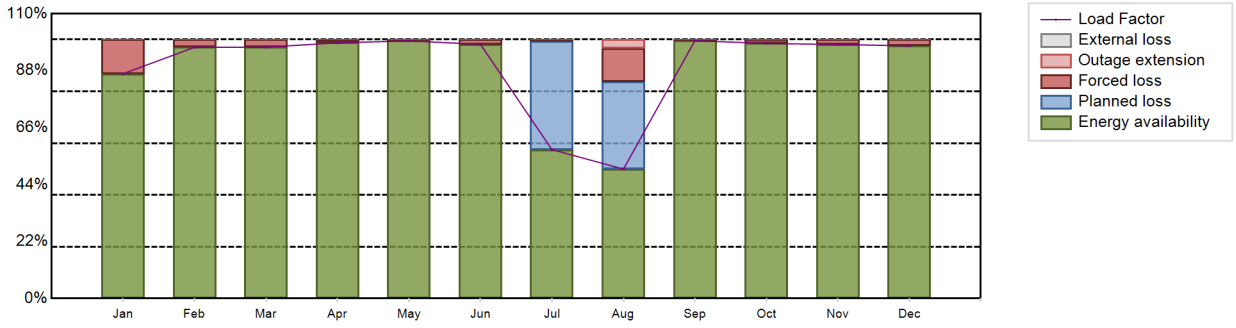
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	11.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	303.3
Fuel material	:	UO2	Number of SG	:	2
Refuelling type	:	ON-line	Containment type	:	Single
Moderator material	:	D2O	Containment design pressure [MPa]	:	0.28
Average fuel enrichment [% of U235]	:	0.85	**Secondary systems**		
Refuelling frequency [month]	:	NA	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	NA	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	11140	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	4.51	HP cylinder inlet steam pressure [MPa]	:	4.26
Active core height/length [m]	:	5.3	Output voltage [kV]	:	21
Number of fissile fuel assemblies/bundles	:	250	Primary means of condenser cooling	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	23.22	Number of main condensate pumps	:	3
Number of control rod assemblies	:	29	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	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	2680.41 GW(e).h	Forced Loss Rate (FLR)	:	3.8 %
Energy Availability Factor (EAF)	:	89.75 %	Unplanned Capability Loss Factor (UCL)	:	3.84 %
Unit Capability Factor (UCF)	:	89.75 %	Planned Unavailability Factor (PUF)	:	6.41 %
Load Factor (LF)	:	89.75 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	91.84 %	Total off-line time	:	717 hours

Annual Summary



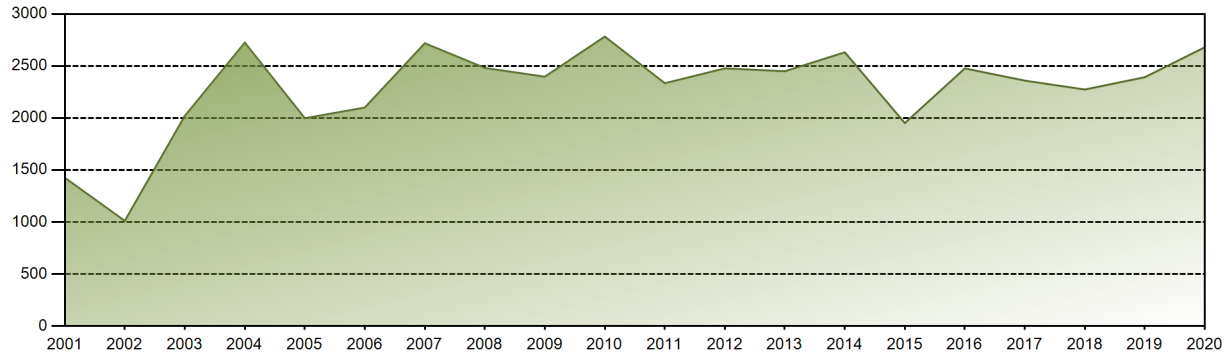
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	219.61	229.57	245.52	241.76	251.69	240.33	145.52	126.44	243.77	249.18	240.19	246.83	2680.41
EAF [%]	86.82	97.01	97.06	98.76	99.50	98.18	57.53	49.98	99.58	98.50	98.12	97.58	89.75
UCF [%]	86.82	97.01	97.06	98.76	99.50	98.18	57.53	49.98	99.58	98.50	98.12	97.58	89.75
LF [%]	86.82	97.01	97.06	98.76	99.50	98.18	57.53	49.98	99.58	98.50	98.12	97.58	89.75
OF [%]	91.53	100.00	100.00	100.00	100.00	100.00	57.53	54.57	100.00	100.00	100.00	100.00	91.84
FLR [%]	13.18	2.99	2.94	1.24	0.50	1.82	0.93	20.42	0.42	1.50	1.88	2.42	3.80
UCL [%]	13.18	2.99	2.94	1.24	0.50	1.82	0.54	16.25	0.42	1.50	1.88	2.42	3.84
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	41.94	33.77	0.00	0.00	0.00	0.00	6.41
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

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Historical Summary

Lifetime energy generation	:	99169.81 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	10.54 %
Cumulative Energy Availability Factor (EAF)	:	74.5 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.07 %
Cumulative Unit Capability Factor (UCF)	:	75.46 %	Cumulative Planned Unavailability Factor (PUF)	:	15.46 %
Cumulative Load Factor (LF)	:	72.49 %	Cumulative Externally cause unavailability (XUF)	:	0.96 %
Cumulative Operating Factor (OF)	:	77.83 %			

Electricity Production (net) [GWh]

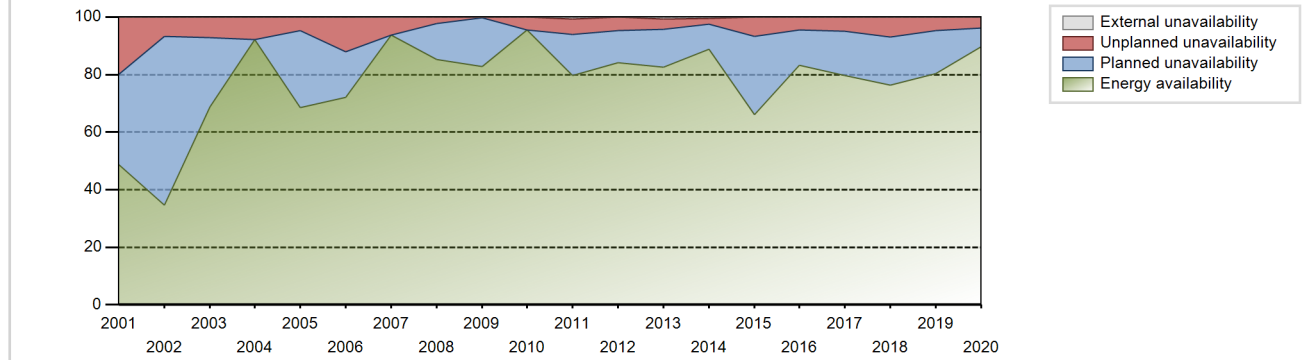


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	947.50	4458	321	50.27	51.01	50.29	65.96	16.06	9.76	39.23	0.73
1975	2357.80	7730	319	85.63	85.63	84.37	88.24	5.33	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

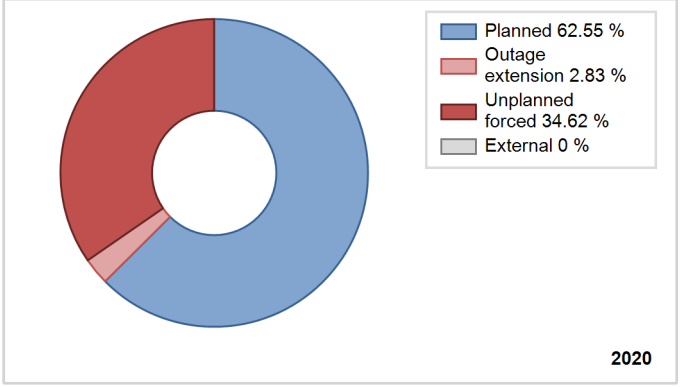
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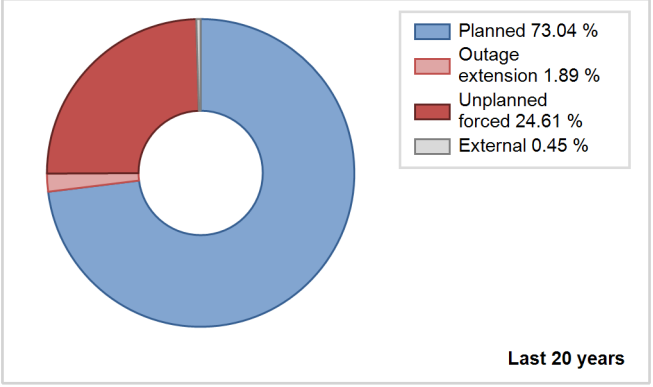
2011	2334.46	7289	335	79.63	80.28	79.55	83.21	4.07	5.45	14.27	0.65
2012	2477.36	7521	335	84.15	84.15	84.19	85.62	5.20	4.61	11.24	0.00
2013	2449.53	7310	340	82.55	83.29	82.75	83.45	2.94	3.49	13.22	0.73
2014	2631.71	7875	340	88.78	89.28	88.36	89.90	0.00	1.89	8.83	0.50
2015	1951.35	6109	340	66.00	66.03	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		169			642	
C.	Inspection, maintenance or repair combined with refuelling				29		
D.	Inspection, maintenance or repair without refuelling	548			1121	12	
E.	Testing of plant systems or components				9		
G.	Major backfitting, refurbishment or upgrading activities without refuelling				31		
H.	Nuclear regulatory requirements					64	
J.	Grid limitation, failure or grid unavailability						16
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						21
L.	Human factor related					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.)						2
Subtotal		548	169		1190	727	39
Total			**717**			**1956**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		97
12. Reactor I&C Systems		46
13. Reactor Auxiliary Systems	25	131
14. Safety Systems	63	36
15. Reactor Cooling Systems	80	152
16. Steam generation systems		48
17. Safety I&C Systems (excluding reactor I&C)		9
21. Fuel Handling and Storage Facilities		16
31. Turbine and auxiliaries		11
32. Feedwater and Main Steam System		22
33. Circulating Water System		10
35. All other I&C Systems		0
41. Main Generator Systems		7
42. Electrical Power Supply Systems		57
Total	**168**	**642**

Highlights (2020)

2020.01.01 12:00 am to 2020.01.06 03:46 am – Normal operation. Loss of energy due to plant performance, due to various factors (fouling of condenser tubes, performance of equipment, etc.) the theorical generation was not reached.

2020.01.06 03:46 am to 2020.01.06 04:05 – Power ramp down.

2020.01.06 04:05 to 2020.01.08 07:08 pm – Manual shutdown for intervention of TB11S03.

08/01/2020 07:08 pm to 2020.01.10 11:00 am – Power rump-up.

10/01/2020 11:00 am to 2020.06.02 11:50 am –Normal operation. Loss of energy due to plant performance, due to various factors (fouling of condenser tubes, performance of equipment, etc.) the theorical generation was not reached.

2020.06.02 11:50 am to 2020.06.02 06:00 pm – Power ramp down.

2020.06.02 06:00 pm to 2020.06.04 01:00 am – Power reduction for intervention of SD11W011.

2020.06.04 01:00 am to 2020.06.04 06:30 pm – Power ramp-up.

2020.06.04 06:30 pm to 2020.07.18 08:16 pm - Normal operation. Normal operation. Loss of energy due to plant performance, due to various factors (fouling of condenser tubes, performance of equipment, etc.) the theorical generation was not reached.

2020.07.18 08:16 pm to 2020.07.19 12:00 am – Automatic scram due to low rotational speed of a main pump (QF02D01).

2020.07.19 12:00 am to 2020.08.10 08:16 pm – Planned outage.

2020.08.10 08:16 pm to 2020.08.11 09:43 pm – Unplanned extension of planned outage.

2020.08.11 09:43 pm to 2020.08.13 05:16 am – Power ramp-up.

2020.08.13 05:16 am to 2020.08.16 09:51 am – Manualshutdown for intervention of QD01S01.

2020.08.16 09:51 am to 2020.08.18 07:40 am – Power rump-up

2020.08.18 07:40 am to 2020.09.07 08:04 am – Normal operation. Normal operation. Loss of energy due to plant performance, due to various factors (fouling of condenser tubes, performance of equipment, etc.) the theorical generation was not reached.

2020.09.07 08:04 am to 2020.09.08 03:50 am – Power reduction for intervention of RM02D001.

2020.09.08 03:50 am to 2020.10.17 02:06 pm - Normal operation. Normal operation. Loss of energy due to plant performance, due to various factors (fouling of condenser tubes, performance of equipment, etc.) the theorical generation was not reached.

2020.10.17 02:06 pm to 2020.10.17 11:35 pm – Power reduction due to YX04X001 anomaly.

2020.10.17 11:35 pm to 2021.01.01 12:00 am - Normal operation. Normal operation. Loss of energy due to plant performance, due to various factors (fouling of condenser tubes, performance of equipment, etc.) the theorical generation was not reached.

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2020 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	:	1981-07-14
Grid Date	:	2014-06-25
Commercial Date	:	2016-05-26
Age at end of year	:	6 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

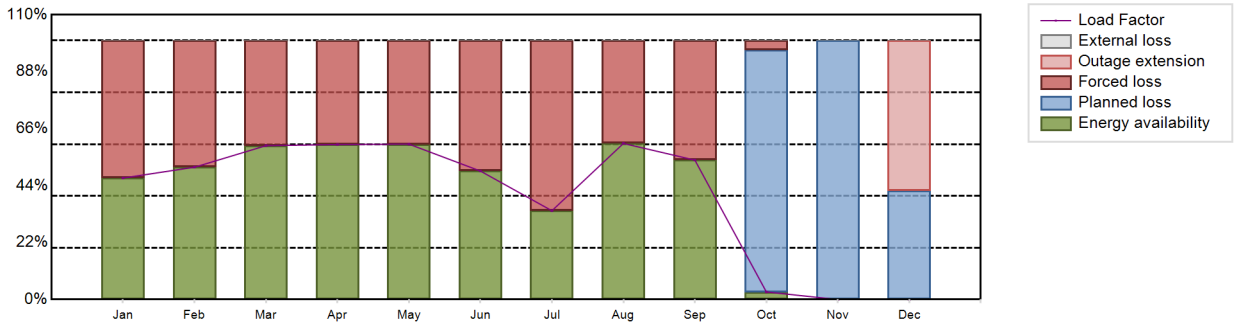
Operating coolant pressure [MPa]	:	4.2
Reactor outlet temperature [°C]	:	312.3
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.48
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	2421.87 GW(e).h
Energy Availability Factor (EAF)	:	39.79 %
Unit Capability Factor (UCF)	:	39.79 %
Load Factor (LF)	:	39.79 %
Operating Factor (OF)	:	70.07 %

Forced Loss Rate (FLR)	:	47.24 %
Unplanned Capability Loss Factor (UCL)	:	40.55 %
Planned Unavailability Factor (PUF)	:	19.67 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	2629 hours

Annual Summary



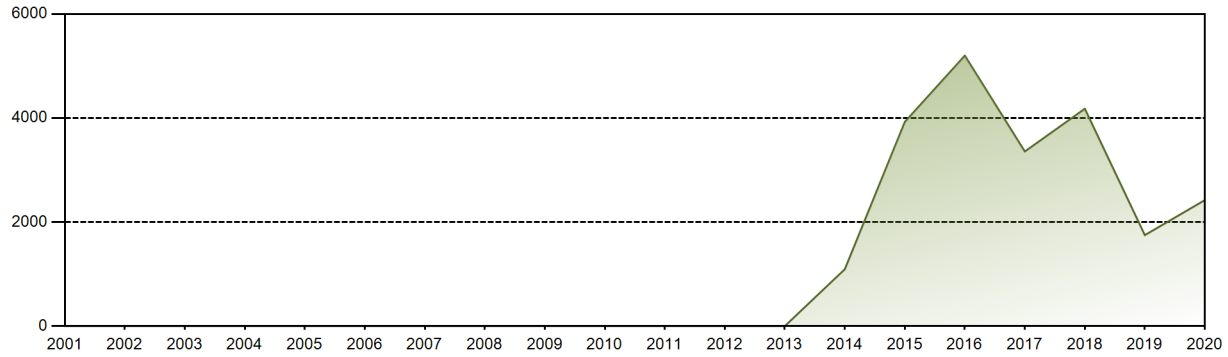
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	241.93	246.48	306.35	298.65	309.49	247.55	176.84	310.82	268.65	15.12	0.00	0.00	2421.87
EAF [%]	46.92	51.10	59.42	59.86	60.03	49.61	34.30	60.28	53.84	2.93	0.00	0.00	39.79
UCF [%]	46.92	51.10	59.42	59.86	60.03	49.61	34.30	60.28	53.84	2.93	0.00	0.00	39.79
LF [%]	46.92	51.10	59.42	59.86	60.03	49.61	34.30	60.28	53.84	2.93	0.00	0.00	39.79
OF [%]	100.00	100.00	100.00	100.00	100.00	81.81	54.44	100.00	100.00	6.59	0.00	0.00	70.07
FLR [%]	53.08	48.90	40.58	40.14	39.97	50.39	65.70	39.72	46.16	55.03	0.00	0.00	47.24
UCL [%]	53.08	48.90	40.58	40.14	39.97	50.39	65.70	39.72	46.16	3.59	0.00	58.06	40.55
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.48	100.00	41.94	19.67
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

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Historical Summary

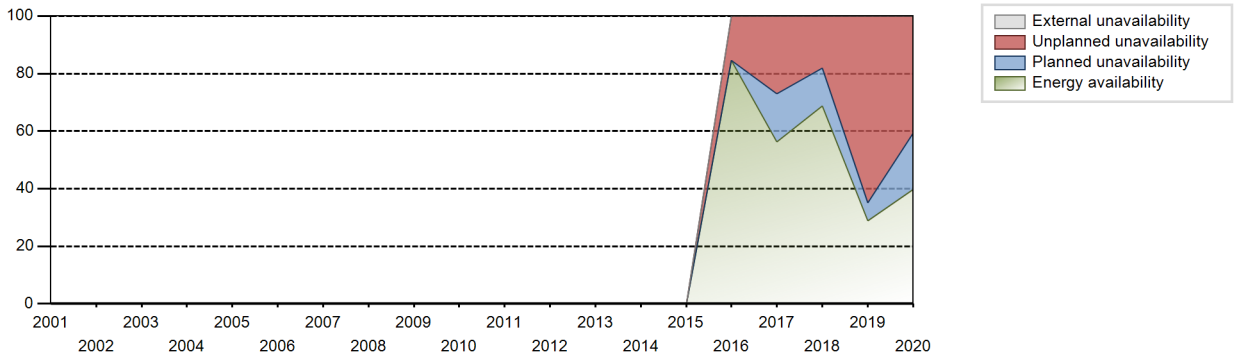
Lifetime energy generation	:	21925.26 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	34.99 %
Cumulative Energy Availability Factor (EAF)	:	53.05 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	34.77 %
Cumulative Unit Capability Factor (UCF)	:	53.05 %	Cumulative Planned Unavailability Factor (PUF)	:	12.18 %
Cumulative Load Factor (LF)	:	52.71 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	72.96 %			

Electricity Production (net) [GWh]

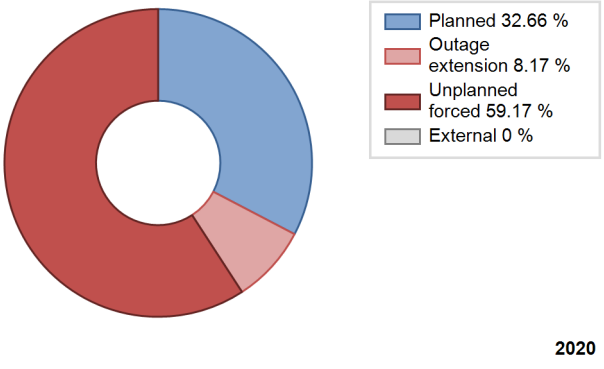


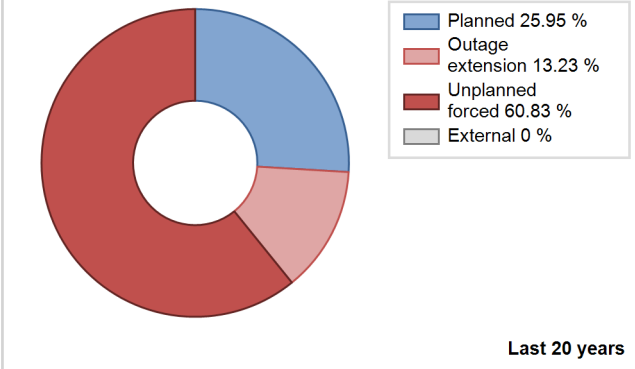
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	5200.54	8063	692	84.64	84.64	83.75	89.49	15.36	15.36	0.00	0.00
2017	3356.61	5130	693	56.27	56.27	55.29	58.56	7.12	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		902			1410	
D. Inspection, maintenance or repair without refuelling	1728			1000		
J. Grid limitation, failure or grid unavailability						1
Subtotal	1728	902		1000	1410	1
Total	**2630**			**2411**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	470	502
12. Reactor I&C Systems	432	86
13. Reactor Auxiliary Systems		53
14. Safety Systems		83
15. Reactor Cooling Systems		499
16. Steam generation systems		15
21. Fuel Handling and Storage Facilities		27
32. Feedwater and Main Steam System		16
42. Electrical Power Supply Systems		10
Total	**902**	**1291**

Highlights (2020)

2020.01.01 12:00 am to 2020.02.19 09:50 pm - Operation at low power (60%). Debris removal strategy from the reactor cooling system.

2020.02.19 09:50 pm to 2020.05.20 11:15 pm - Operation at low power (70%). Debris removal strategy from the reactor cooling system.

2020.05.20 11:15 pm to 2020.05.21 08:47 am – Power ramp down.

2020.05.21 08:47 am to 2020.05.23 07:16 am – Operation at low power due to high sodium concentration in the SG blowdown.

2020.05.23 07:16 am to 2020.05.23 08:38 am – Power ramp-up.

2020.05.23 08:38 am to 2020.06.25 12:43 pm - Operation at low power (70%). Debris removal strategy from the reactor cooling system.

2020.06.25 12:43 pm to 2020.07.15 02:30 am - Manual shutdown to repair a moderator pump (JFB30AP001).

2020.07.15 02:30 am to 2020.07.15 09:05 am - Power ramp-up.

2020.07.15 09:05 am to 2020.08.20 08:00 am - Operation at low power (70%). Debris removal strategy from the reactor cooling system.

2020.08.20 08:00 am to 2020.09.23 06:23 pm – Operation at low power (65%) due to preliminary work for the planned outage.

2020.09.23 06:23 pm to 2020.09.26 01:38 am – Power ramp down.

2020.09.26 01:38 am to 2020.10.03 12:30 am - Operation at low power (55%) due to preliminary work for the planned outage.

2020.10.03 12:30 am to 2020.12.14 12:00 am– Planned outage.

2020.12.14 12:00 am to 2021.01.01 12:00 am – Unplanned extension of planned outage. Reactor Internal Inspection

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2020 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	:	1974-04-01
Grid Date	:	1983-04-25
Commercial Date	:	1984-01-20
Age at end of year	:	37 years

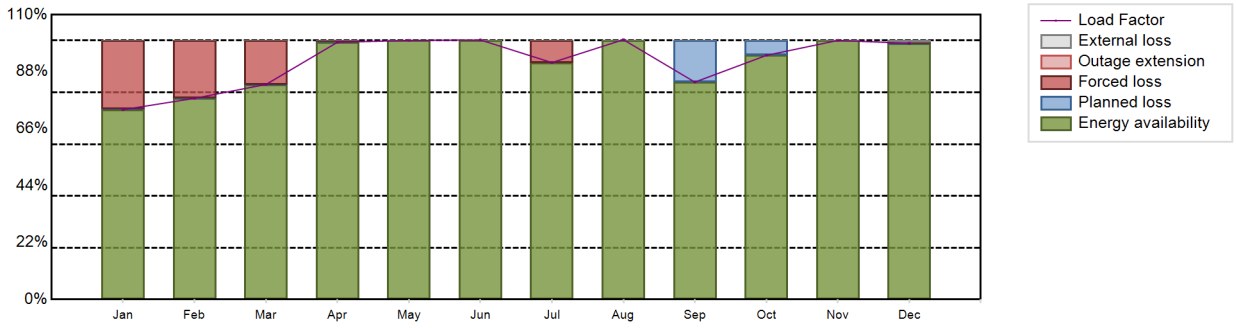
Design Characteristics

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]	:	NA
Part of the core refuelled [%]	:	-
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	:	-
Number of on-site safety related diesel generators	:	-
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	4910.14 GW(e).h
Energy Availability Factor (EAF)	:	91.88 %
Unit Capability Factor (UCF)	:	91.93 %
Load Factor (LF)	:	91.94 %
Operating Factor (OF)	:	96.16 %
Forced Loss Rate (FLR)	:	6.33 %
Unplanned Capability Loss Factor (UCL)	:	6.22 %
Planned Unavailability Factor (PUF)	:	1.85 %
Externally cause unavailability (XUF)	:	0.05 %
Total off-line time	:	337 hours

Annual Summary



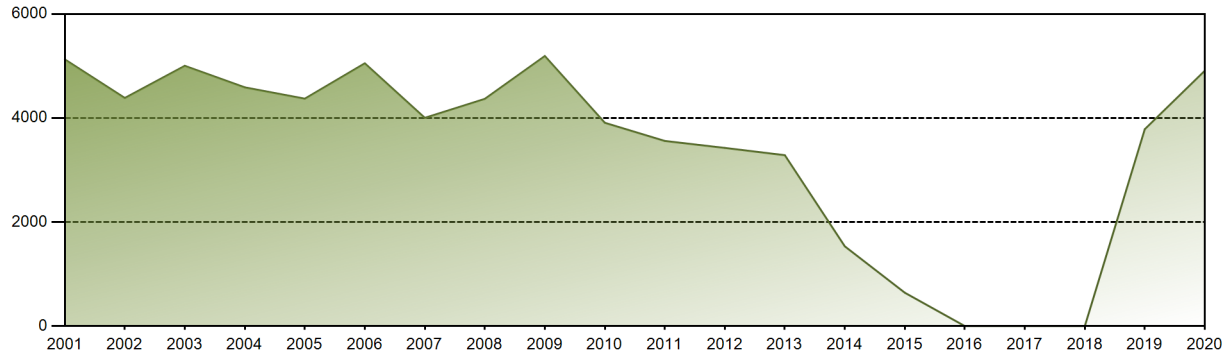
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	331.67	328.79	375.73	434.95	452.62	438.83	413.90	453.95	367.57	426.52	438.05	447.57	4910.14
EAF [%]	73.32	77.70	83.06	99.36	100.00	100.00	91.50	100.00	83.97	94.29	100.00	98.94	91.88
UCF [%]	73.32	77.70	83.06	99.36	100.00	100.00	91.50	100.00	83.97	94.29	100.00	99.58	91.93
LF [%]	73.32	77.70	83.06	99.36	100.06	100.25	91.50	100.35	83.97	94.29	100.07	98.94	91.94
OF [%]	100.00	91.67	91.67	100.00	100.00	100.00	91.80	100.00	83.89	94.62	100.00	100.00	96.16
FLR [%]	26.45	22.22	16.92	0.44	0.00	0.00	8.50	0.00	0.00	0.00	0.00	0.42	6.33
UCL [%]	26.37	22.20	16.92	0.44	0.00	0.00	8.50	0.00	0.00	0.00	0.00	0.42	6.22
PUF [%]	0.31	0.11	0.02	0.21	0.00	0.00	0.00	0.00	16.03	5.71	0.00	0.00	1.85
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.05

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Historical Summary

Lifetime energy generation	:	142321.32 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.01 %
Cumulative Energy Availability Factor (EAF)	:	78.58 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.47 %
Cumulative Unit Capability Factor (UCF)	:	78.87 %	Cumulative Planned Unavailability Factor (PUF)	:	18.65 %
Cumulative Load Factor (LF)	:	72.46 %	Cumulative Externally cause unavailability (XUF)	:	0.29 %
Cumulative Operating Factor (OF)	:	76.87 %			

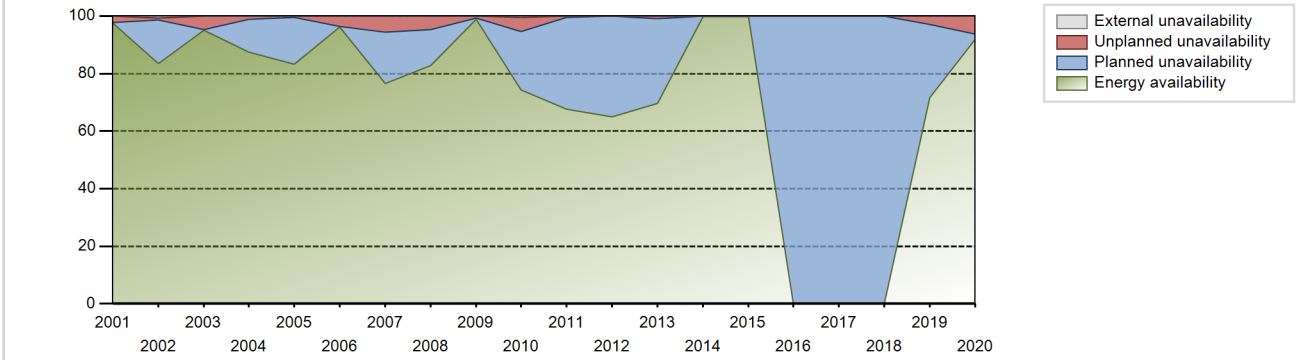
Electricity Production (net) [GWh]



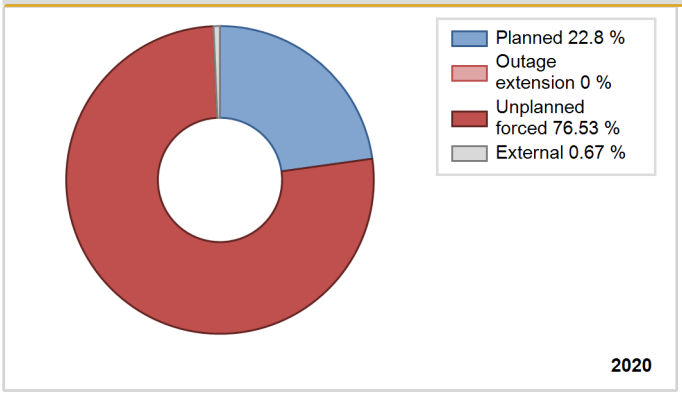
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	2527.07	6355	600	68.74	68.74	44.29	70.56	5.92	4.32	26.93	0.00
1985	3778.57	8170	600	93.44	93.44	71.89	93.26	6.15	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

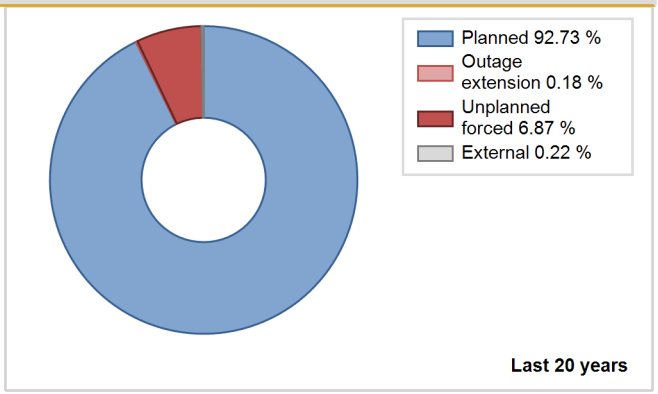
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		180			216	
C. Inspection, maintenance or repair combined with refuelling				95		
D. Inspection, maintenance or repair without refuelling	157			663		
E. Testing of plant systems or components				39	1	
G. Major backfitting, refurbishment or upgrading activities without refuelling				742		
H. Nuclear regulatory requirements					1	
J. Grid limitation, failure or grid unavailability						16
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						17
L. Human factor related					1	
M. Governmental requirements or court decisions						332
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
Z. Other					2	
Subtotal	157	180		1539	221	366
Total	**337**			**2126**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	62	8
12. Reactor I&C Systems		5
13. Reactor Auxiliary Systems		32
14. Safety Systems		1
15. Reactor Cooling Systems		11
16. Steam generation systems		63
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		25
32. Feedwater and Main Steam System	118	22
33. Circulating Water System		1
34. Miscellaneous Systems		4
41. Main Generator Systems		38
42. Electrical Power Supply Systems		8
Total	**180**	**221**

Highlights (2020)

2020.01.01 12:00 am to 2020.01.05 08:37 am – Power reduction due to limitations of the Reactor Regulating System.

2020.01.01 12:00 am to 2020.02.08 01:00 am - Loss of energy due to condenser vacuum reduction.

2020.02.08 12:00 am to 2020.02.08 01:00 am – Power ramp down.

2020.02.08 01:00 am to 2020.02.10 10:48 am - Loss of water in steam generator feedwater header.

2020.02.10 10:48 am to 2020.02.10 09:28 pm – Power ramp-up.

2020.02.10 09:28 pm to 2020.03.13 02:15 pm - Loss of energy due to condenser vacuum reduction.

2020.03.13 02:22 pm to 2020.03.13 03:16 pm – Power ramp down.

2020.03.13 03:16 pm to 2020.03.16 05:16 am – Manual shutdown due to a blocked shield plug.

2020.03.16 05:16 am to 2020.02.16 09:30 am – Power ramp-up.

2020.03.16 09:30 am to 2020.03.21 02:00 pm – Power reduction due to failure of sea water.

2020.03.21 02:00 pm to 2020.04:30 12:00 am - Loss of energy due to condenser vacuum reduction.

2020.07.26 03:00 pm to 2020.07.29 03:19 am - Automatic scram due to failure of a feedwater valve.

2020.07.29 03:19 am to 2020.07.30 06:00 am – Power ramp-up.

2020.09.26 01.05 am to 2020.09.26 04:44 am - Power ramp down.

2020.09.26 04:44 am am to 2020.10.02 05:15 pm – Planned outage.

2020.10.02 05:15 pm to 2020.10.03 01:57 pm – Power ramp-up.

2020.12.01 12:00 am to 2020.12.31 11:59 pm - Loss of performance due to variation of cooling water temperature.

2020.12.21 05:55 pm to 2020.12.22 12:33 pm – Power reduction to carry out testing of the turbine emergency valves.

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2020 Operating Experience

AM-19 ARMENIAN-2 ARMENIA



Status at end of year	:	**Operational**
Operator	:	ANPPCJSC (Closed Joint Stock Company Armenian NPP)
Owner	:	M.E. (Ministry of Energy and Natural Resources of RA)
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	:	451 MWe
Reference unit power (net)	:	415 MWe

Key Dates

Construction Date	:	1975-07-01
Grid Date	:	1980-01-05
Commercial Date	:	1980-05-03
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 [%]	:	-
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

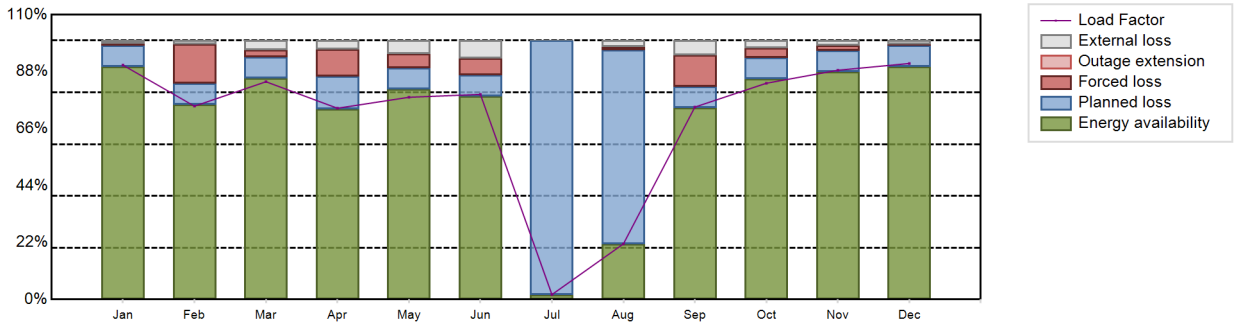
Operating coolant pressure [MPa]	:	12.5
Reactor outlet temperature [°C]	:	295.8
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
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	:	none

Annual Production Results (2020)

Net Energy Production	:	2551.8 GW(e).h
Energy Availability Factor (EAF)	:	70.3 %
Unit Capability Factor (UCF)	:	73.3 %
Load Factor (LF)	:	70 %
Operating Factor (OF)	:	83.05 %

Forced Loss Rate (FLR)	:	6.29 %
Unplanned Capability Loss Factor (UCL)	:	4.92 %
Planned Unavailability Factor (PUF)	:	21.78 %
Externally cause unavailability (XUF)	:	3 %
Total off-line time	:	1489 hours

Annual Summary



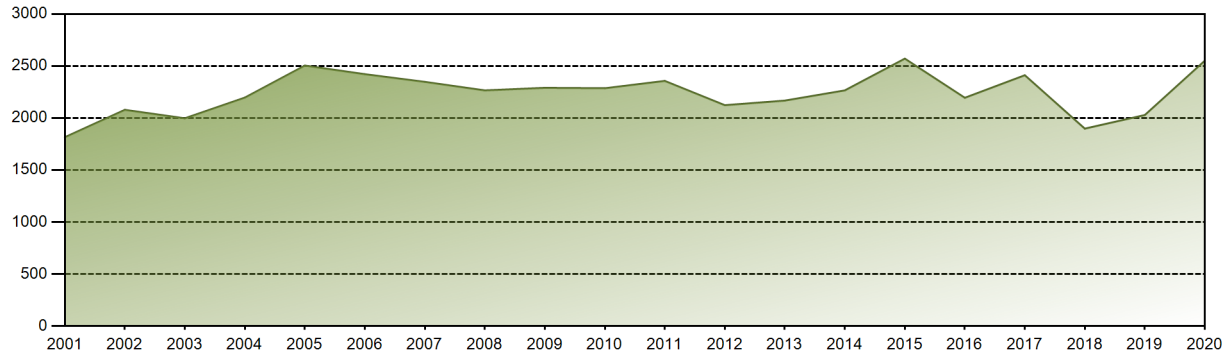
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	279.45	215.69	259.69	220.74	241.18	236.73	5.90	66.34	222.09	257.91	264.57	281.51	2551.80
EAF [%]	89.96	75.37	85.42	73.54	81.34	78.61	1.91	21.49	74.16	85.13	88.02	89.99	70.30
UCF [%]	91.21	76.75	89.04	76.98	86.44	85.48	1.91	23.91	79.88	88.11	89.89	91.48	73.30
LF [%]	90.51	74.67	84.11	73.88	78.11	79.23	1.91	21.49	74.33	83.53	88.55	91.17	70.00
OF [%]	100.00	86.93	100.00	94.86	100.00	100.00	3.09	25.94	87.64	100.00	100.00	100.00	83.05
FLR [%]	0.70	16.44	3.06	11.93	5.89	6.93	0.00	5.06	13.03	4.07	2.13	0.40	6.29
UCL [%]	0.64	15.10	2.81	10.43	5.41	6.36	0.00	1.27	11.97	3.74	1.96	0.37	4.92
PUF [%]	8.15	8.15	8.15	12.58	8.15	8.15	98.09	74.82	8.15	8.15	8.15	8.15	21.78
XUF [%]	1.24	1.38	3.61	3.44	5.09	6.88	0.00	2.42	5.71	2.97	1.87	1.49	3.00

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Historical Summary

Lifetime energy generation	:	75957.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.18 %
Cumulative Energy Availability Factor (EAF)	:	65.73 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.17 %
Cumulative Unit Capability Factor (UCF)	:	67.77 %	Cumulative Planned Unavailability Factor (PUF)	:	29.06 %
Cumulative Load Factor (LF)	:	65.31 %	Cumulative Externally cause unavailability (XUF)	:	2.04 %
Cumulative Operating Factor (OF)	:	79.46 %			

Electricity Production (net) [GWh]

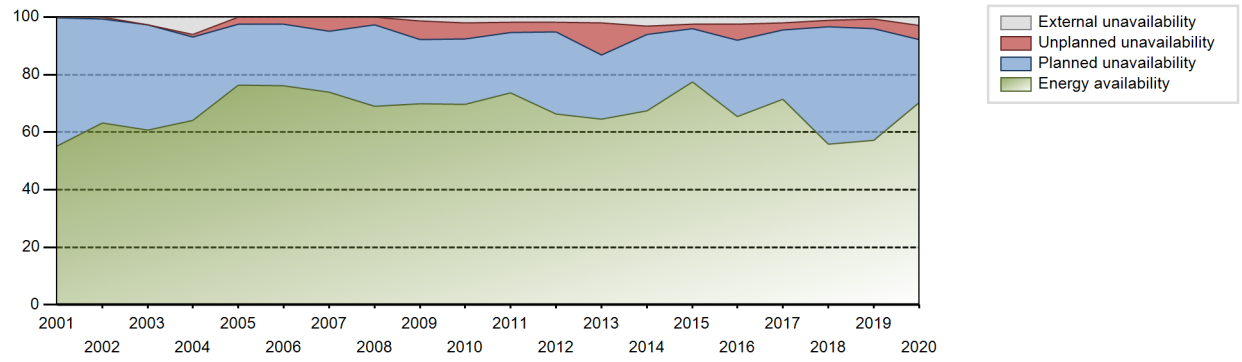


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	Data not provided										
1981	"										
1982	"										
1983	"										
1984	"										
1985	"										
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 - Long-term shutdown										
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

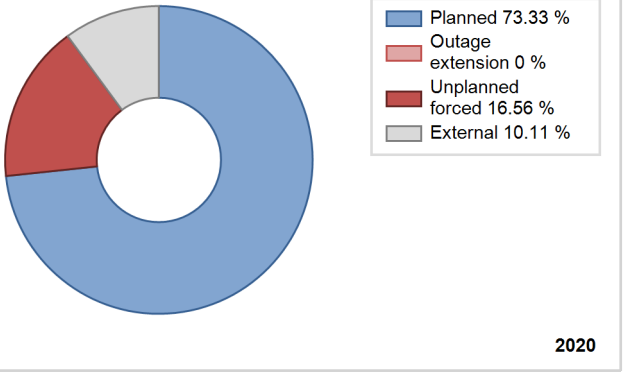
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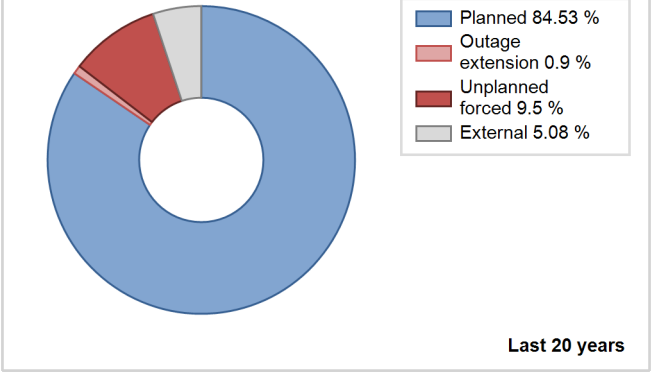
2017	2411.39	7341	375	71.41	73.43	73.41	83.80	3.19	2.42	24.15	2.02
2018	1898.08	7169	375	55.75	56.87	57.78	81.84	3.81	2.25	40.88	1.12
2019	2028.96	6252	375	57.15	57.76	61.76	71.37	5.62	3.44	38.80	0.60
2020	2551.80	7295	415	70.30	73.30	70.00	83.05	6.29	4.92	21.78	3.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		190			104	
C. Inspection, maintenance or repair combined with refuelling	1262			1437	15	
D. Inspection, maintenance or repair without refuelling				144		
E. Testing of plant systems or components					2	
F. Major backfitting, refurbishment or upgrading activities with refuelling				57		
J. Grid limitation, failure or grid unavailability						10
L. Human factor related					2	
Z. Other		37			1	
Subtotal	1262	227		1638	124	10
Total	**1489**			**1772**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	99	29
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		9
15. Reactor Cooling Systems	91	16
16. Steam generation systems		8
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		2
34. Miscellaneous Systems		25
35. All other I&C Systems		1
41. Main Generator Systems		1
42. Electrical Power Supply Systems		4
Total	**190**	**110**

RUP revision during the year (2020) due to power uprate

RUP at the end of previous year : 375 [MWe]

Month	Capacity [MWe]	Power Uprate	Main modifications	Description
January	415	Extended power uprate (>7%)	Balance of plant	Turbine modernization

Highlights (2020)

With the view of implementing outage-2020 covering a large scope of activities to be performed in the framework of the Armenian NPP life extension program. In 2020 in the framework of the Armenian NPP life extension program the Armenian NPP Unit 2 its' capacity increases to 451 MW on account of increase of turbines' capacity. But Armenian NPP has operational permission for 92 % of thermal capacity of nuclear reactor (415 MW).

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2020 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

Reactor type and model	:	PWR / VVER V-491
Thermal power	:	3200 MWth
Gross electrical power	:	1194 MWe
Reference unit power (net)	:	1110 MWe

Key Dates

Construction Date	:	2013-11-08
Grid Date	:	2020-11-03
Commercial Date	:	
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]	:	-
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	-
Average discharge burnup [MWd/t]	:	55500
Active core diameter [m]	:	3.16
Active core height/length [m]	:	3.73
Number of fissile fuel assemblies/bundles	:	163
Fuel linear heat generation rate [kW/m]	:	16.87
Number of control rod assemblies	:	121
Number of external reactor coolant loops	:	4
Coolant type	:	H2O

Operating coolant pressure [MPa]	:	16.2
Reactor outlet temperature [°C]	:	328.6
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	0.4
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]	:	6.8
Output voltage [kV]	:	24
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	:	5
Non-electrical applications	:	none

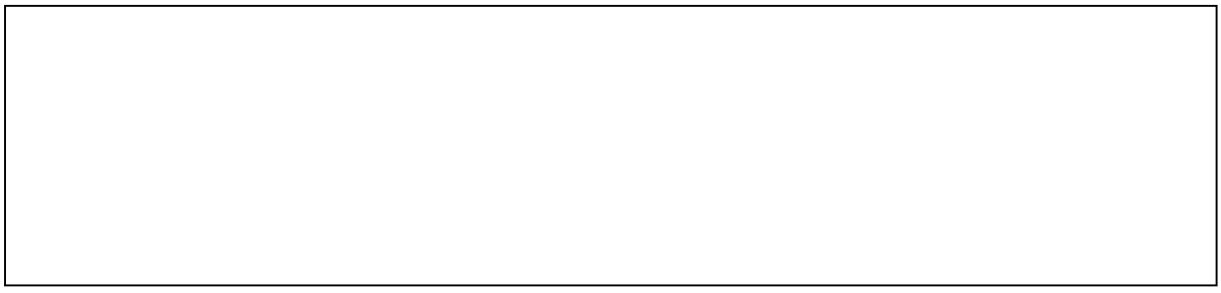
Annual Production Results (2020)

Net Energy Production	:	338.43 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	:	907 hours

Annual Summary

No data found



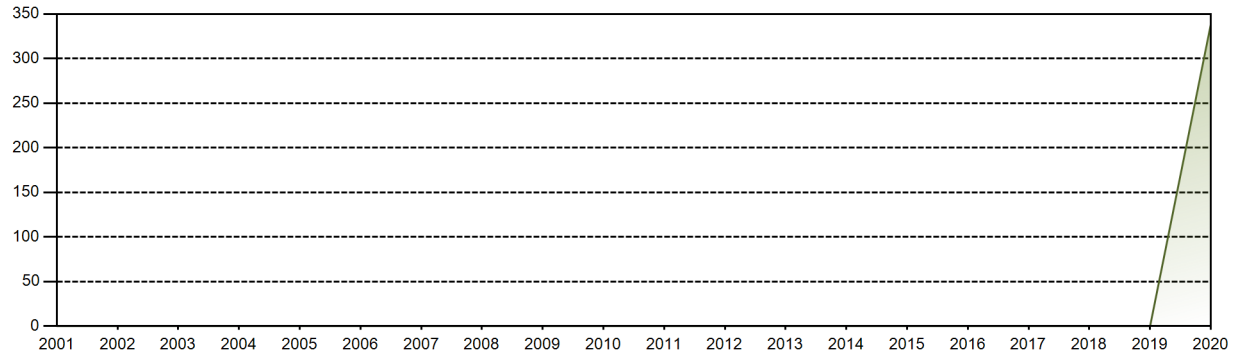
	Jan	Oct	Nov	Dec	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
GW(e)-h												
EAF [%]												
UCF [%]												
LF [%]												
OF [%]												
FLR [%]												
UCL [%]												
PUF [%]												
XUF [%]												

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Historical Summary

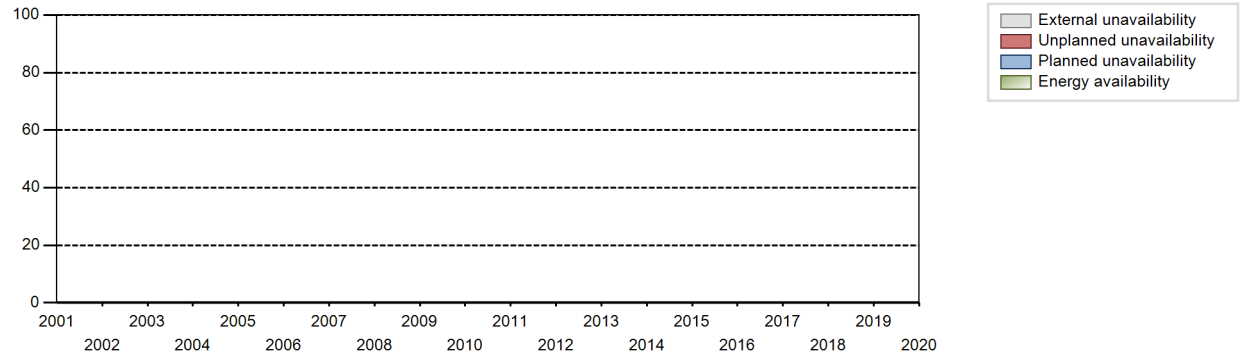
Lifetime energy generation	:	338.42 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	0 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	0 %	Cumulative Planned Unavailability Factor (PUF)	:	0 %
Cumulative Load Factor (LF)	:	0 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	0 %			

Electricity Production (net) [GWh]

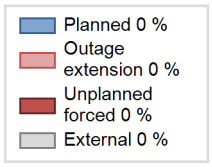


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]

Key Factors in Last 20 Years [%]



Energy Losses by Type



2020

No Data Available

Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			1 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
Subtotal						
Total	0			0		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1 to 2020
	Hours Lost	Average hours lost per reactor-year
Total		

Highlights (2020)

1. Stage "Physical start-up": 2020-08-06;
1.1. Criticality Date: 2020-10-11.
2. Stage "Energy start-up": 2020-10.23;
2.1. Grid Date: 2020-11-03.
3. Trial operation: 2020-12-22.

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2020 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	:	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]	:	-
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

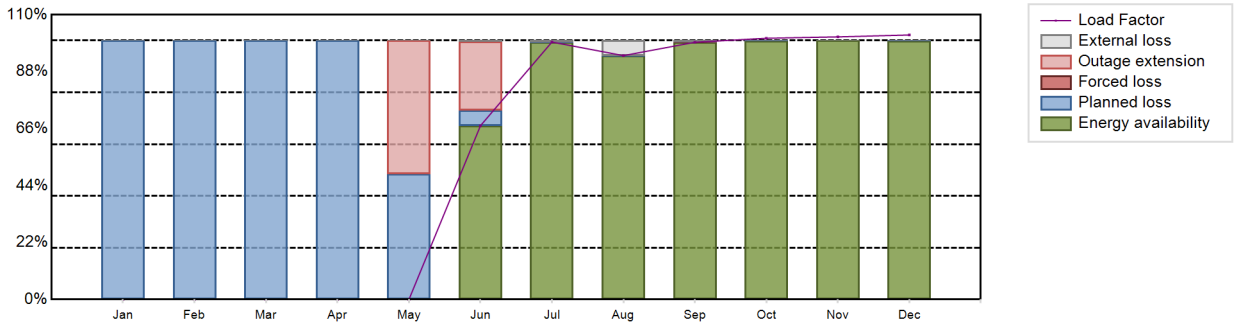
Operating coolant pressure [MPa]	:	15.73
Reactor outlet temperature [°C]	:	315.08
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	2.9
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
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 (2020)

Net Energy Production	:	2172.18 GW(e).h
Energy Availability Factor (EAF)	:	55.19 %
Unit Capability Factor (UCF)	:	55.81 %
Load Factor (LF)	:	55.57 %
Operating Factor (OF)	:	56.31 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	6.55 %
Planned Unavailability Factor (PUF)	:	37.64 %
Externally cause unavailability (XUF)	:	0.62 %
Total off-line time	:	3838 hours

Annual Summary



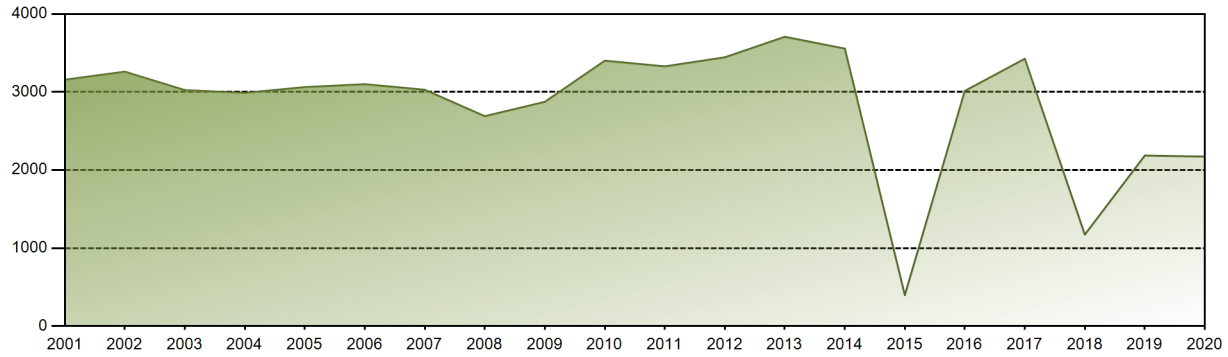
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	215.00	329.22	311.87	318.32	334.52	325.00	338.25	2172.18
EAF [%]	0.00	0.00	0.00	0.00	0.00	67.10	99.44	94.20	99.41	99.98	100.00	99.98	55.19
UCF [%]	0.00	0.00	0.00	0.00	0.00	67.61	99.95	99.96	99.94	99.98	100.00	99.98	55.81
LF [%]	0.00	0.00	0.00	0.00	0.00	67.10	99.44	94.20	99.35	100.90	101.44	102.17	55.57
OF [%]	0.00	0.00	0.00	0.00	0.00	73.47	100.00	100.00	100.00	100.00	100.00	100.00	56.31
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
UCL [%]	0.00	0.00	0.00	0.00	51.61	26.51	0.00	0.00	0.03	0.00	0.00	0.00	6.55
PUF [%]	100.00	100.00	100.00	100.00	48.39	5.88	0.05	0.04	0.03	0.02	0.00	0.02	37.64
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.51	0.51	5.77	0.53	0.00	0.00	0.00	0.62

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Historical Summary

Lifetime energy generation	:	133233.48 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.18 %
Cumulative Energy Availability Factor (EAF)	:	83.39 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.14 %
Cumulative Unit Capability Factor (UCF)	:	84.22 %	Cumulative Planned Unavailability Factor (PUF)	:	12.64 %
Cumulative Load Factor (LF)	:	81.71 %	Cumulative Externally cause unavailability (XUF)	:	0.82 %
Cumulative Operating Factor (OF)	:	83.35 %			

Electricity Production (net) [GWh]

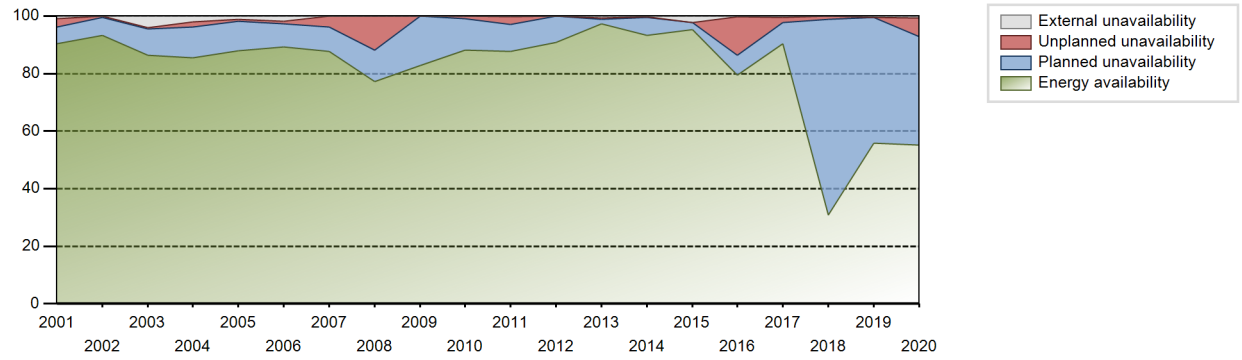


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	2557.60	7257	392	75.78	75.78	75.77	81.78	24.22	24.22	0.00	0.00
1976	2667.10	6928	395	75.48	75.48	76.87	78.87	12.67	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

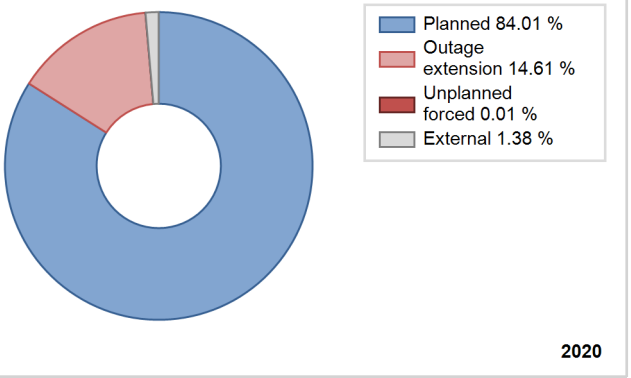
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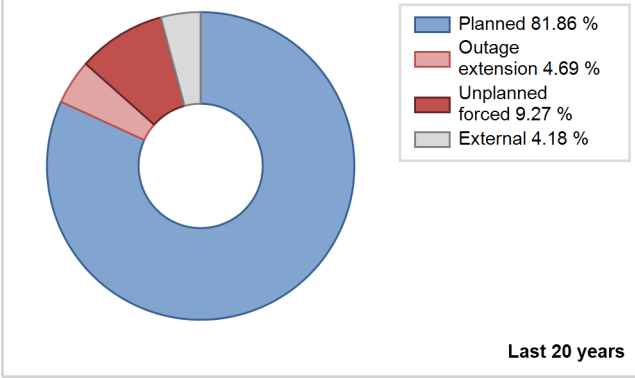
2012	3444.69	8019	433	90.91	90.91	90.57	91.29	0.08	0.07	9.02	0.00
2013	3707.93	8595	433	97.23	97.93	97.76	98.12	0.37	0.36	1.71	0.70
2014	3556.42	8230	433	93.35	93.62	93.76	93.95	0.32	0.30	6.08	0.27
2015	396.78	1143	433	95.33	97.63	10.46	13.05	0.00	0.00	2.37	2.30
2016	3014.51	7056	433	79.41	79.64	79.26	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					198	
C.	Inspection, maintenance or repair combined with refuelling				722		
D.	Inspection, maintenance or repair without refuelling				6		
E.	Testing of plant systems or components				47	1	
F.	Major backfitting, refurbishment or upgrading activities with refuelling	3263			284		
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		575			26	
M.	Governmental requirements or court decisions						162
P.	Fire					1	
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				18	34	
Z.	Other					1	
Subtotal		3263	575		1077	266	167
Total		**3838**			**1510**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		8
12. Reactor I&C Systems		31
13. Reactor Auxiliary Systems		4
14. Safety Systems		12
15. Reactor Cooling Systems		34
16. Steam generation systems		32
31. Turbine and auxiliaries		59
32. Feedwater and Main Steam System		17
33. Circulating Water System		0
41. Main Generator Systems		7
42. Electrical Power Supply Systems		1
Total		**205**

Highlights (2020)

Continuation Refuelling outage and from 16-05-2020 Refuelling outage extention (finish a number of changes for LTO)
Start cycle 45 on 08-06-2020

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2020 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	:	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 [%]	:	-
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

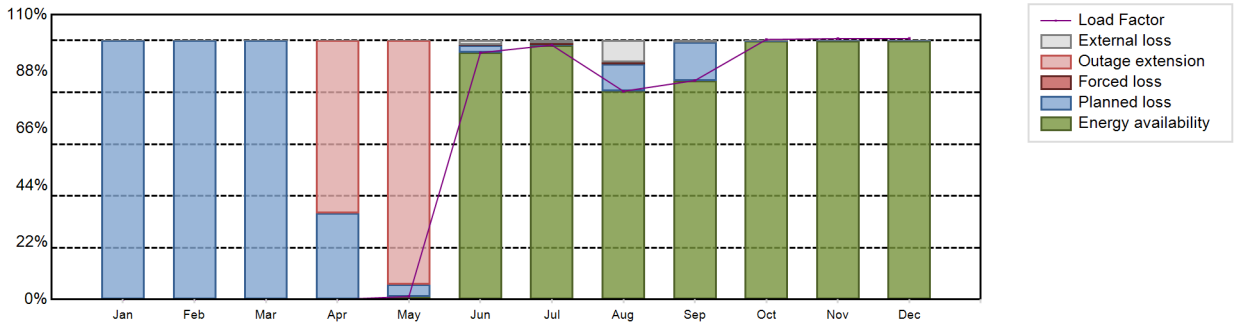
Operating coolant pressure [MPa]	:	15.73
Reactor outlet temperature [°C]	:	315.08
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	2.9
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	2161.14 GW(e).h
Energy Availability Factor (EAF)	:	55.74 %
Unit Capability Factor (UCF)	:	56.73 %
Load Factor (LF)	:	55.91 %
Operating Factor (OF)	:	56.96 %

Forced Loss Rate (FLR)	:	0.26 %
Unplanned Capability Loss Factor (UCL)	:	13.38 %
Planned Unavailability Factor (PUF)	:	29.89 %
Externally cause unavailability (XUF)	:	0.99 %
Total off-line time	:	3781 hours

Annual Summary



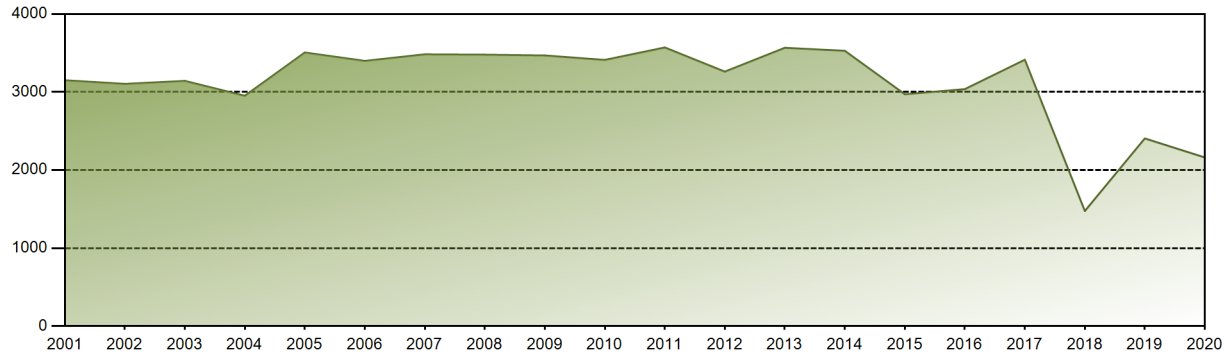
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	3.73	305.43	325.28	266.31	270.93	332.90	322.84	333.72	2161.14
EAF [%]	0.00	0.00	0.00	0.00	1.16	95.33	98.25	80.44	84.58	99.91	99.97	99.98	55.74
UCF [%]	0.00	0.00	0.00	0.00	1.16	97.01	99.07	88.80	85.31	99.98	99.97	99.98	56.73
LF [%]	0.00	0.00	0.00	0.00	1.16	95.33	98.25	80.44	84.56	100.41	100.76	100.80	55.91
OF [%]	0.00	0.00	0.00	0.00	5.65	100.00	100.00	89.92	85.97	100.00	100.00	100.00	56.96
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.12	0.90	0.77	0.00	0.00	0.00	0.00	0.26
UCL [%]	0.00	0.00	0.00	66.67	94.22	0.11	0.90	0.69	0.00	0.00	0.00	0.00	13.38
PUF [%]	100.00	100.00	100.00	33.33	4.62	2.88	0.03	10.52	14.69	0.02	0.03	0.02	29.89
XUF [%]	0.00	0.00	0.00	0.00	0.00	1.68	0.82	8.36	0.74	0.06	0.00	0.00	0.99

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Historical Summary

Lifetime energy generation	:	131647.39 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.57 %
Cumulative Energy Availability Factor (EAF)	:	80.94 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.43 %
Cumulative Unit Capability Factor (UCF)	:	81.7 %	Cumulative Planned Unavailability Factor (PUF)	:	14.87 %
Cumulative Load Factor (LF)	:	81.18 %	Cumulative Externally cause unavailability (XUF)	:	0.76 %
Cumulative Operating Factor (OF)	:	82.06 %			

Electricity Production (net) [GWh]

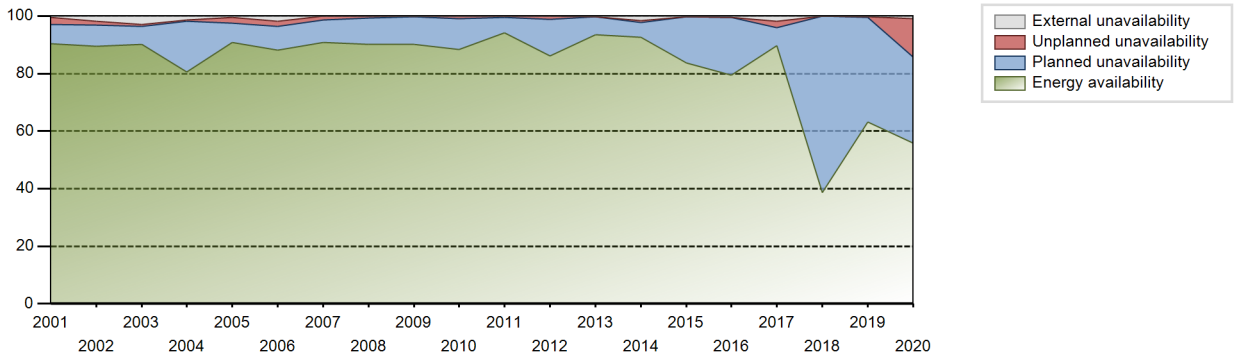


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	711.50	2305	392	91.30	91.30	91.34	93.28	8.70	8.70	0.00	0.00
1976	2462.80	6519	395	71.64	71.64	70.98	74.21	6.58	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

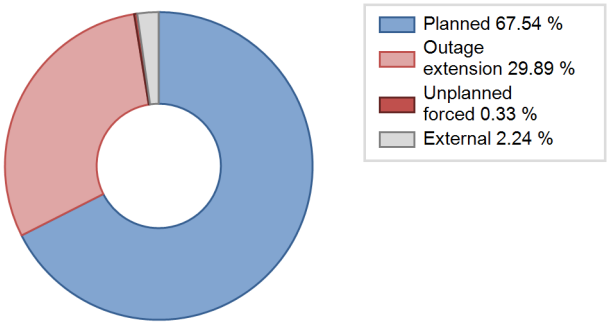
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2012	3261.59	7605	433	86.06	86.14	85.75	86.58	1.34	1.17	12.68	0.09
2013	3566.80	8238	433	93.52	93.77	94.03	94.04	0.02	0.02	6.21	0.26
2014	3528.42	8291	433	92.67	94.33	93.02	94.65	0.59	0.56	5.10	1.66
2015	2971.43	6883	433	83.77	83.98	78.34	78.57	0.02	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

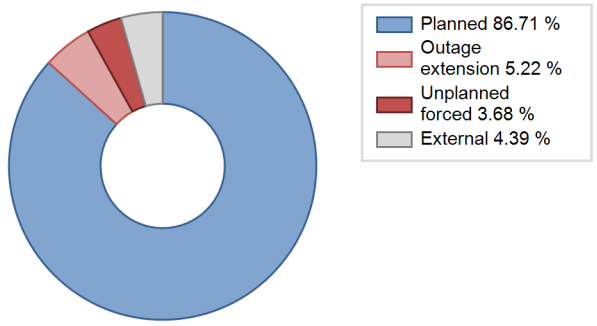
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					239	
C.	Inspection, maintenance or repair combined with refuelling				775		
D.	Inspection, maintenance or repair without refuelling	176			146		
E.	Testing of plant systems or components				66	10	
F.	Major backfitting, refurbishment or upgrading activities with refuelling	2423			242		
J.	Grid limitation, failure or grid unavailability						0
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						16
L.	Human factor related		1181			44	
M.	Governmental requirements or court decisions						12
P.	Fire					1	
Z.	Other					8	
Subtotal		2599	1181		1229	302	28
Total		**3780**			**1559**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		7
14. Safety Systems		10
15. Reactor Cooling Systems		20
16. Steam generation systems		66
21. Fuel Handling and Storage Facilities		21
31. Turbine and auxiliaries		67
32. Feedwater and Main Steam System		14
34. Miscellaneous Systems		19
41. Main Generator Systems		20
42. Electrical Power Supply Systems		7
Total		**262**

Highlights (2020)

Continuation refuelling outage (+ LTO) and from 11-04-2020 Refuelling outage extention (finish changes for LTO)
Start cycle 45 on 30-05-2020 with extensive testing new turbine
from 28-08-2020 to 05-09-2020: Shutdown for maintenance interventions

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2020 Operating Experience

BE-5 DOEL-3 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	:	FRAMACEC (FRAMACECO (FRAMATOME-ACEC-COCKERILL))
Turbine Supplier	:	ARLACEC (TURBINE: (ALSTHOM - RATEAU - LA MEUSE); ALTERNATOR: ACEC)

Reactor Unit Details

Reactor type and model	:	PWR / WH 3LP
Thermal power	:	3054 MWth
Gross electrical power	:	1056 MWe
Reference unit power (net)	:	1006 MWe

Key Dates

Construction Date	:	1975-01-01
Grid Date	:	1982-06-23
Commercial Date	:	1982-10-01
Age at end of year	:	38 years

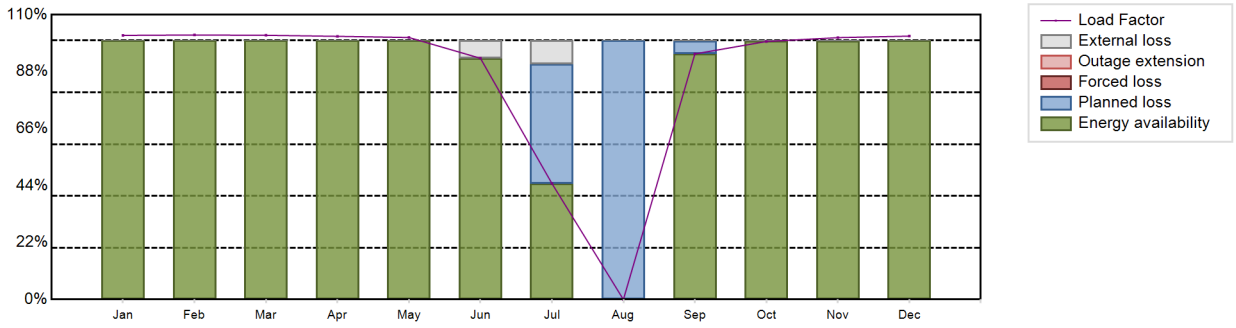
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.73
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	315.08
Fuel material	:	UO2/MOX	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	Double
Moderator material	:	H2O	Containment design pressure [MPa]	:	3.5
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]	:	49000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	5.8
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]	:	20	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	:	4	Number of on-site safety related diesel generators	:	-
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	7673.49 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	85.85 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	87.22 %	Planned Unavailability Factor (PUF)	:	12.78 %
Load Factor (LF)	:	86.84 %	Externally cause unavailability (XUF)	:	1.37 %
Operating Factor (OF)	:	87.6 %	Total off-line time	:	1089 hours

Annual Summary



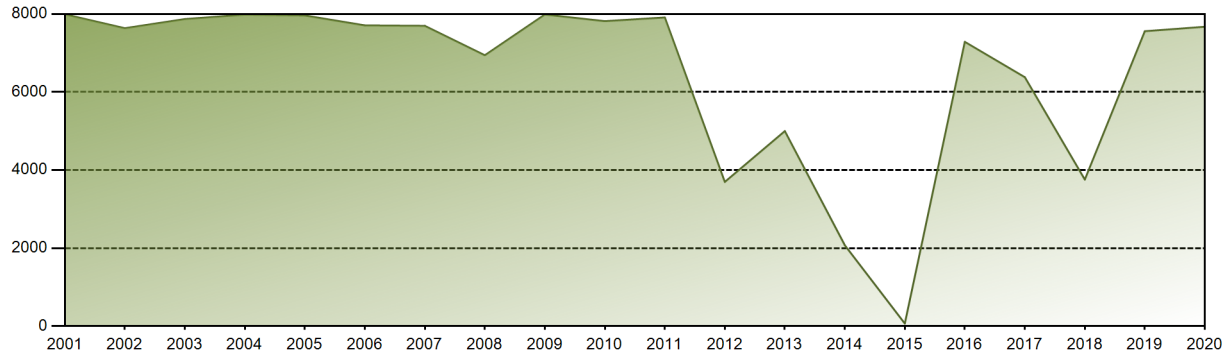
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	763.46	715.32	762.67	736.29	757.37	674.92	335.49	0.00	687.08	746.88	732.54	761.47	7673.49
EAF [%]	100.00	100.00	100.00	100.00	100.00	93.18	44.82	0.00	94.81	99.76	99.92	100.00	85.85
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	53.92	0.00	95.02	100.00	100.00	100.00	87.22
LF [%]	102.00	102.16	102.03	101.65	101.19	93.18	44.82	0.00	94.86	99.65	101.14	101.74	86.84
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	54.17	0.00	99.44	100.00	100.00	100.00	87.60
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	46.08	100.00	4.98	0.00	0.00	0.00	12.78
XUF [%]	0.00	0.00	0.00	0.00	0.00	6.82	9.10	0.00	0.20	0.24	0.08	0.00	1.37

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Historical Summary

Lifetime energy generation	:	256782.78 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.99 %
Cumulative Energy Availability Factor (EAF)	:	78.48 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.42 %
Cumulative Unit Capability Factor (UCF)	:	79.52 %	Cumulative Planned Unavailability Factor (PUF)	:	9.07 %
Cumulative Load Factor (LF)	:	78.5 %	Cumulative Externally cause unavailability (XUF)	:	1.04 %
Cumulative Operating Factor (OF)	:	80.63 %			

Electricity Production (net) [GWh]

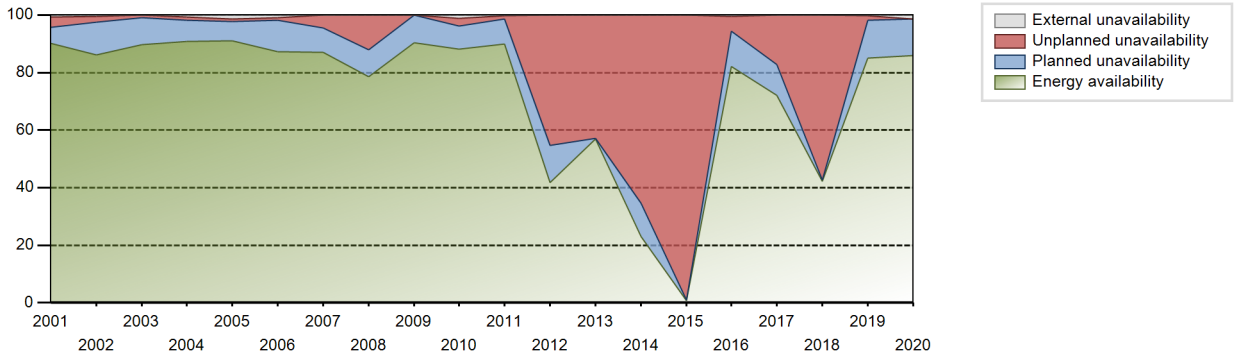


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1982	2631.00	3505	944	88.80	88.80	88.77	92.07	0.00	0.00	11.20	0.00
1983	6705.00	7807	900	85.04	85.04	85.05	89.12	2.78	2.43	12.54	0.00
1984	7074.00	8084	900	89.52	89.52	89.48	92.03	10.48	10.48	0.00	0.00
1985	6496.29	7515	900	82.39	82.39	82.40	85.79	4.28	3.69	13.93	0.00
1986	6860.00	8007	897	88.46	88.46	87.30	91.40	0.00	0.00	11.54	0.00
1987	5713.16	6905	897	73.48	75.68	72.71	78.82	17.70	16.28	8.04	2.20
1988	6777.55	7875	890	85.94	88.73	86.69	89.65	1.25	1.13	10.15	2.78
1989	5774.90	7470	900	73.44	82.12	73.25	85.27	5.63	4.89	12.99	8.68
1990	6811.76	8021	900	86.40	89.86	86.40	91.56	1.59	1.45	8.68	3.46
1991	6742.92	7913	900	85.80	89.95	85.53	90.33	0.12	0.11	9.94	4.15
1992	6732.24	7778	900	90.08	92.30	85.16	88.55	0.53	0.49	7.22	2.22
1993	5377.22	6198	900	65.85	69.58	68.20	70.75	4.34	3.16	27.27	3.73
1994	7482.35	7888	970	87.74	88.39	88.06	90.05	3.43	3.14	8.47	0.65
1995	7025.06	7396	970	82.57	83.41	82.68	84.43	8.34	7.59	9.00	0.83
1996	7334.15	7447	993	83.81	84.44	84.03	84.78	5.27	4.70	10.86	0.63
1997	8108.24	8250	1006	91.95	93.51	92.01	94.18	0.48	0.45	6.04	1.56
1998	8012.55	8171	1006	90.93	91.96	90.92	93.28	0.14	0.13	7.91	1.04
1999	8231.24	8330	1006	93.40	94.78	93.40	95.09	0.02	0.01	5.21	1.37
2000	7884.93	7892	1006	88.98	89.30	89.23	89.85	4.01	3.73	6.97	0.32
2001	7993.26	7989	1006	90.21	90.86	90.70	91.20	3.79	3.58	5.56	0.65
2002	7636.59	7647	1006	86.25	86.70	86.66	87.29	2.26	2.00	11.30	0.45
2003	7870.79	7928	1006	89.73	89.84	89.31	90.50	0.90	0.81	9.35	0.10
2004	7984.83	8104	1006	90.84	91.64	90.36	92.26	1.09	1.01	7.35	0.80
2005	7962.73	8147	1006	91.05	92.40	90.36	93.00	1.00	0.94	6.67	1.35
2006	7708.74	7764	1006	87.29	88.15	87.47	88.63	0.09	0.97	10.88	0.86
2007	7697.09	7710	1006	87.13	87.24	87.34	88.01	2.07	4.38	8.38	0.10
2008	6943.53	6980	1006	78.53	78.53	78.58	79.46	13.40	12.16	9.31	0.00
2009	7987.11	7947	1006	90.37	90.37	90.63	90.72	0.10	0.09	9.54	0.00
2010	7817.20	7862	1006	88.16	89.29	88.71	89.75	2.92	2.68	8.03	1.13
2011	7911.69	7933	1006	90.00	90.22	89.78	90.56	0.00	1.19	8.59	0.21
2012	3695.33	3668	1006	41.71	41.71	41.82	41.76	0.00	45.37	12.92	0.00
2013	4998.23	5023	1006	56.87	56.87	56.72	57.34	1.17	42.78	0.34	0.00
2014	2072.29	2030	1006	23.16	23.16	23.52	23.17	73.83	65.33	11.51	0.00
2015	64.44	94	1006	0.73	0.73	0.73	1.07	99.27	98.94	0.33	0.00
2016	7286.59	7293	1006	82.02	82.40	82.46	83.03	3.00	5.24	12.36	0.39
2017	6380.11	6330	1006	71.99	72.10	72.40	72.26	0.50	17.08	10.82	0.11
2018	3755.51	3751	1006	42.16	42.19	42.62	42.82	4.32	57.28	0.53	0.03

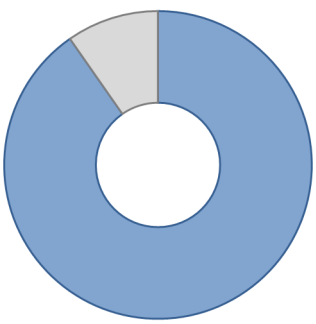
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2019	7559.30	7512	1006	85.08	85.26	85.78	85.75	1.88	1.63	13.11	0.17
2020	7673.49	7695	1006	85.85	87.22	86.84	87.60	0.00	0.00	12.78	1.37

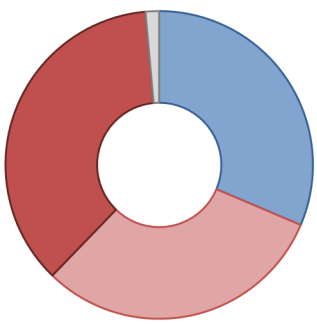
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1982 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					699	
C. Inspection, maintenance or repair combined with refuelling	1089			729	2	
D. Inspection, maintenance or repair without refuelling				5		
E. Testing of plant systems or components				1	1	
H. Nuclear regulatory requirements					203	
L. Human factor related					21	
P. Fire					1	
Z. Other					7	
Subtotal	1089			735	934	
Total	**1089**			**1669**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1982 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		587
12. Reactor I&C Systems		2
13. Reactor Auxiliary Systems		1
14. Safety Systems		167
15. Reactor Cooling Systems		47
16. Steam generation systems		35
17. Safety I&C Systems (excluding reactor I&C)		12
31. Turbine and auxiliaries		21
32. Feedwater and Main Steam System		19
34. Miscellaneous Systems		1
41. Main Generator Systems		5
42. Electrical Power Supply Systems		7
Total		**904**

Highlights (2020)

30-05-2020 to 17-07-2020 : Coastdown operation
17-07-2020 to 01-09-2020 : Refuelling outage (end cycle 35)

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2020 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)	:	1038 MWe

Key Dates

Construction Date	:	1978-12-01
Grid Date	:	1985-04-08
Commercial Date	:	1985-07-01
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]	:	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

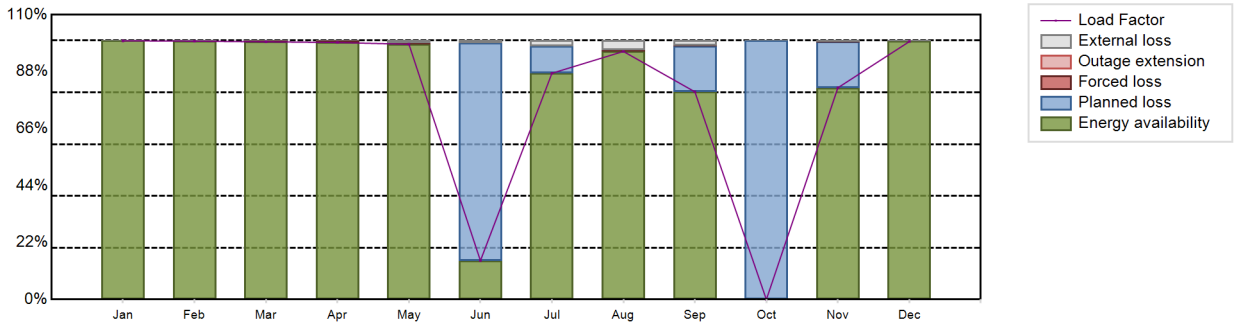
Operating coolant pressure [MPa]	:	15.73
Reactor outlet temperature [°C]	:	315.08
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	3.5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
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	:	none

Annual Production Results (2020)

Net Energy Production	:	7270.15 GW(e).h
Energy Availability Factor (EAF)	:	79.8 %
Unit Capability Factor (UCF)	:	80.6 %
Load Factor (LF)	:	79.74 %
Operating Factor (OF)	:	81.36 %

Forced Loss Rate (FLR)	:	0.28 %
Unplanned Capability Loss Factor (UCL)	:	0.23 %
Planned Unavailability Factor (PUF)	:	19.17 %
Externally cause unavailability (XUF)	:	0.81 %
Total off-line time	:	1637 hours

Annual Summary



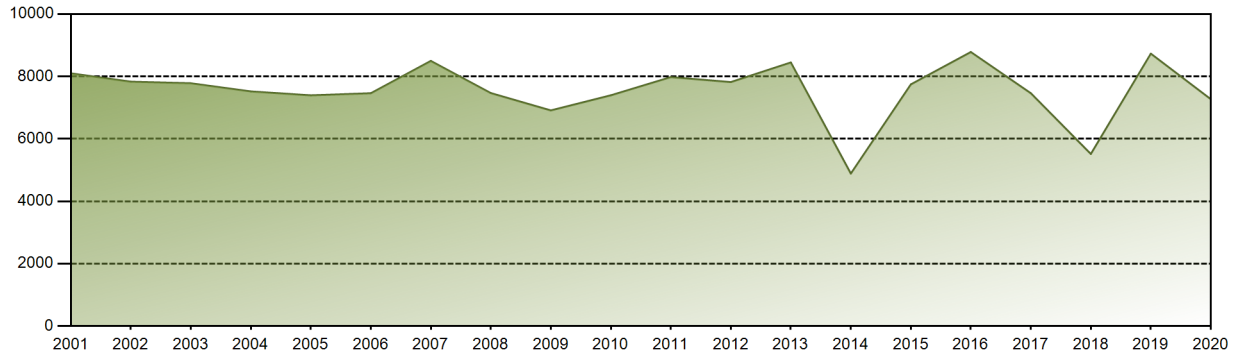
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	771.68	720.96	767.58	741.85	761.23	112.11	674.86	739.88	599.51	0.00	611.18	769.32	7270.15
EAF [%]	100.00	99.90	99.55	99.26	98.57	15.00	87.39	95.99	80.24	0.00	81.78	99.92	79.80
UCF [%]	100.00	99.90	99.55	99.26	99.40	15.77	89.61	99.61	82.05	0.00	82.05	100.00	80.60
LF [%]	99.92	99.79	99.53	99.26	98.57	15.00	87.39	95.81	80.22	0.00	81.78	99.62	79.74
OF [%]	100.00	100.00	100.00	100.00	100.00	16.39	93.28	100.00	82.92	0.00	83.75	100.00	81.36
FLR [%]	0.00	0.10	0.45	0.74	0.60	0.00	0.00	0.39	0.38	0.00	0.20	0.00	0.28
UCL [%]	0.00	0.10	0.45	0.74	0.60	0.00	0.00	0.39	0.32	0.00	0.16	0.00	0.23
PUF [%]	0.00	0.00	0.00	0.00	0.00	84.23	10.39	0.00	17.63	100.00	17.79	0.00	19.17
XUF [%]	0.00	0.00	0.00	0.00	0.83	0.77	2.23	3.63	1.81	0.00	0.27	0.08	0.81

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Historical Summary

Lifetime energy generation	:	261974.08 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.28 %
Cumulative Energy Availability Factor (EAF)	:	83.33 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.94 %
Cumulative Unit Capability Factor (UCF)	:	83.96 %	Cumulative Planned Unavailability Factor (PUF)	:	10.1 %
Cumulative Load Factor (LF)	:	83.04 %	Cumulative Externally cause unavailability (XUF)	:	0.62 %
Cumulative Operating Factor (OF)	:	85.36 %			

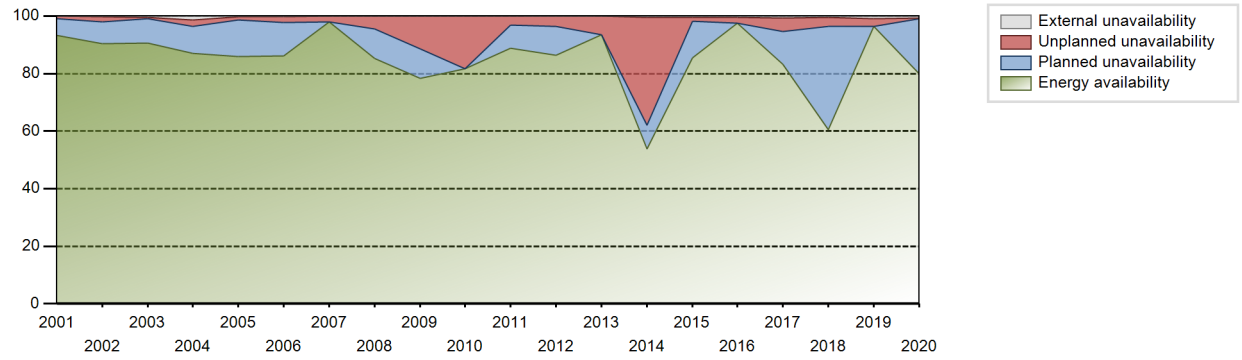
Electricity Production (net) [GWh]



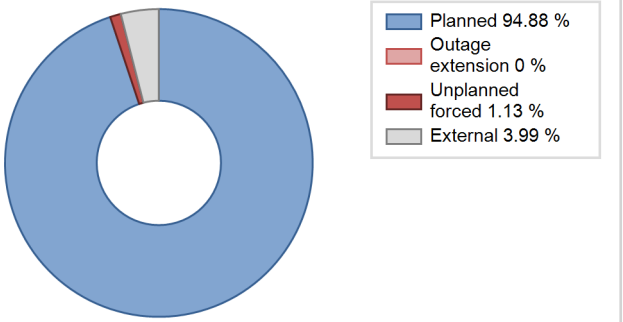
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	4282.13	5263	981	82.56	82.56	82.59	87.93	17.44	17.44	0.00	0.00
1986	7722.89	7973	1006	87.77	87.77	87.64	91.02	0.00	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

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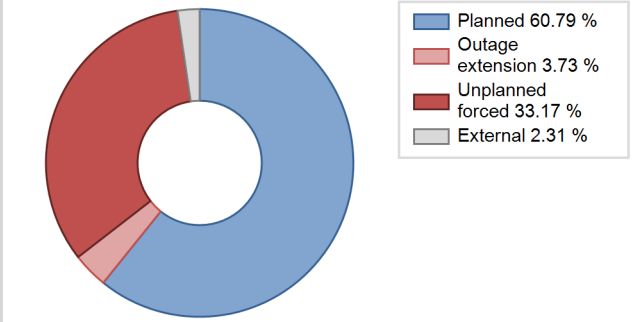
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					368	
C. Inspection, maintenance or repair combined with refuelling	652			716		
D. Inspection, maintenance or repair without refuelling	985			47		
E. Testing of plant systems or components				1	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				91		
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					26	
P. Fire					25	
Z. Other					32	
Subtotal	1637			855	453	4
Total	**1637**			**1312**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	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		10
15. Reactor Cooling Systems		16
16. Steam generation systems		144
31. Turbine and auxiliaries		166
32. Feedwater and Main Steam System		13
33. Circulating Water System		6
41. Main Generator Systems		48
42. Electrical Power Supply Systems		4
Total		**415**

Highlights (2020)

15-05-2020 to 05-06-2020 : coastdown operation
05-06-2020 to 03-07-2020 : Refuelling outage (end cycle 30)
25-09-2020 to 05-11-2020 : Revision maintenance part 2 (no refuelling)

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2020 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	:	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]	:	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

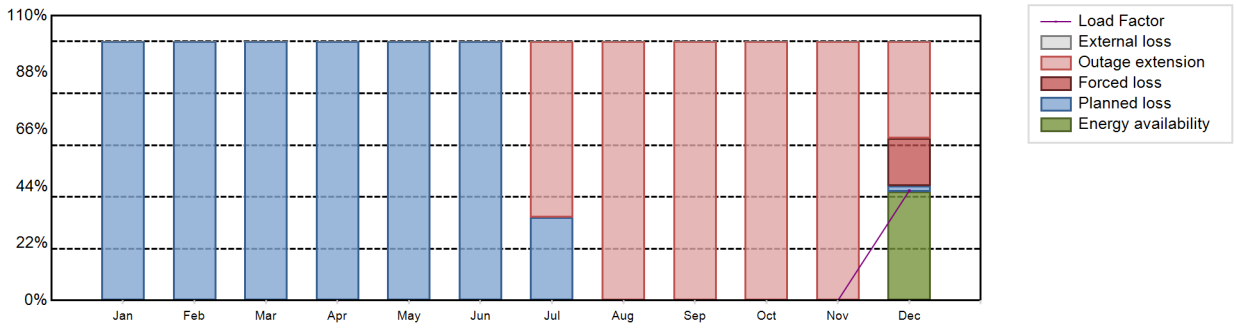
Operating coolant pressure [MPa]	:	15.41
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Double
Containment design pressure [MPa]	:	0.41
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	303.85 GW(e).h
Energy Availability Factor (EAF)	:	3.57 %
Unit Capability Factor (UCF)	:	3.57 %
Load Factor (LF)	:	3.6 %
Operating Factor (OF)	:	4.94 %

Forced Loss Rate (FLR)	:	30.28 %
Unplanned Capability Loss Factor (UCL)	:	43.82 %
Planned Unavailability Factor (PUF)	:	52.61 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8350 hours

Annual Summary



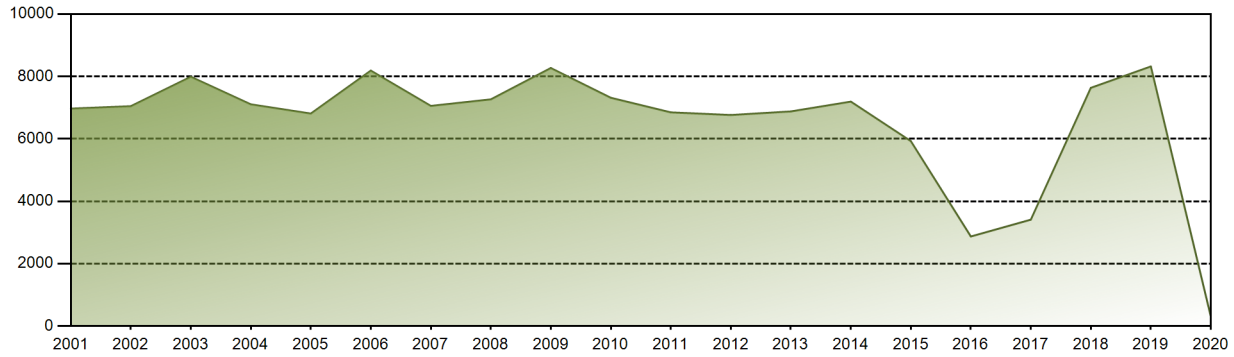
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	303.85	303.85
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.14	3.57
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.14	3.57
LF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.45	3.60
OF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.33	4.94
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.28	30.28
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	67.88	100.00	100.00	100.00	100.00	55.79	43.82
PUF [%]	100.00	100.00	100.00	100.00	100.00	100.00	32.12	0.00	0.00	0.00	0.00	2.07	52.61
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

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Historical Summary

Lifetime energy generation	:	293251.85 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.35 %
Cumulative Energy Availability Factor (EAF)	:	79.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.98 %
Cumulative Unit Capability Factor (UCF)	:	81.92 %	Cumulative Planned Unavailability Factor (PUF)	:	12.1 %
Cumulative Load Factor (LF)	:	79.73 %	Cumulative Externally cause unavailability (XUF)	:	2.07 %
Cumulative Operating Factor (OF)	:	83.52 %			

Electricity Production (net) [GWh]

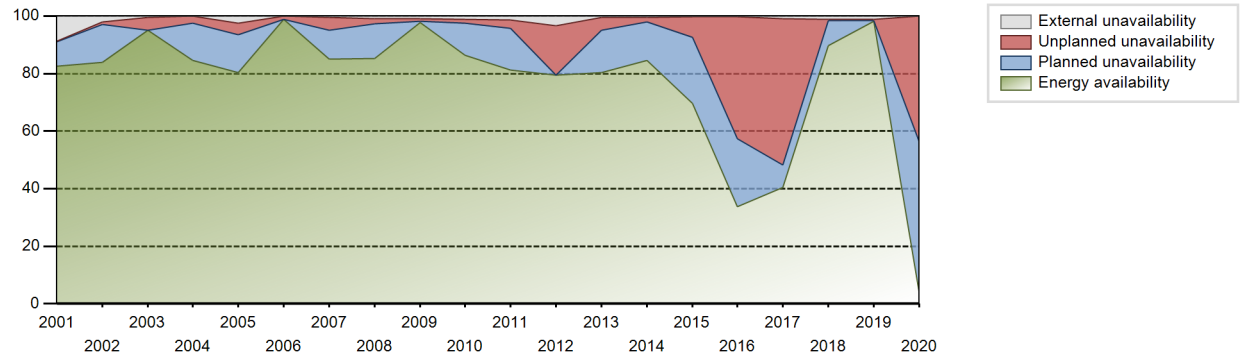


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	3096.30	5360	885	76.15	76.15	76.16	94.52	23.85	23.85	0.00	0.00
1976	4409.50	6354	870	57.54	89.78	57.70	72.34	3.70	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

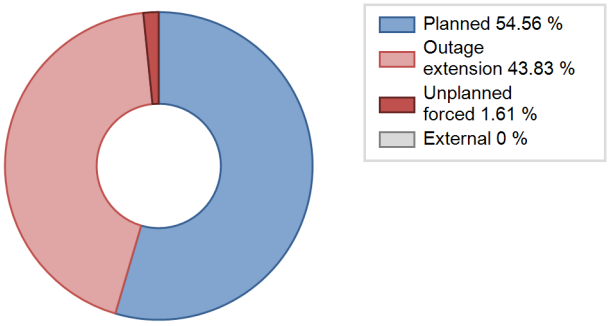
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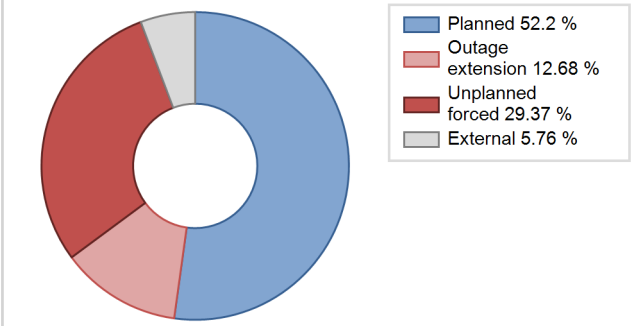
2012	6763.30	8784	962	79.44	82.88	80.04	100.00	17.12	17.12	0.00	3.44
2013	6878.12	7203	962	80.40	80.90	81.62	82.23	1.20	4.40	14.70	0.49
2014	7192.76	7503	962	84.51	85.06	85.35	85.65	0.32	1.57	13.37	0.55
2015	5927.29	6211	962	69.69	69.84	70.34	70.90	7.56	7.34	22.82	0.15
2016	2871.03	3026	962	33.69	33.85	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		2			294	
C.	Inspection, maintenance or repair combined with refuelling	4606			909		
D.	Inspection, maintenance or repair without refuelling				24		
G.	Major backfitting, refurbishment or upgrading activities without refuelling				43		
L.	Human factor related		3741			88	
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.)						63
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						7
Z.	Other					6	
Subtotal		4606	3743		976	388	70
Total		**8349**			**1434**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems	3712	93
13. Reactor Auxiliary Systems		5
14. Safety Systems		17
15. Reactor Cooling Systems		61
16. Steam generation systems		13
31. Turbine and auxiliaries	2	10
32. Feedwater and Main Steam System		147
33. Circulating Water System		2
34. Miscellaneous Systems		1
35. All other I&C Systems		0
41. Main Generator Systems		13
42. Electrical Power Supply Systems	29	15
Total	**3743**	**377**

Highlights (2020)

From 2020-01-01 to 2020-07-10 : continuation of planned shutdown for maintenance, LTO & refuelling.
From 2020-07-10 to 2020-12-12 : unplanned extension of planned shutdown.
From 2020-12-12 to 2020-12-20 : during planned power escalation after planned shutdown and extension : south group connection to grid + south group trip + unplanned automatic scram (NOR SOUTH GROUP NOR NORTH GROUP CONNECTED TO THE GRID WHEN THE SCRAM OCCURS => NO LOSS ASSOCIATED TO THE SCRAM) + south group connection to grid + south group trip + north group connection to grid + south group connection to grid + unplanned north group shutdown + north group connexion to grid.

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2020 Operating Experience

BE-6 TIHANGE-2 BELGIUM



Status at end of year	:	**Operational**
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	:	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]	:	4.35
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

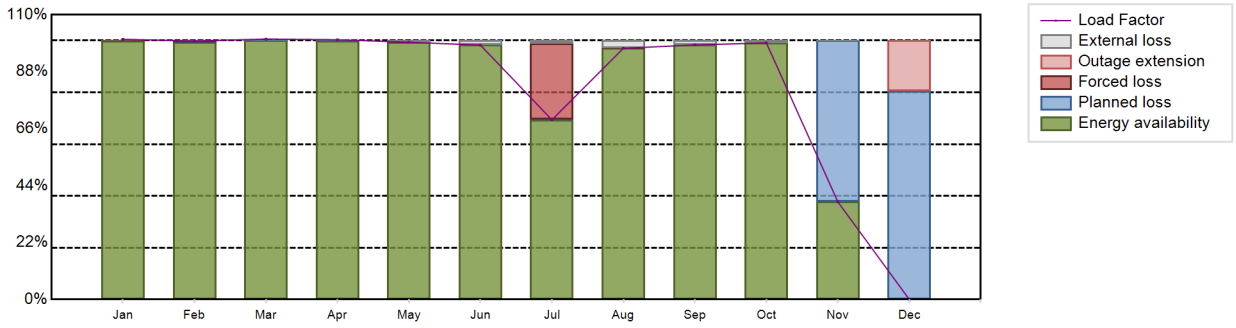
Operating coolant pressure [MPa]	:	15.52
Reactor outlet temperature [°C]	:	324.7
Number of SG	:	3
Containment type	:	Double
Containment design pressure [MPa]	:	0.35
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	3
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 (2020)

Net Energy Production	:	7373.82 GW(e).h
Energy Availability Factor (EAF)	:	83.13 %
Unit Capability Factor (UCF)	:	83.88 %
Load Factor (LF)	:	83.28 %
Operating Factor (OF)	:	84.22 %

Forced Loss Rate (FLR)	:	2.92 %
Unplanned Capability Loss Factor (UCL)	:	4.17 %
Planned Unavailability Factor (PUF)	:	11.95 %
Externally cause unavailability (XUF)	:	0.75 %
Total off-line time	:	1386 hours

Annual Summary



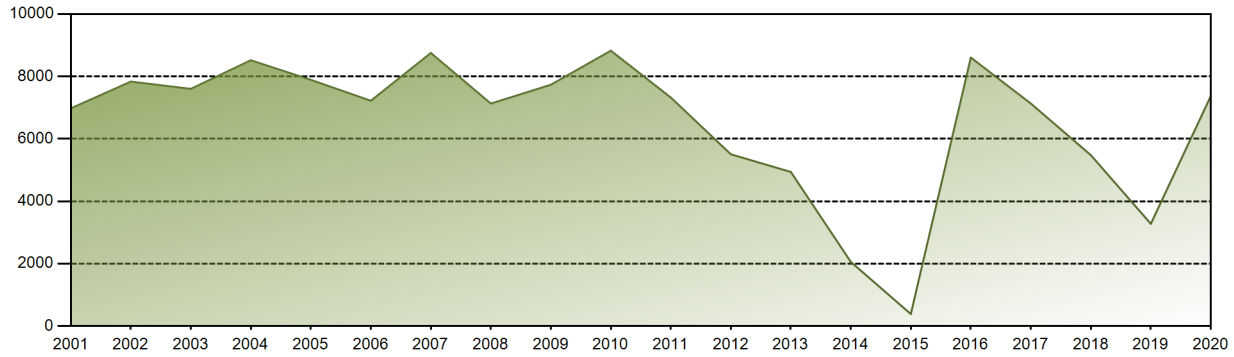
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	753.71	700.44	753.43	728.24	745.27	713.00	520.52	727.69	713.51	744.23	273.78	0.00	7373.82
EAF [%]	99.99	99.48	99.99	99.98	99.38	98.25	69.41	97.03	98.31	99.10	37.72	0.00	83.13
UCF [%]	99.99	99.48	99.99	99.98	99.96	99.95	70.66	99.98	99.96	99.97	37.73	0.00	83.88
LF [%]	100.50	99.84	100.60	100.34	99.38	98.24	69.41	97.03	98.31	99.10	37.72	0.00	83.28
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	72.58	100.00	100.00	100.00	39.17	0.00	84.22
FLR [%]	0.01	0.52	0.00	0.00	0.00	0.00	29.28	0.00	0.00	0.00	0.00	0.00	2.92
UCL [%]	0.01	0.52	0.00	0.00	0.00	0.00	29.25	0.00	0.00	0.00	0.00	19.49	4.17
PUF [%]	0.00	0.00	0.01	0.02	0.03	0.05	0.09	0.02	0.04	0.03	62.27	80.51	11.95
XUF [%]	0.00	0.00	0.00	0.00	0.59	1.69	1.25	2.95	1.65	0.87	0.01	0.00	0.75

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Historical Summary

Lifetime energy generation	:	255032.32 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.35 %
Cumulative Energy Availability Factor (EAF)	:	79.73 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	10.64 %
Cumulative Unit Capability Factor (UCF)	:	80.59 %	Cumulative Planned Unavailability Factor (PUF)	:	8.76 %
Cumulative Load Factor (LF)	:	79.73 %	Cumulative Externally cause unavailability (XUF)	:	0.86 %
Cumulative Operating Factor (OF)	:	81.47 %			

Electricity Production (net) [GWh]

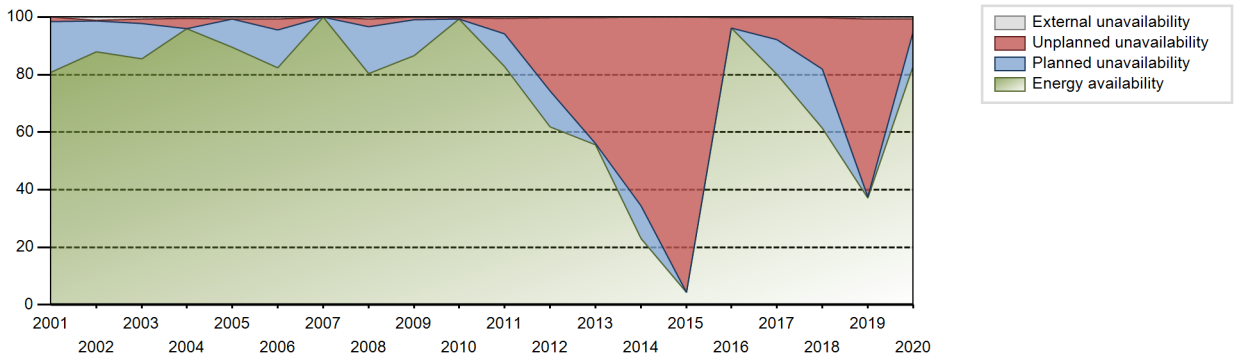


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	5507.00	6373	901	86.91	86.91	86.90	89.78	6.11	5.65	7.44	0.00
1984	6856.00	7693	901	86.39	86.39	86.63	87.58	4.58	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

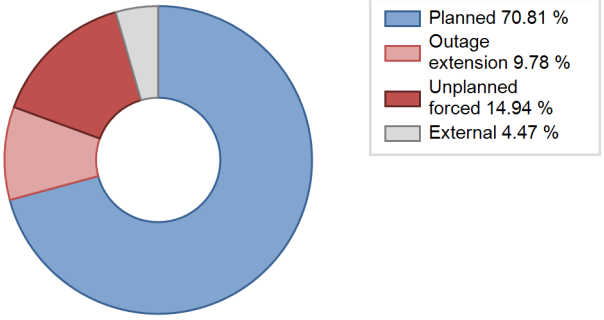
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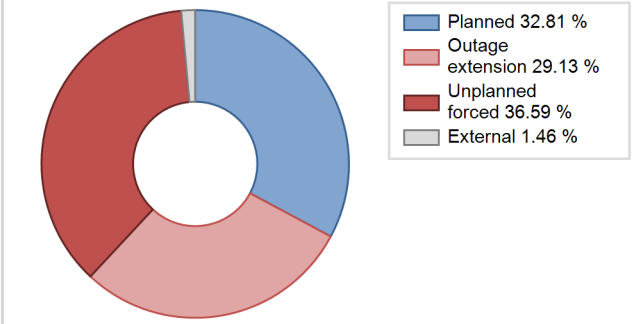
2020	7373.82	7398	1008	83.13	83.88	83.28	84.22	2.92	4.17	11.95	0.75

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1983 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		349			830	
B. Refuelling without maintenance					13	
C. Inspection, maintenance or repair combined with refuelling	1037			701	4	
D. Inspection, maintenance or repair without refuelling				89		
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					30	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						11
Z. Other				10	2	
Subtotal	1037	349		800	881	11
Total	**1386**			**1692**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		518
12. Reactor I&C Systems		9
13. Reactor Auxiliary Systems	145	19
14. Safety Systems		2
15. Reactor Cooling Systems		40
16. Steam generation systems		20
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries	204	31
32. Feedwater and Main Steam System		163
33. Circulating Water System		1
34. Miscellaneous Systems		12
41. Main Generator Systems		2
42. Electrical Power Supply Systems		11
Total	**349**	**829**

Highlights (2020)

2020-02-29 : Load reduction to +/- 25 % for unplanned intervention on feedwater valve.
2020-07-10 : Load decrease followed by manual turbine trip and unplanned hot reactor shutdown due to leakage on the supply manifold of the heaters 5.
2020-11-12 : Planned shutdown for inspection, maintenance & refuelling.
2020-12-25 : Unplanned extension of planned shutdown.

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2020 Operating Experience

BE-8 TIHANGE-3 BELGIUM



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

Reactor Unit Details

Reactor type and model	:	PWR / WH 3LP
Thermal power	:	3000 MWth
Gross electrical power	:	1089 MWe
Reference unit power (net)	:	1038 MWe

Key Dates

Construction Date	:	1978-11-01
Grid Date	:	1985-06-15
Commercial Date	:	1985-09-01
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]	:	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]	:	16.47
Number of control rod assemblies	:	28
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

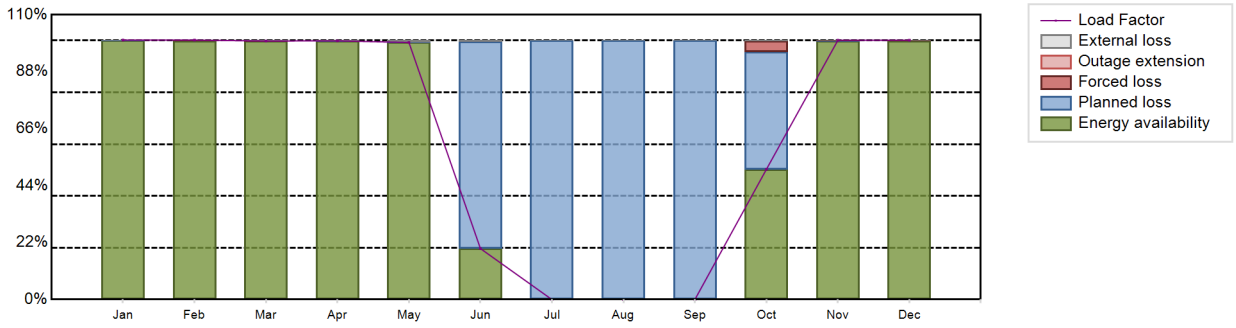
Operating coolant pressure [MPa]	:	15.52
Reactor outlet temperature [°C]	:	330.3
Number of SG	:	3
Containment type	:	Double
Containment design pressure [MPa]	:	0.35
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	7.28
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 (2020)

Net Energy Production	:	5838.22 GW(e).h
Energy Availability Factor (EAF)	:	63.97 %
Unit Capability Factor (UCF)	:	64.08 %
Load Factor (LF)	:	64.03 %
Operating Factor (OF)	:	64.73 %

Forced Loss Rate (FLR)	:	0.59 %
Unplanned Capability Loss Factor (UCL)	:	0.38 %
Planned Unavailability Factor (PUF)	:	35.54 %
Externally cause unavailability (XUF)	:	0.11 %
Total off-line time	:	3098 hours

Annual Summary



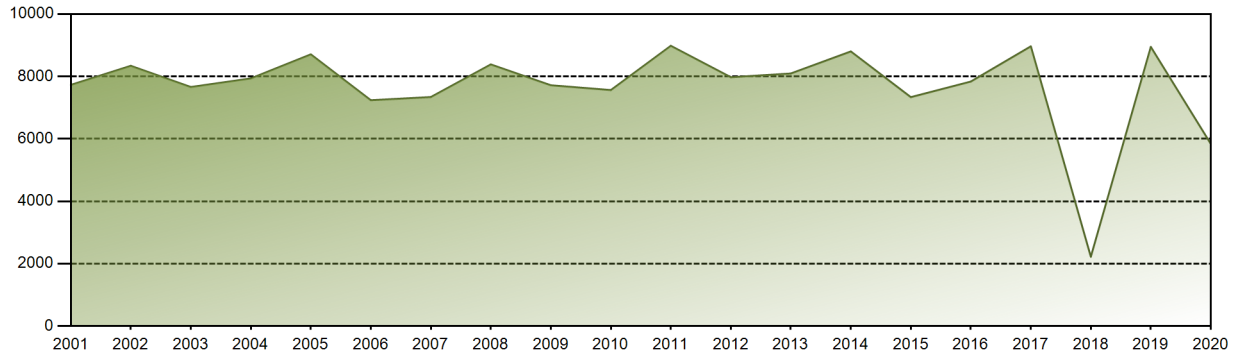
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	773.66	723.89	769.96	746.68	766.63	147.09	0.00	0.00	0.00	388.66	748.21	773.44	5838.22
EAF [%]	100.00	99.99	99.86	99.92	99.27	19.68	0.00	0.00	0.00	50.26	99.94	99.97	63.97
UCF [%]	100.00	99.99	99.89	100.00	100.00	20.06	0.00	0.00	0.00	50.33	99.94	99.97	64.08
LF [%]	100.18	100.20	99.83	99.91	99.27	19.68	0.00	0.00	0.00	50.26	100.11	100.15	64.03
OF [%]	100.00	100.00	100.00	100.00	100.00	20.42	0.00	0.00	0.00	57.45	100.00	100.00	64.73
FLR [%]	0.00	0.01	0.10	0.00	0.00	0.00	0.00	0.00	0.00	7.88	0.02	0.03	0.59
UCL [%]	0.00	0.01	0.10	0.00	0.00	0.00	0.00	0.00	0.00	4.31	0.02	0.03	0.38
PUF [%]	0.00	0.00	0.01	0.00	0.00	79.94	100.00	100.00	100.00	45.36	0.04	0.00	35.54
XUF [%]	0.00	0.00	0.04	0.08	0.73	0.38	0.00	0.00	0.00	0.07	0.00	0.00	0.11

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Historical Summary

Lifetime energy generation	:	273192.6 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.72 %
Cumulative Energy Availability Factor (EAF)	:	85.94 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.63 %
Cumulative Unit Capability Factor (UCF)	:	87.31 %	Cumulative Planned Unavailability Factor (PUF)	:	9.05 %
Cumulative Load Factor (LF)	:	85.69 %	Cumulative Externally cause unavailability (XUF)	:	1.37 %
Cumulative Operating Factor (OF)	:	87.82 %			

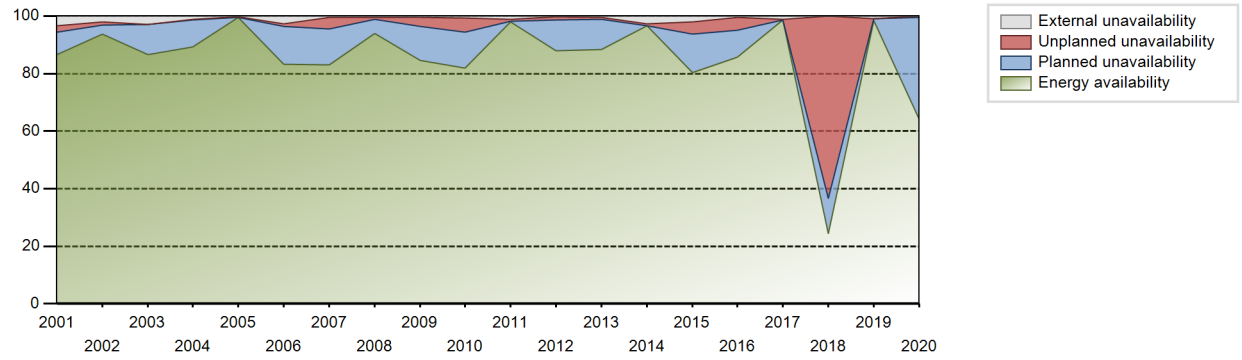
Electricity Production (net) [GWh]



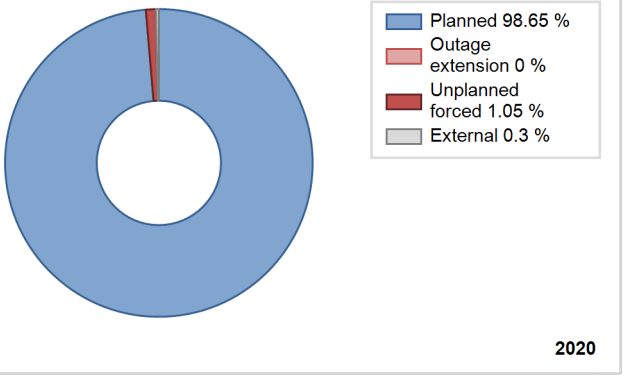
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	Data not provided										
1986	7558.00	7733	1020	85.57	86.51	84.59	88.28	4.86	4.42	9.07	0.94
1987	7829.00	7872	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

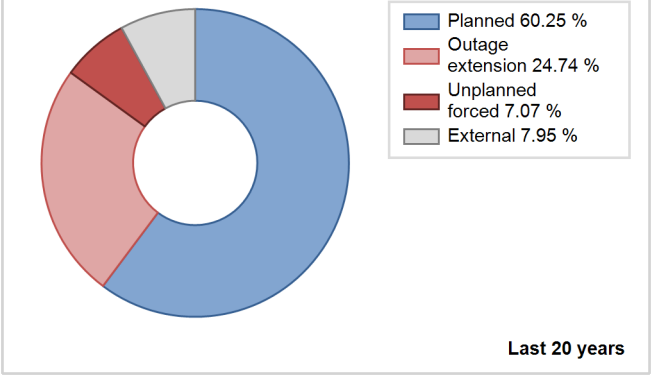
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		18			279	
C. Inspection, maintenance or repair combined with refuelling	3080			716	7	
D. Inspection, maintenance or repair without refuelling				23		
E. Testing of plant systems or components				1		
H. Nuclear regulatory requirements					2	
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)				15		17
Z. Other				4		
Subtotal	3080	18		759	291	18
Total		**3098**			**1068**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		7
15. Reactor Cooling Systems		27
16. Steam generation systems		32
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries	18	29
32. Feedwater and Main Steam System		174
33. Circulating Water System		6
34. Miscellaneous Systems		1
41. Main Generator Systems		2
42. Electrical Power Supply Systems		4
Total	**18**	**285**

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Highlights (2020)

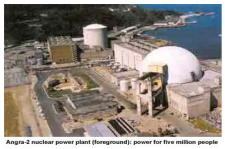
2020-06-07 : Planned shutdown for inspection, maintenance, refuelling and concrete repair works.
2020-10-13 : Connexion to grid (beginning of Cycle 27).
2020-10-13 : During load increase : unplanned turbine shutdown.
2020-10-14 : Reconnection to grid.
2020-10-17 : During load increase : power maintained at 95%.

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2020 Operating Experience

BR-1 ANGRA-1 BRAZIL

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



Angra-2 nuclear power plant (foreground): power for five million people

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	:	38 years

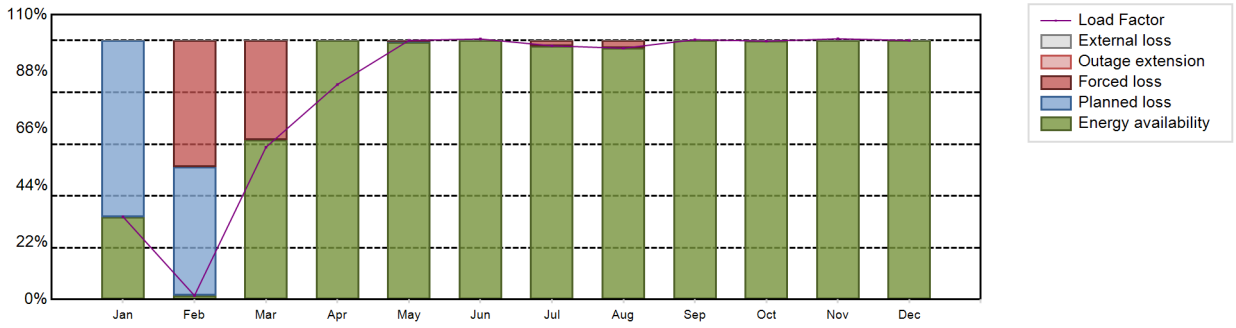
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.0
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	:	none

Annual Production Results (2020)

Net Energy Production	:	4347.14 GW(e).h	Forced Loss Rate (FLR)	:	8.37 %
Energy Availability Factor (EAF)	:	82.69 %	Unplanned Capability Loss Factor (UCL)	:	7.56 %
Unit Capability Factor (UCF)	:	82.69 %	Planned Unavailability Factor (PUF)	:	9.75 %
Load Factor (LF)	:	81.26 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	83.09 %	Total off-line time	:	1485 hours

Annual Summary



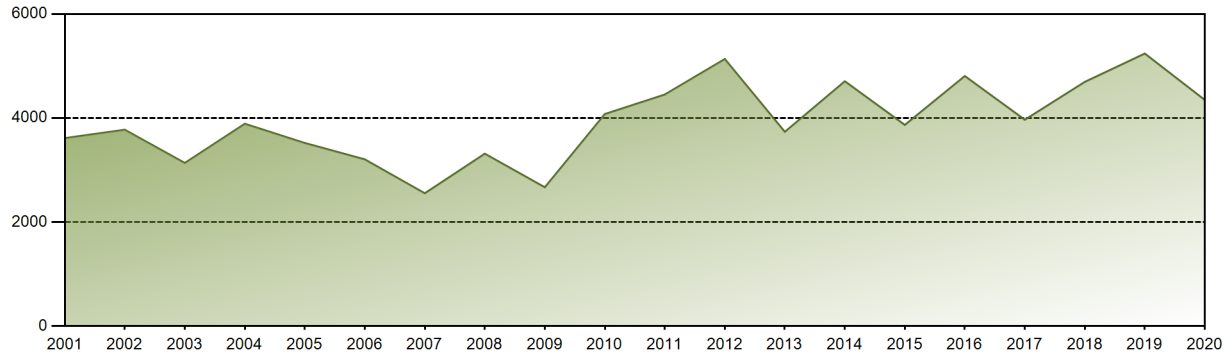
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	144.91	6.45	266.51	364.14	453.31	441.20	443.93	439.73	439.99	452.09	441.54	453.32	4347.14
EAF [%]	31.98	1.52	61.72	100.00	99.26	100.00	97.98	97.05	100.00	99.78	100.00	100.00	82.69
UCF [%]	31.98	1.52	61.72	100.00	99.26	100.00	97.98	97.05	100.00	99.78	100.00	100.00	82.69
LF [%]	31.98	1.52	58.82	83.05	100.05	100.62	97.98	97.05	100.34	99.78	100.70	100.05	81.26
OF [%]	31.32	4.74	61.83	100.00	100.00	100.00	98.25	98.12	100.00	100.00	100.00	100.00	83.09
FLR [%]	0.00	96.97	38.28	0.00	0.39	0.00	2.02	2.95	0.00	0.00	0.00	0.00	8.37
UCL [%]	0.00	48.73	38.28	0.00	0.39	0.00	2.02	2.95	0.00	0.00	0.00	0.00	7.56
PUF [%]	68.02	49.75	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.22	0.00	0.00	9.75
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

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Historical Summary

Lifetime energy generation	:	109829.82 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	16.11 %
Cumulative Energy Availability Factor (EAF)	:	62.86 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.44 %
Cumulative Unit Capability Factor (UCF)	:	67.81 %	Cumulative Planned Unavailability Factor (PUF)	:	18.75 %
Cumulative Load Factor (LF)	:	55.8 %	Cumulative Externally cause unavailability (XUF)	:	4.95 %
Cumulative Operating Factor (OF)	:	69.82 %			

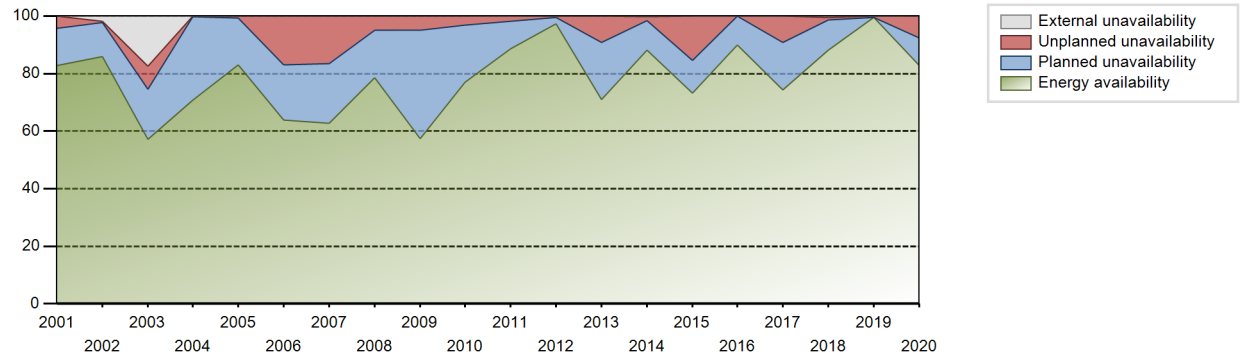
Electricity Production (net) [GWh]



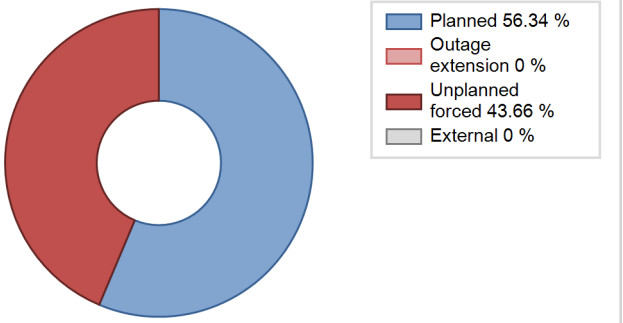
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	3169.38	6847	626	57.80	57.80	57.80	78.16	37.49	34.66	7.55	0.00
1986	132.36	512	626	3.70	3.70	2.41	5.84	89.62	31.97	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

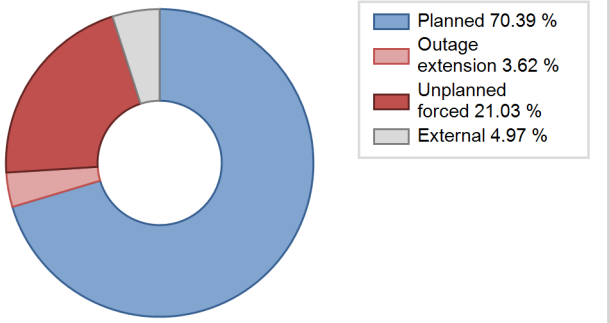
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		652			1232	
B. Refuelling without maintenance				29		
C. Inspection, maintenance or repair combined with refuelling	826			1033		
D. Inspection, maintenance or repair without refuelling				245		
E. Testing of plant systems or components				52	0	
F. Major backfitting, refurbishment or upgrading activities with refuelling				88		
H. Nuclear regulatory requirements					1	
J. Grid limitation, failure or grid unavailability						13
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						7
L. Human factor related					18	
M. Governmental requirements or court decisions						229
P. Fire					0	
Z. Other					18	2
Subtotal	826	652		1447	1269	251
Total	**1478**			**2967**		

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Equipment Related Unplanned Full Outages, Analysis by System

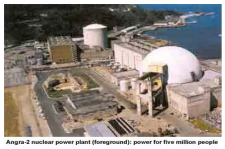
System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		275
12. Reactor I&C Systems		47
13. Reactor Auxiliary Systems		81
14. Safety Systems		1
15. Reactor Cooling Systems		12
16. Steam generation systems		30
31. Turbine and auxiliaries		116
32. Feedwater and Main Steam System	27	44
33. Circulating Water System		7
34. Miscellaneous Systems		0
41. Main Generator Systems	626	375
42. Electrical Power Supply Systems		185
Total	**653**	**1173**

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2020 Operating Experience

BR-2 ANGRA-2 BRAZIL

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



Angra-2 nuclear power plant (foreground): power for five million people

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	:	20 years

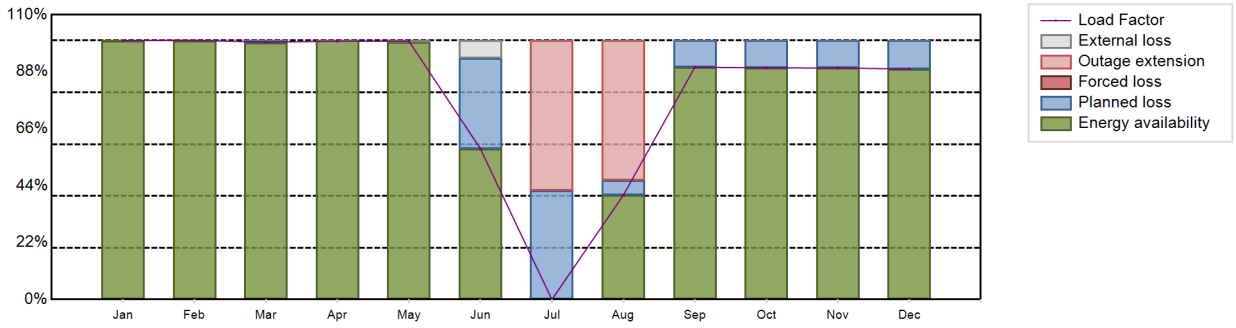
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.9
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	326
Fuel material	:	UO2	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	Double
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.53
Average fuel enrichment [% of U235]	:	4.5	**Secondary systems**		
Refuelling frequency [month]	:	12	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	33.3	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	35000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.61	HP cylinder inlet steam pressure [MPa]	:	6.295
Active core height/length [m]	:	3.9	Output voltage [kV]	:	25
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	20.79	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	:	4	Number of on-site safety related diesel generators	:	8
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	8897.22 GW(e).h	Forced Loss Rate (FLR)	:	0.03 %
Energy Availability Factor (EAF)	:	79.38 %	Unplanned Capability Loss Factor (UCL)	:	9.5 %
Unit Capability Factor (UCF)	:	79.99 %	Planned Unavailability Factor (PUF)	:	10.51 %
Load Factor (LF)	:	79.44 %	Externally cause unavailability (XUF)	:	0.61 %
Operating Factor (OF)	:	84.51 %	Total off-line time	:	1361 hours

Annual Summary



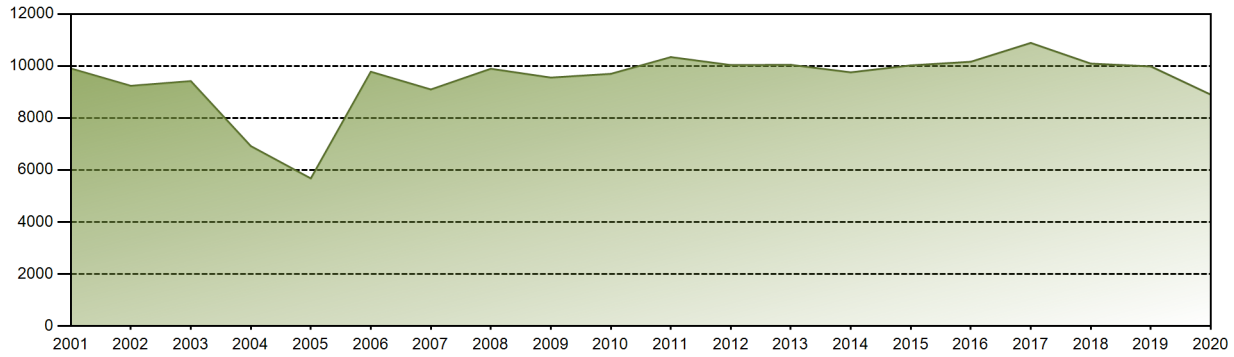
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	948.73	888.36	943.16	915.87	946.43	534.34	0.00	382.75	823.62	848.62	821.01	844.34	8897.22
EAF [%]	99.80	99.96	99.18	100.00	99.36	58.21	0.00	40.35	89.72	89.46	89.43	89.01	79.38
UCF [%]	99.80	99.96	99.18	100.00	100.00	64.98	0.00	40.35	89.72	89.46	89.43	89.01	79.99
LF [%]	100.01	100.11	99.43	99.77	99.77	58.21	0.00	40.35	89.72	89.46	89.43	89.01	79.44
OF [%]	100.00	100.00	100.00	100.00	100.00	70.00	0.00	46.10	100.00	100.00	100.00	100.00	84.51
FLR [%]	0.20	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
UCL [%]	0.20	0.04	0.00	0.00	0.00	0.00	58.06	53.89	0.00	0.00	0.00	0.00	9.50
PUF [%]	0.00	0.00	0.82	0.00	0.00	35.02	41.94	5.76	10.28	10.54	10.57	10.99	10.51
XUF [%]	0.00	0.00	0.00	0.00	0.64	6.78	0.00	0.00	0.00	0.00	0.00	0.00	0.61

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Historical Summary

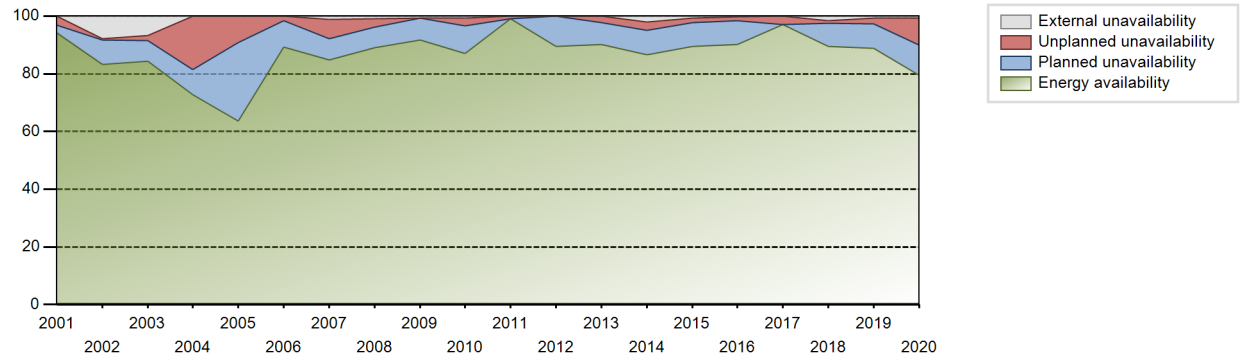
Lifetime energy generation	:	191828.84 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.46 %
Cumulative Energy Availability Factor (EAF)	:	86.97 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.53 %
Cumulative Unit Capability Factor (UCF)	:	88.2 %	Cumulative Planned Unavailability Factor (PUF)	:	8.27 %
Cumulative Load Factor (LF)	:	84.58 %	Cumulative Externally cause unavailability (XUF)	:	1.23 %
Cumulative Operating Factor (OF)	:	89.09 %			

Electricity Production (net) [GWh]



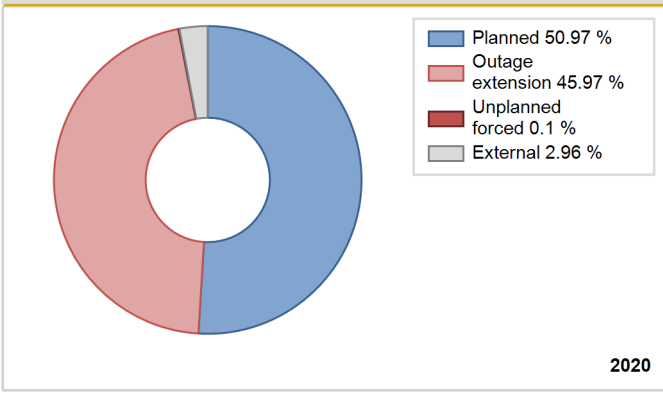
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2001	9904.99	8315	1350	94.21	94.34	85.69	97.27	3.11	3.02	2.64	0.13
2002	9238.24	8060	1275	83.33	91.26	82.71	92.01	0.43	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

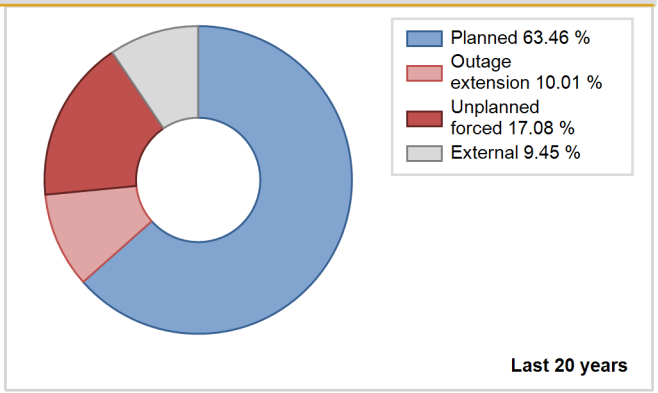
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2001 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		833			237	
C. Inspection, maintenance or repair combined with refuelling	528			566	27	
D. Inspection, maintenance or repair without refuelling				164		
E. Testing of plant systems or components				3	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.)					9	
Subtotal	528	833		733	274	4
Total	**1361**			**1011**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2001 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	833	43
13. Reactor Auxiliary Systems		30
14. Safety Systems		1
15. Reactor Cooling Systems		20
16. Steam generation systems		0
31. Turbine and auxiliaries		6
32. Feedwater and Main Steam System		10
33. Circulating Water System		3
41. Main Generator Systems		60
42. Electrical Power Supply Systems		84
Total	**833**	**257**

Highlights (2020)

Angra 2 remained connected to the National Electrical Grid for 309.3 days in 2020 and performed its refuelling outage (16th) in 56.7 days, for refuelling, maintenance and periodic tests.

On June 19, Angra 2 reached a historic milestone. The unit - which started commercial operation in 2001 - reached a cumulative production of 200 million MWh of gross energy.

During the unloading of the core, in the course of its 16th refuelling outage, it was found an unexpected superficial corrosion on the cladding surfaces of the R series Fuel Assemblies, which were loaded in the previous refuelling outage (15th). As a result, a set of measures were necessary to ensure the plant's safe, reliable and quick return to operation. Therefore, the 16th refuelling outage's duration was extended.

One of the measures provided after the above-mentioned event was to start and continue the operation of the Plant with 90% of the rated full power in fuel operating cycle 17.

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2020 Operating Experience

BG-5 KOZLODUY-5 BULGARIA

Status at end of year	:	**Operational**
Operator	:	KOZNPP (KOZLODUY NPP, PLC.)
Owner	:	BEH (Bulgarian Energy Holding Company)
Reactor Supplier	:	AEE (ATOMENERGOEXPORT)
Turbine Supplier	:	AEE (ATOMENERGOEXPORT)

Reactor Unit Details

Reactor type and model	:	PWR / VVER V-320
Thermal power	:	3000 MWth
Gross electrical power	:	1000 MWe
Reference unit power (net)	:	1003 MWe

Key Dates

Construction Date	:	1980-07-09
Grid Date	:	1987-11-29
Commercial Date	:	1988-12-23
Age at end of year	:	33 years

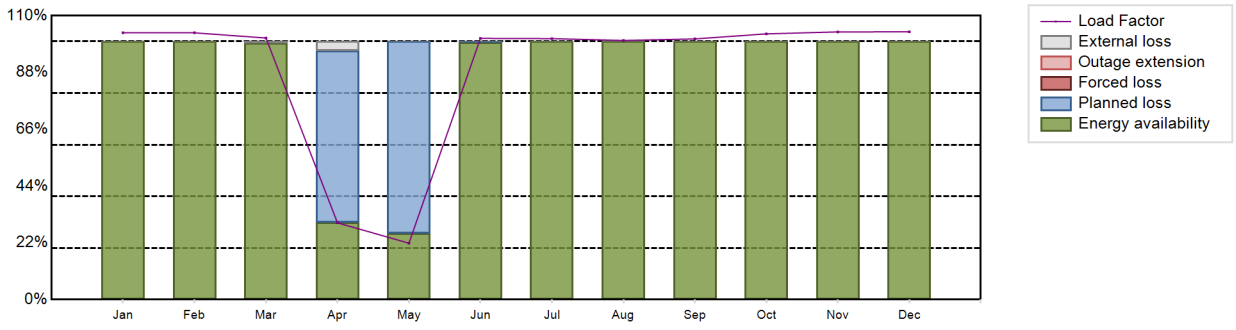
Design Characteristics

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]	:	12
Part of the core refuelled [%]	:	30
Average discharge burnup [MWd/t]	:	27000
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]	:	17.6
Number of control rod assemblies	:	-
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]	:	-
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]	:	-
Primary means of condenser cooling	:	River (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 (2020)

Net Energy Production	:	7881.46 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	87.85 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	88.2 %	Planned Unavailability Factor (PUF)	:	11.8 %
Load Factor (LF)	:	89.46 %	Externally cause unavailability (XUF)	:	0.34 %
Operating Factor (OF)	:	88.43 %	Total off-line time	:	1016 hours
Equivalent non-electrical energy generated (NEG)	:	37.53 GW(e).h			

Annual Summary



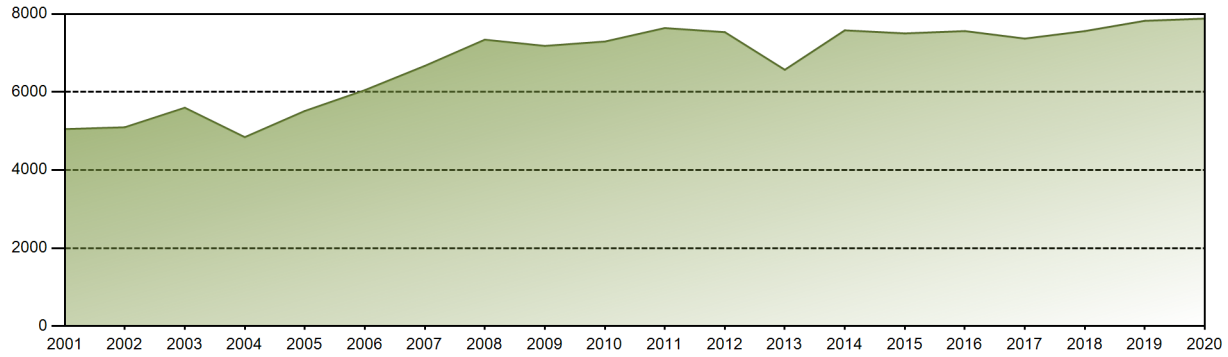
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	771.14	721.39	756.20	214.91	163.21	730.75	754.41	749.10	729.24	768.16	748.89	774.06	7881.46
EAF [%]	100.00	100.00	99.37	29.76	25.59	99.60	100.00	100.00	100.00	100.00	100.00	100.00	87.85
UCF [%]	100.00	100.00	100.00	33.29	25.59	99.60	100.00	100.00	100.00	100.00	100.00	100.00	88.20
LF [%]	103.34	103.34	101.34	29.76	21.87	101.19	101.10	100.38	100.98	102.94	103.70	103.73	89.46
OF [%]	100.00	100.00	100.00	33.61	27.69	100.00	100.00	100.00	100.00	100.00	100.00	100.00	88.43
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	66.71	74.41	0.40	0.00	0.00	0.00	0.00	0.00	0.00	11.80
XUF [%]	0.00	0.00	0.63	3.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34

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Historical Summary

Lifetime energy generation	:	179983.46 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.39 %
Cumulative Energy Availability Factor (EAF)	:	72.81 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.84 %
Cumulative Unit Capability Factor (UCF)	:	74.91 %	Cumulative Planned Unavailability Factor (PUF)	:	23.26 %
Cumulative Load Factor (LF)	:	66.74 %	Cumulative Externally cause unavailability (XUF)	:	2.09 %
Cumulative Operating Factor (OF)	:	75.28 %			

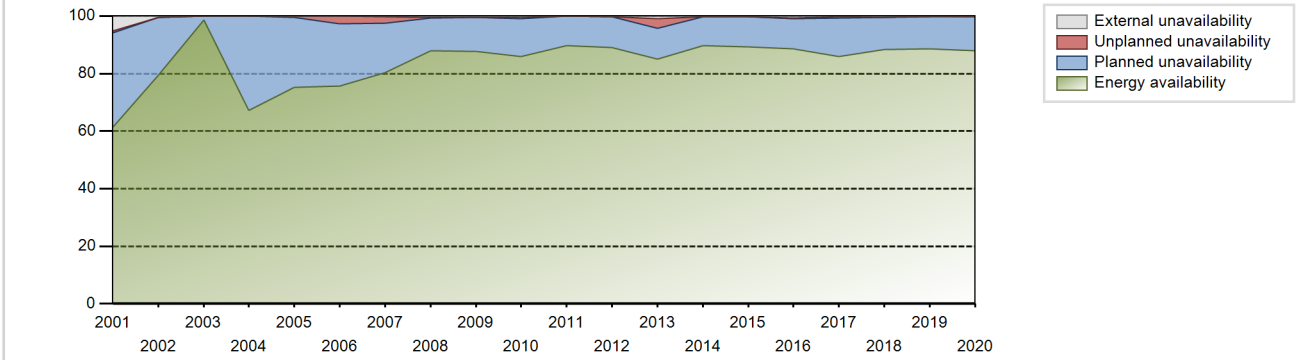
Electricity Production (net) [GWh]



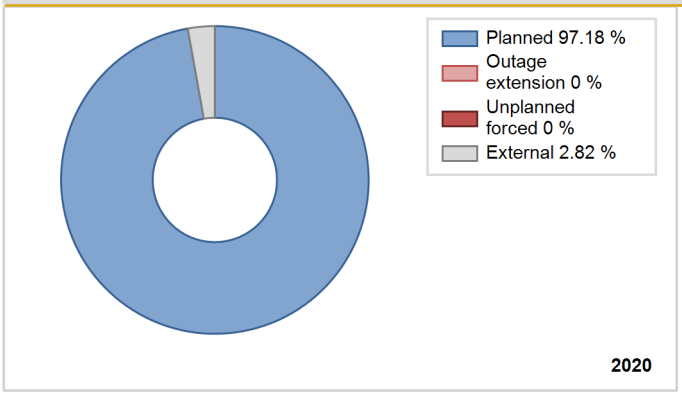
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	3933.16	7027	887	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	3355.08	4663	953	51.52	51.52	40.19	53.23	5.32	2.90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

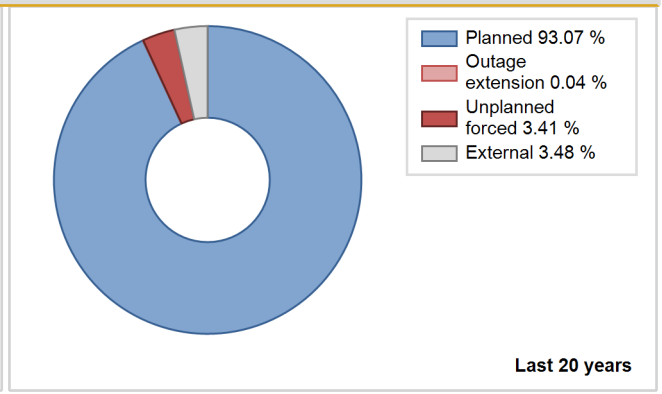
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					125	
C. Inspection, maintenance or repair combined with refuelling	1016			1465		
D. Inspection, maintenance or repair without refuelling				160		
E. Testing of plant systems or components				0		
F. Major backfitting, refurbishment or upgrading activities with refuelling				77		
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	1016			1702	131	1
Total	**1016**			**1834**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		7
13. Reactor Auxiliary Systems		1
15. Reactor Cooling Systems		6
16. Steam generation systems		7
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		11
32. Feedwater and Main Steam System		11
35. All other I&C Systems		2
41. Main Generator Systems		73
42. Electrical Power Supply Systems		2
Total		**121**

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Highlights (2020)

Unit 5 was operated on base load mode at the power level 104 %, in accordance with the load schedule agreed by Bulgarian Transmission System Operator (TSO) incl. fuel coast down mode in March-April.
The planned outage for annual maintenance, refuelling and modernization was performed in the period 11th April – 23 th May (total outage duration – 42 days).
During the planned outage ware carried out a number of modernizations related to the Unit life time prolongation.
In 2020 there is no unplanned Reactor Scram or any events with significant Energy Losses.
The restrictive measures introduced in the country in connection with the Covid 19 pandemic did not require a change in the planned period for annual maintenance.
Due to the reduced electricity consumption, a restriction was imposed in the period of loading of the unit after the unit start up in May.

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2020 Operating Experience

BG-6 KOZLODUY-6 BULGARIA

Status at end of year	:	**Operational**
Operator	:	KOZNPP (KOZLODUY NPP, PLC.)
Owner	:	BEH (Bulgarian Energy Holding Company)
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	:	29 years

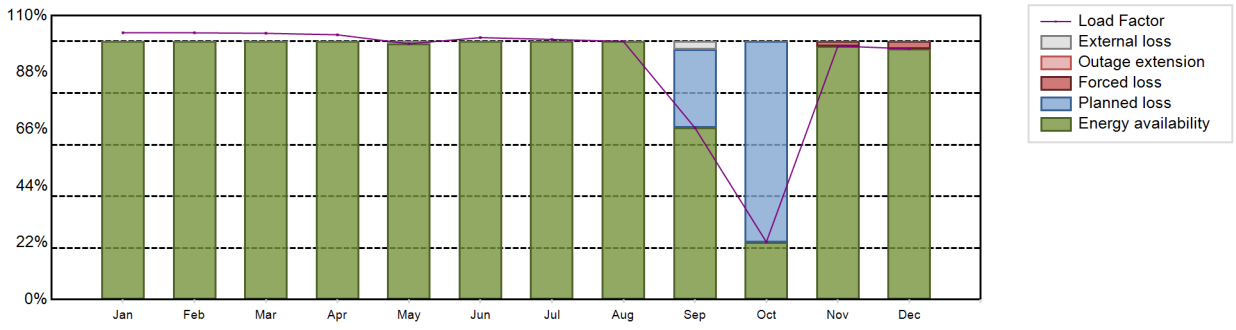
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	-
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	33.3
Average discharge burnup [MWd/t]	:	27000
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]	:	17.6
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]	:	320
Number of SG	:	4
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]	:	6
Output voltage [kV]	:	-
Primary means of condenser cooling	:	River (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 (2020)

Net Energy Production	:	8056.13 GW(e).h
Energy Availability Factor (EAF)	:	90.2 %
Unit Capability Factor (UCF)	:	90.54 %
Load Factor (LF)	:	91.44 %
Operating Factor (OF)	:	91.15 %
Equivalent non-electrical energy generated (NEG)	:	8 GW(e).h
Forced Loss Rate (FLR)	:	0.42 %
Unplanned Capability Loss Factor (UCL)	:	0.39 %
Planned Unavailability Factor (PUF)	:	9.08 %
Externally cause unavailability (XUF)	:	0.33 %
Total off-line time	:	777 hours

Annual Summary



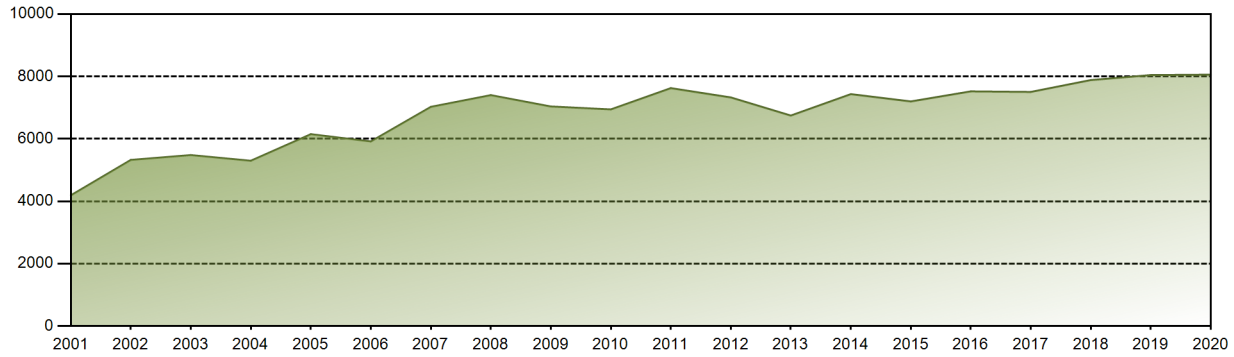
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	771.43	721.44	769.75	740.87	739.42	733.01	752.10	746.31	480.77	166.60	709.29	725.15	8056.13
EAF [%]	100.00	100.00	100.00	100.00	99.03	100.00	100.00	100.00	66.57	22.19	98.22	97.17	90.20
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	69.64	22.19	98.22	97.17	90.54
LF [%]	103.38	103.34	103.15	102.59	99.09	101.50	100.79	100.01	66.57	22.33	98.22	97.17	91.44
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	70.00	24.60	100.00	100.00	91.15
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	2.83	0.42
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	2.83	0.39
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.36	77.81	0.00	0.00	9.08
XUF [%]	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	3.07	0.00	0.00	0.00	0.33

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Historical Summary

Lifetime energy generation	:	167597.13 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.66 %
Cumulative Energy Availability Factor (EAF)	:	78.67 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.66 %
Cumulative Unit Capability Factor (UCF)	:	80.46 %	Cumulative Planned Unavailability Factor (PUF)	:	18.88 %
Cumulative Load Factor (LF)	:	73.62 %	Cumulative Externally cause unavailability (XUF)	:	1.8 %
Cumulative Operating Factor (OF)	:	80.92 %			

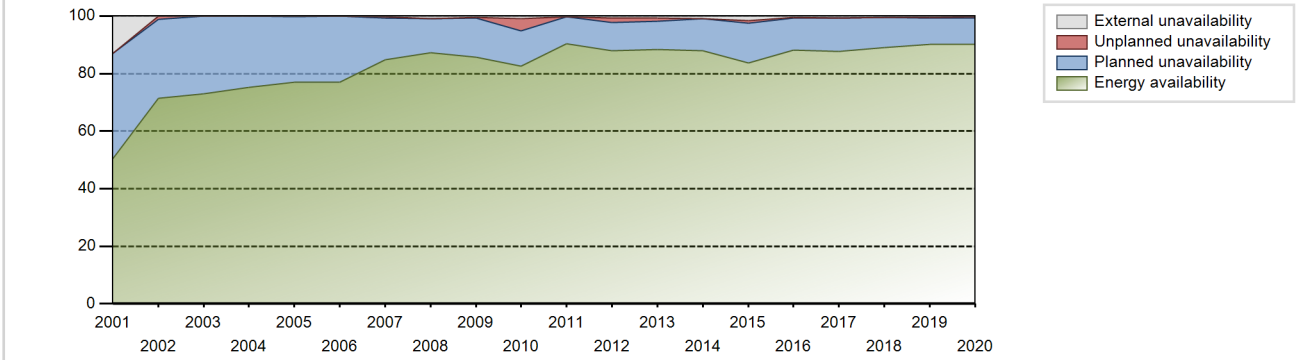
Electricity Production (net) [GWh]



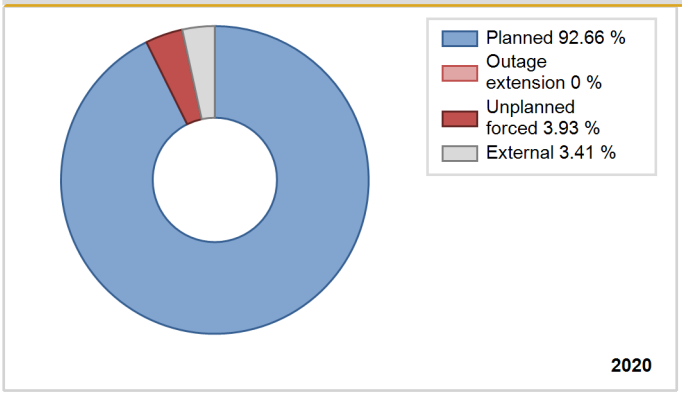
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	2799.64	4032	953	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	4862.58	7817	953	87.61	88.72	58.25	89.24	0.50	0.45	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

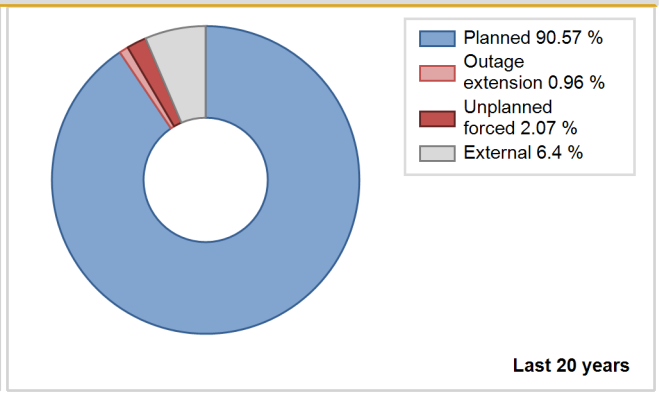
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1993 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					146	
C. Inspection, maintenance or repair combined with refuelling	778			1405		
D. Inspection, maintenance or repair without refuelling				84		
E. Testing of plant systems or components				7	0	
F. Major backfitting, refurbishment or upgrading activities with refuelling				80		
J. Grid limitation, failure or grid unavailability						3
L. Human factor related					0	
Subtotal	778			1576	146	3
Total	**778**			**1725**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1993 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		9
14. Safety Systems		18
31. Turbine and auxiliaries		10
32. Feedwater and Main Steam System		1
35. All other I&C Systems		0
41. Main Generator Systems		10
42. Electrical Power Supply Systems		88
Total		**136**

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Highlights (2020)

Unit 6 was operated on base load mode at the power level 104 % in accordance with the load schedule agreed by Bulgarian Transmission System Operator (TSO) incl. fuel coast down mode in September.
The planned outage for annual maintenance, refuelling and modernization was performed in the period 22 th September – 24 th October (total outage duration – 32 days).
During the planned outage ware carried out a number of projects related to the Unit life time prolongation.
In 2020 there is no unplanned Reactor Scram or any events with significant Energy Losses.
The restrictive measures introduced in the country in connection with the Covid 19 pandemic did not require a change in the planned period for annual maintenance.
Due to the reduced electricity consumption, a load restriction was imposed in May (in the period of the unit 5 start up after planned outage).

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2020 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

Reactor type and model	:	PHWR / CANDU 791
Thermal power	:	2620 MWth
Gross electrical power	:	830 MWe
Reference unit power (net)	:	774 MWe

Key Dates

Construction Date	:	1971-06-01
Grid Date	:	1977-01-14
Commercial Date	:	1977-09-01
Age at end of year	:	43 years

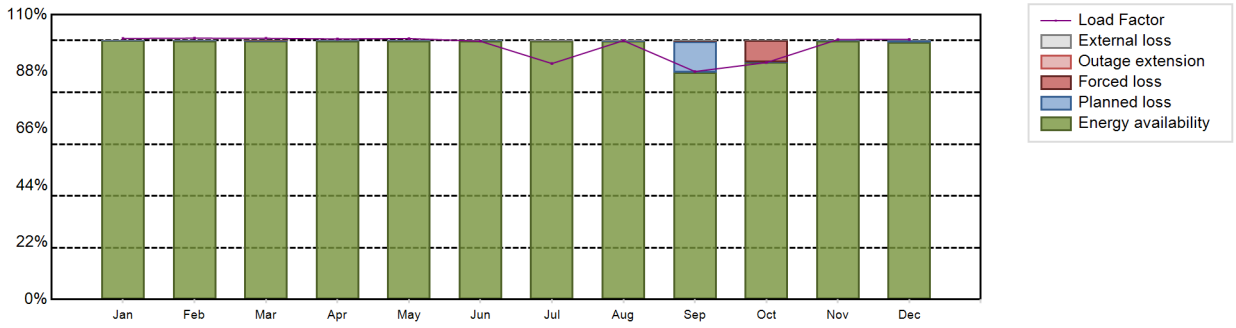
Design Characteristics

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	:	-
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.74
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]	:	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	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	6658.49 GW(e).h	Forced Loss Rate (FLR)	:	0.76 %
Energy Availability Factor (EAF)	:	98.13 %	Unplanned Capability Loss Factor (UCL)	:	0.75 %
Unit Capability Factor (UCF)	:	98.15 %	Planned Unavailability Factor (PUF)	:	1.1 %
Load Factor (LF)	:	97.94 %	Externally cause unavailability (XUF)	:	0.02 %
Operating Factor (OF)	:	98.25 %	Total off-line time	:	154 hours

Annual Summary



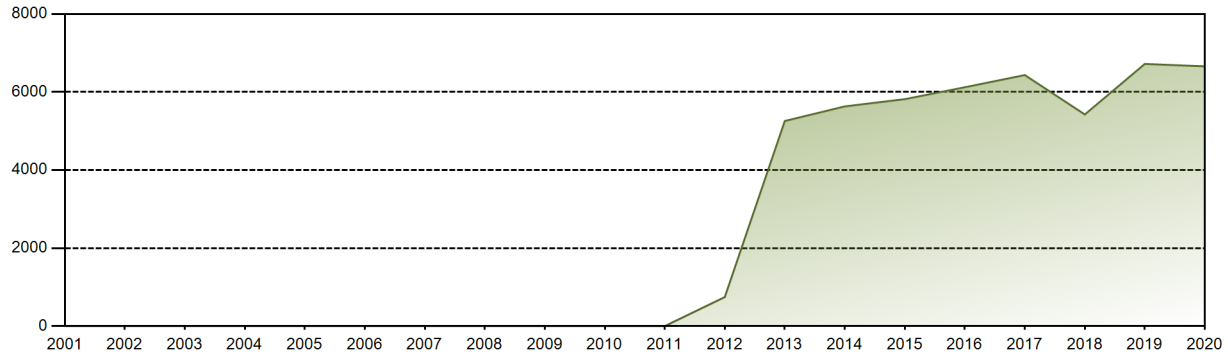
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	580.58	543.79	580.86	560.81	580.36	555.83	524.78	575.72	490.67	526.97	559.55	578.57	6658.49
EAF [%]	99.99	99.99	99.79	99.90	99.85	99.77	99.92	99.74	87.60	91.64	99.78	99.47	98.13
UCF [%]	99.99	99.99	99.79	99.90	99.85	99.77	100.00	99.93	87.61	91.64	99.78	99.47	98.15
LF [%]	100.82	100.94	100.87	100.63	100.78	99.74	91.13	99.98	88.05	91.51	100.41	100.47	97.94
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	87.92	90.99	100.00	100.00	98.25
FLR [%]	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.42	8.34	0.00	0.00	0.76
UCL [%]	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.37	8.34	0.00	0.00	0.75
PUF [%]	0.01	0.01	0.04	0.10	0.15	0.23	0.00	0.07	12.02	0.01	0.22	0.53	1.10
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.19	0.01	0.00	0.00	0.00	0.02

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Historical Summary

Lifetime energy generation	:	140376.33 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	19.26 %
Cumulative Energy Availability Factor (EAF)	:	71.99 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	17.3 %
Cumulative Unit Capability Factor (UCF)	:	72.46 %	Cumulative Planned Unavailability Factor (PUF)	:	10.24 %
Cumulative Load Factor (LF)	:	71.38 %	Cumulative Externally cause unavailability (XUF)	:	0.47 %
Cumulative Operating Factor (OF)	:	80.59 %			

Electricity Production (net) [GWh]

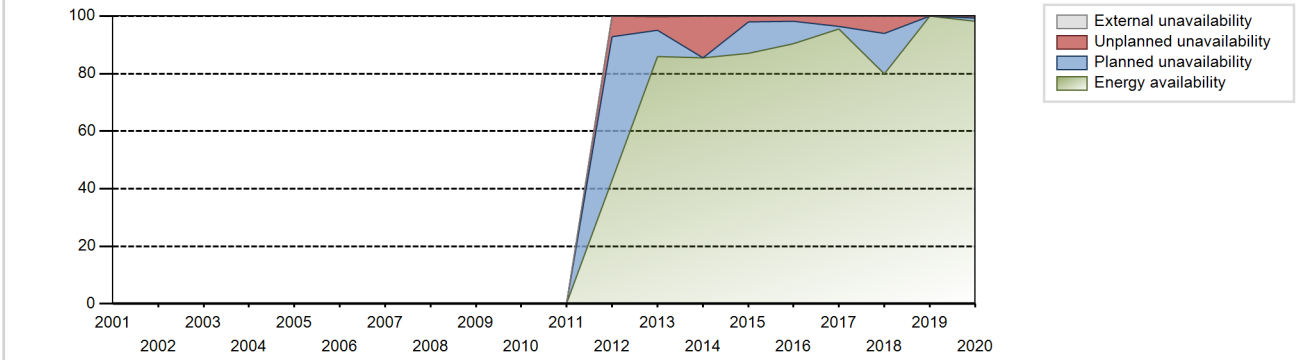


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	1860.70	2698	740	88.40	88.40	88.04	94.47	11.60	11.60	0.00	0.00
1978	4152.60	6649	740	72.65	72.65	64.24	76.11	15.38	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 - Long-term shutdown										
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

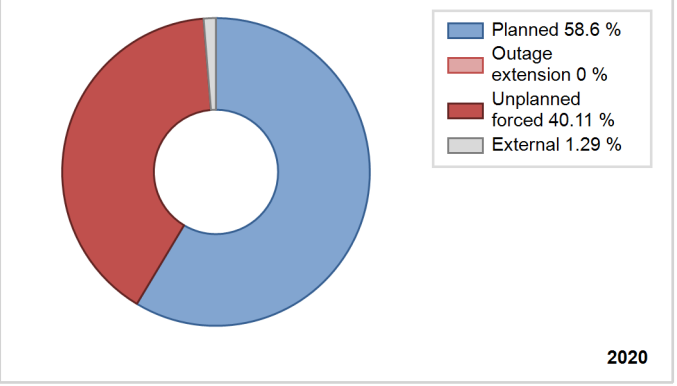
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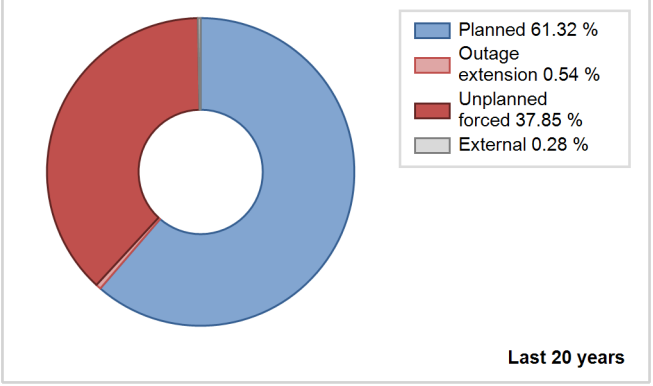
2014	5630.95	7540	772	85.52	85.52	83.26	86.07	14.48	14.48	0.00	0.00
2015	5816.97	7711	760	86.96	86.96	87.37	88.03	2.37	2.11	10.94	0.00
2016	6122.17	8004	760	90.36	90.42	91.71	91.12	1.55	1.69	7.89	0.06
2017	6434.23	8412	760	95.42	95.42	96.64	96.03	3.40	3.59	0.99	0.01
2018	5424.38	7046	760	79.92	79.93	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		76			811	
D. Inspection, maintenance or repair without refuelling	79			751		
E. Testing of plant systems or components				80	3	
H. Nuclear regulatory requirements					18	
J. Grid limitation, failure or grid unavailability						5
L. Human factor related					6	
P. Fire					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.)						14
Z. Other				12	3	
Subtotal	79	76		843	846	19
Total	**155**			**1708**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		51
12. Reactor I&C Systems	76	78
13. Reactor Auxiliary Systems		86
14. Safety Systems		61
15. Reactor Cooling Systems		88
16. Steam generation systems		227
21. Fuel Handling and Storage Facilities		28
31. Turbine and auxiliaries		38
32. Feedwater and Main Steam System		24
34. Miscellaneous Systems		21
41. Main Generator Systems		60
42. Electrical Power Supply Systems		45
Total	**76**	**807**

RUP revision during the year (2020) due to power uprate

RUP at the end of previous year : 760 [MWe]

Month	Capacity [MWe]	Power Uprate	Main modifications	Description
January	774	Stretch power uprate (2-7%)	Balance of plant	Reference Unit Power revised to 774MWs. Increase from 760MW (2019) due to engineering analysis of generator (previous limiting factor) which allowed increase in yearly net average output. Change in RUP retroactive to 1 Jan 2020.

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2020 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

Reactor type and model	:	PHWR / CANDU 791
Thermal power	:	2620 MWth
Gross electrical power	:	830 MWe
Reference unit power (net)	:	777 MWe

Key Dates

Construction Date	:	1970-12-01
Grid Date	:	1976-09-04
Commercial Date	:	1977-09-01
Age at end of year	:	44 years

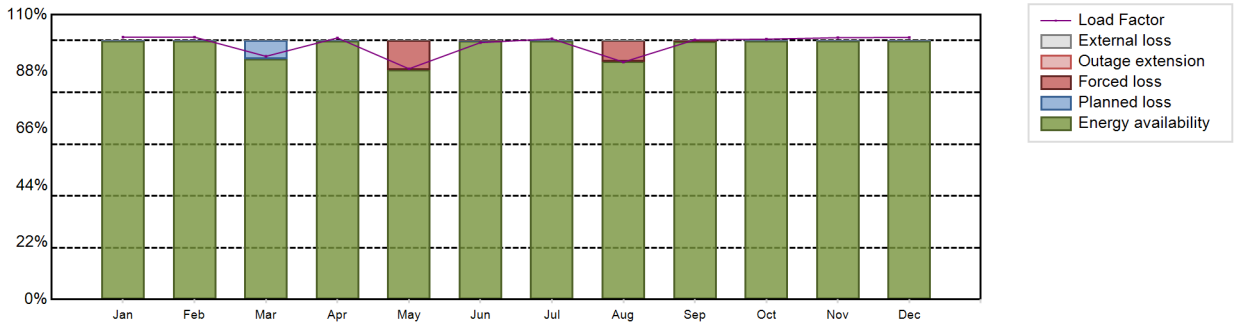
Design Characteristics

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	:	-
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.74
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]	:	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	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	6717.44 GW(e).h	Forced Loss Rate (FLR)	:	1.69 %
Energy Availability Factor (EAF)	:	97.69 %	Unplanned Capability Loss Factor (UCL)	:	1.68 %
Unit Capability Factor (UCF)	:	97.69 %	Planned Unavailability Factor (PUF)	:	0.63 %
Load Factor (LF)	:	98.42 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	97.72 %	Total off-line time	:	200 hours

Annual Summary



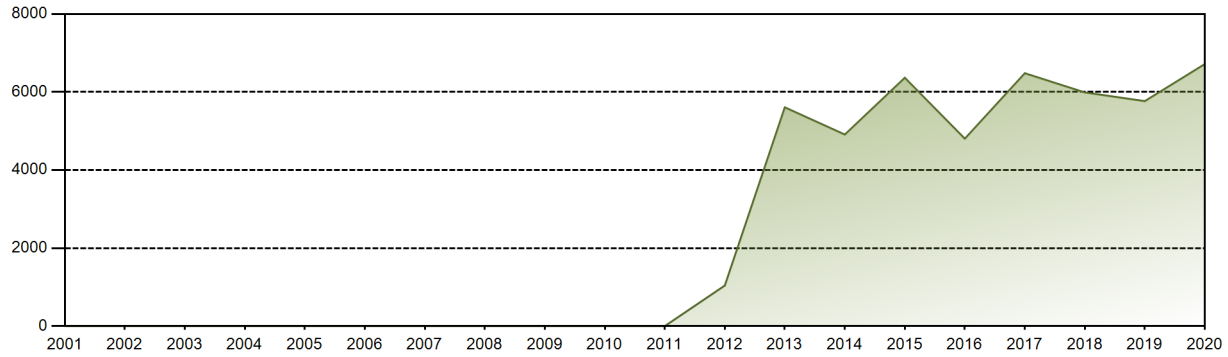
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	585.74	548.02	542.94	565.16	515.12	555.03	582.03	530.19	561.10	581.24	565.71	585.17	6717.44
EAF [%]	99.97	99.98	92.84	99.98	88.77	99.89	99.97	91.87	99.57	99.95	99.94	99.95	97.69
UCF [%]	99.97	99.98	92.84	99.98	88.77	99.89	99.97	91.87	99.57	99.95	99.94	99.95	97.69
LF [%]	101.32	101.34	93.92	101.02	89.11	99.21	100.68	91.71	100.30	100.55	101.12	101.23	98.42
OF [%]	100.00	100.00	92.74	100.00	88.71	100.00	100.00	91.67	100.00	100.00	100.00	100.00	97.72
FLR [%]	0.00	0.00	0.00	0.00	11.23	0.06	0.00	8.13	0.43	0.00	0.00	0.00	1.69
UCL [%]	0.00	0.00	0.00	0.00	11.23	0.06	0.00	8.13	0.43	0.00	0.00	0.00	1.68
PUF [%]	0.03	0.02	7.16	0.02	0.00	0.06	0.03	0.00	0.00	0.05	0.06	0.05	0.63
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

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Historical Summary

Lifetime energy generation	:	123445.1 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	21.22 %
Cumulative Energy Availability Factor (EAF)	:	68.82 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	18.85 %
Cumulative Unit Capability Factor (UCF)	:	69.3 %	Cumulative Planned Unavailability Factor (PUF)	:	11.85 %
Cumulative Load Factor (LF)	:	68.24 %	Cumulative Externally cause unavailability (XUF)	:	0.48 %
Cumulative Operating Factor (OF)	:	75.52 %			

Electricity Production (net) [GWh]

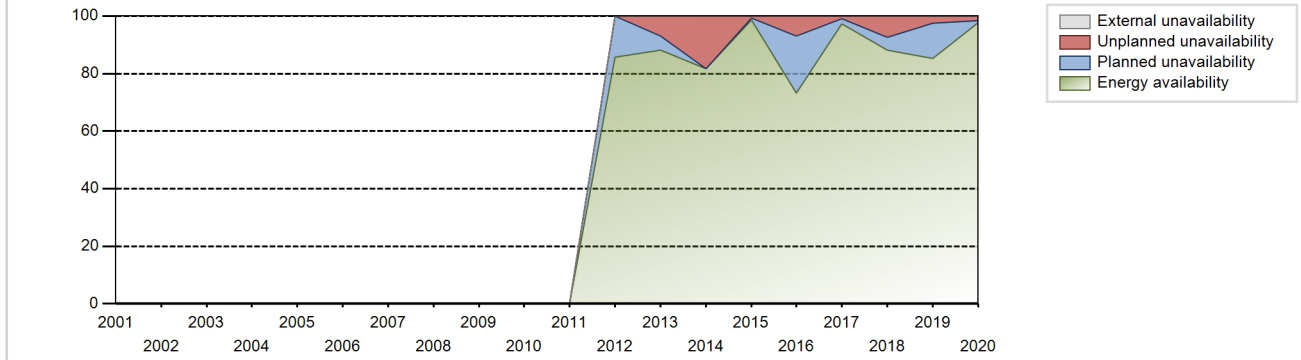


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	1696.80	2481	740	87.01	87.01	80.29	86.87	12.99	12.99	0.00	0.00
1978	3603.80	5946	740	65.23	65.45	55.75	68.06	22.17	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 - Long-term shutdown										
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

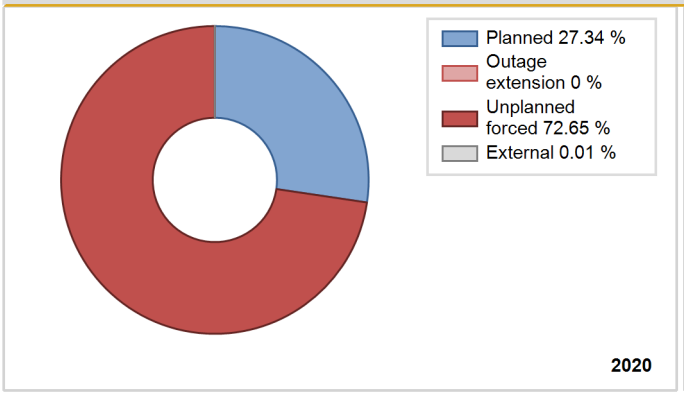
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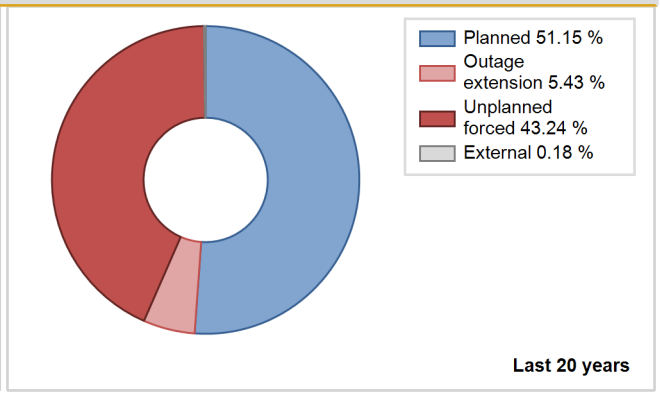
2014	4910.32	6984	734	81.74	81.74	76.37	79.73	18.26	18.26	0.00	0.00
2015	6365.71	8660	730	98.65	98.65	99.55	98.86	0.68	0.68	0.68	0.00
2016	4804.60	6408	760	73.21	73.23	73.17	72.95	2.57	6.93	19.84	0.02
2017	6482.56	8560	760	97.35	97.35	97.37	97.72	0.88	0.87	1.78	0.00
2018	5989.70	7828	760	88.11	88.12	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		140			1051	
D.	Inspection, maintenance or repair without refuelling	49			950		
E.	Testing of plant systems or components					2	
H.	Nuclear regulatory requirements					10	
J.	Grid limitation, failure or grid unavailability						27
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						2
L.	Human factor related					41	
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.)						16
Z.	Other					34	
Subtotal		49	140		950	1138	45
Total		**189**			**2133**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		132
12. Reactor I&C Systems		51
13. Reactor Auxiliary Systems		6
14. Safety Systems		12
15. Reactor Cooling Systems		142
16. Steam generation systems		473
21. Fuel Handling and Storage Facilities		29
31. Turbine and auxiliaries		22
32. Feedwater and Main Steam System	56	13
34. Miscellaneous Systems		15
35. All other I&C Systems		2
41. Main Generator Systems	84	139
42. Electrical Power Supply Systems		30
Total	**140**	**1066**

RUP revision during the year (2020) due to power uprate

RUP at the end of previous year : 760 [MWe]

Month	Capacity [MWe]	Power Uprate	Main modifications	Description
January	777	Stretch power uprate (2-7%)	Balance of plant	Reference Unit Power revised to 777MWs. Increase from 760MW (2019) due to engineering analysis performed on Main Output Transformer limitations allowing net average output increase. Change in RUP retroactive to 1 Jan 2020.

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2020 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

Reactor type and model	:	PHWR / CANDU 750A
Thermal power	:	2550 MWth
Gross electrical power	:	830 MWe
Reference unit power (net)	:	770 MWe

Key Dates

Construction Date	:	1972-07-01
Grid Date	:	1977-12-12
Commercial Date	:	1978-02-01
Age at end of year	:	43 years

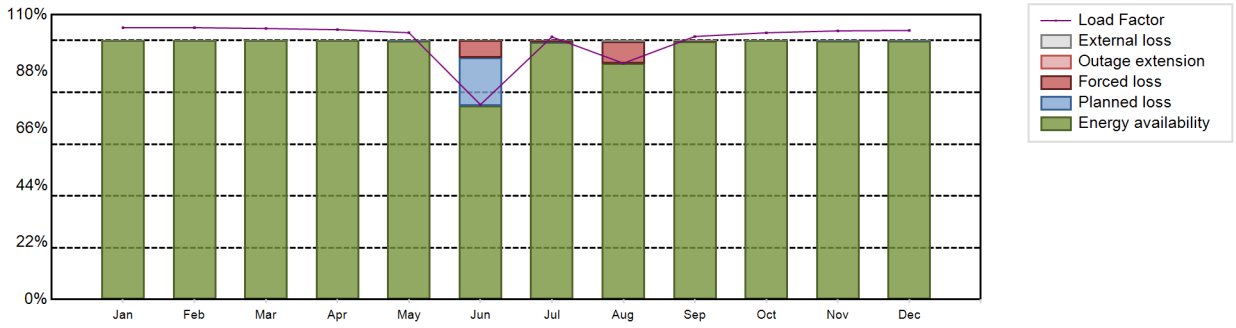
Design Characteristics

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	:	-
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.74
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]	:	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	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	6776.48 GW(e).h	Forced Loss Rate (FLR)	:	1.35 %
Energy Availability Factor (EAF)	:	97.08 %	Unplanned Capability Loss Factor (UCL)	:	1.33 %
Unit Capability Factor (UCF)	:	97.12 %	Planned Unavailability Factor (PUF)	:	1.54 %
Load Factor (LF)	:	100.19 %	Externally cause unavailability (XUF)	:	0.04 %
Operating Factor (OF)	:	97.61 %	Total off-line time	:	210 hours

Annual Summary



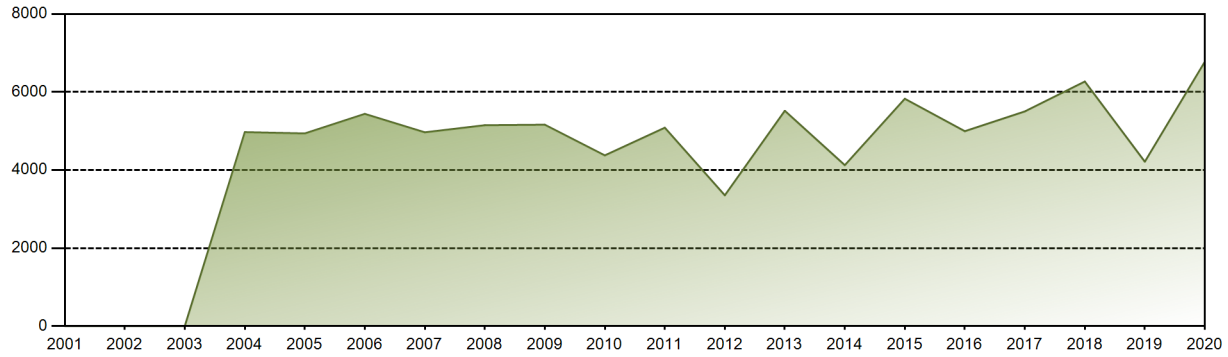
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	601.55	562.69	599.55	577.77	590.25	417.18	581.01	522.71	563.21	590.16	575.17	595.23	6776.48
EAF [%]	100.00	100.00	100.00	100.00	99.98	74.77	99.36	91.07	99.70	100.00	99.90	99.96	97.08
UCF [%]	100.00	100.00	100.00	100.00	99.98	74.77	99.36	91.36	99.87	100.00	99.90	99.96	97.12
LF [%]	105.00	105.00	104.66	104.22	103.03	75.25	101.42	91.24	101.59	103.02	103.75	103.90	100.19
OF [%]	100.00	100.00	100.00	100.00	100.00	79.72	100.00	91.40	100.00	100.00	100.00	100.00	97.61
FLR [%]	0.00	0.00	0.00	0.00	0.00	8.14	0.58	8.64	0.13	0.00	0.00	0.00	1.35
UCL [%]	0.00	0.00	0.00	0.00	0.00	6.63	0.58	8.64	0.13	0.00	0.00	0.00	1.33
PUF [%]	0.00	0.00	0.00	0.00	0.02	18.61	0.06	0.00	0.00	0.00	0.10	0.04	1.54
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.18	0.00	0.00	0.00	0.04

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Historical Summary

Lifetime energy generation	:	176588.25 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.13 %
Cumulative Energy Availability Factor (EAF)	:	74.6 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.64 %
Cumulative Unit Capability Factor (UCF)	:	75.19 %	Cumulative Planned Unavailability Factor (PUF)	:	11.17 %
Cumulative Load Factor (LF)	:	74.58 %	Cumulative Externally cause unavailability (XUF)	:	0.59 %
Cumulative Operating Factor (OF)	:	80.19 %			

Electricity Production (net) [GWh]

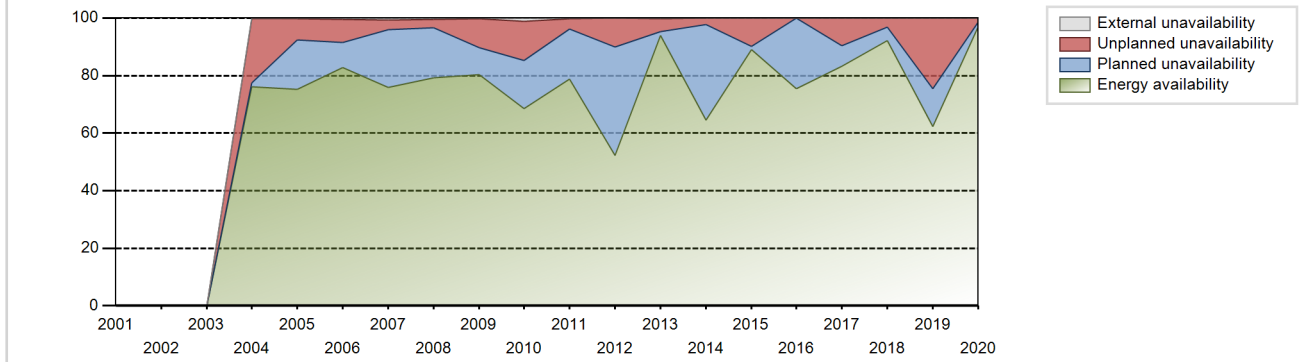


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1978	4793.00	7361	740	87.56	87.56	82.03	93.22	12.44	12.44	0.00	0.00
1979	4797.90	6885	740	77.78	77.78	73.21	77.74	11.80	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 - Long-term shutdown										
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

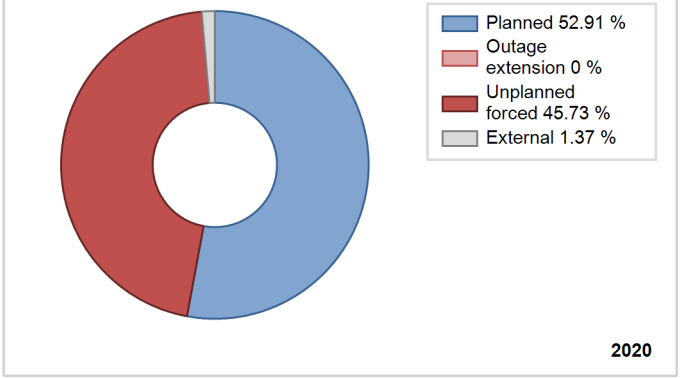
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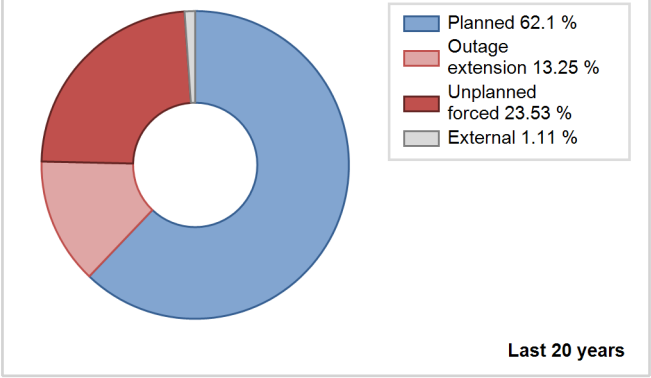
2015	5827.57	7831	750	89.01	89.01	88.90	89.39	10.00	9.89	1.09	0.00
2016	4995.72	6579	750	75.54	75.60	75.83	74.90	0.00	0.00	24.40	0.06
2017	5502.68	7344	750	83.22	83.22	83.75	83.84	0.08	9.65	7.13	0.00
2018	6268.88	8079	750	92.18	92.21	95.42	92.23	3.26	3.11	4.68	0.03
2019	4213.89	5592	750	62.40	62.40	64.14	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1978 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		25			728	
C. Inspection, maintenance or repair combined with refuelling	123			40	0	
D. Inspection, maintenance or repair without refuelling				825		
E. Testing of plant systems or components				14	1	
G. Major backfitting, refurbishment or upgrading activities without refuelling				78		
J. Grid limitation, failure or grid unavailability						3
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						17
L. Human factor related		59			11	
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.)						13
Z. Other					1	
Subtotal	123	84		957	741	34
Total	**207**			**1732**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1978 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		131
12. Reactor I&C Systems		45
13. Reactor Auxiliary Systems		24
14. Safety Systems		66
15. Reactor Cooling Systems		87
16. Steam generation systems		104
17. Safety I&C Systems (excluding reactor I&C)		3
21. Fuel Handling and Storage Facilities		31
31. Turbine and auxiliaries	59	96
32. Feedwater and Main Steam System		35
33. Circulating Water System		5
34. Miscellaneous Systems		7
35. All other I&C Systems		6
41. Main Generator Systems		81
42. Electrical Power Supply Systems	25	19
Total	**84**	**740**

RUP revision during the year (2020) due to power uprate

RUP at the end of previous year : 750 [MWe]

Month	Capacity [MWe]	Power Uprate	Main modifications	Description
January	770	Stretch power uprate (2-7%)	Balance of plant	Reference Unit Power revised to 770MWs. Increase from 750MW (2019) due to secondary side equipment upgrades including: seal oil, generator rewind, condenser cooling water pump replacement and installation of HX5A/5B bypass project. Change in RUP r

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2020 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

Reactor type and model	:	PHWR / CANDU 750A
Thermal power	:	2550 MWth
Gross electrical power	:	830 MWe
Reference unit power (net)	:	769 MWe

Key Dates

Construction Date	:	1972-09-01
Grid Date	:	1978-12-21
Commercial Date	:	1979-01-18
Age at end of year	:	42 years

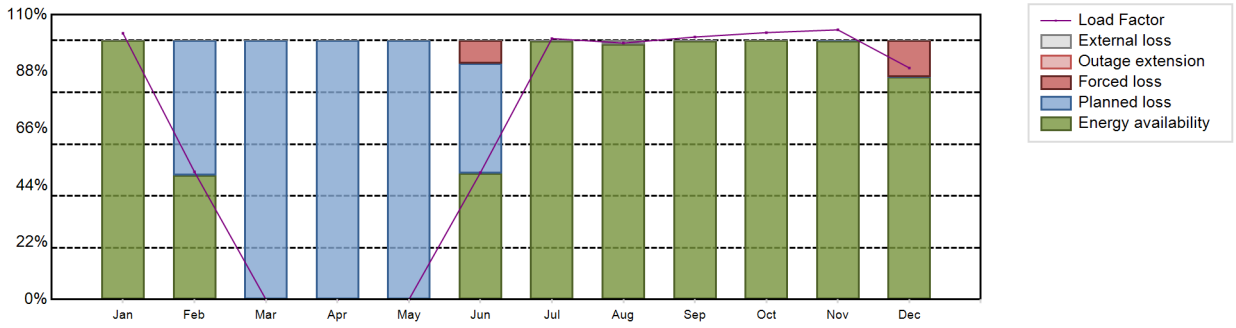
Design Characteristics

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	:	-
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	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	4506.1 GW(e).h	Forced Loss Rate (FLR)	:	2.84 %
Energy Availability Factor (EAF)	:	65.21 %	Unplanned Capability Loss Factor (UCL)	:	1.91 %
Unit Capability Factor (UCF)	:	65.35 %	Planned Unavailability Factor (PUF)	:	32.74 %
Load Factor (LF)	:	66.71 %	Externally cause unavailability (XUF)	:	0.14 %
Operating Factor (OF)	:	65.74 %	Total off-line time	:	3009 hours

Annual Summary



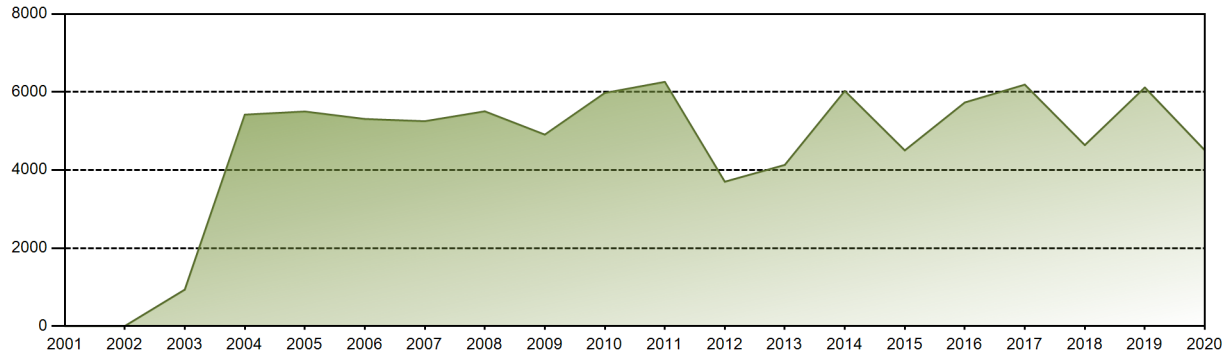
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	588.08	263.91	0.00	0.00	0.00	271.31	576.62	566.77	561.32	589.80	576.65	511.64	4506.10
EAF [%]	100.00	47.99	0.00	0.00	0.00	48.67	99.77	98.71	99.83	100.00	99.95	86.02	65.21
UCF [%]	100.00	47.99	0.00	0.00	0.00	48.67	100.00	100.00	100.00	100.00	99.95	86.02	65.35
LF [%]	102.79	49.31	0.00	0.00	0.00	49.00	100.78	99.06	101.38	103.09	104.15	89.43	66.71
OF [%]	100.00	47.99	0.00	0.00	0.00	51.39	100.00	100.00	100.00	100.00	100.00	88.04	65.74
FLR [%]	0.00	0.00	0.00	0.00	0.00	15.43	0.00	0.00	0.00	0.00	0.00	13.93	2.84
UCL [%]	0.00	0.00	0.00	0.00	0.00	8.88	0.00	0.00	0.00	0.00	0.00	13.92	1.91
PUF [%]	0.00	52.01	100.00	100.00	100.00	42.44	0.00	0.00	0.00	0.00	0.05	0.05	32.74
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.23	1.29	0.17	0.00	0.00	0.00	0.14

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Historical Summary

Lifetime energy generation	:	172606.41 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.81 %
Cumulative Energy Availability Factor (EAF)	:	73.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	14 %
Cumulative Unit Capability Factor (UCF)	:	74.6 %	Cumulative Planned Unavailability Factor (PUF)	:	11.41 %
Cumulative Load Factor (LF)	:	73.61 %	Cumulative Externally cause unavailability (XUF)	:	0.67 %
Cumulative Operating Factor (OF)	:	78.92 %			

Electricity Production (net) [GWh]

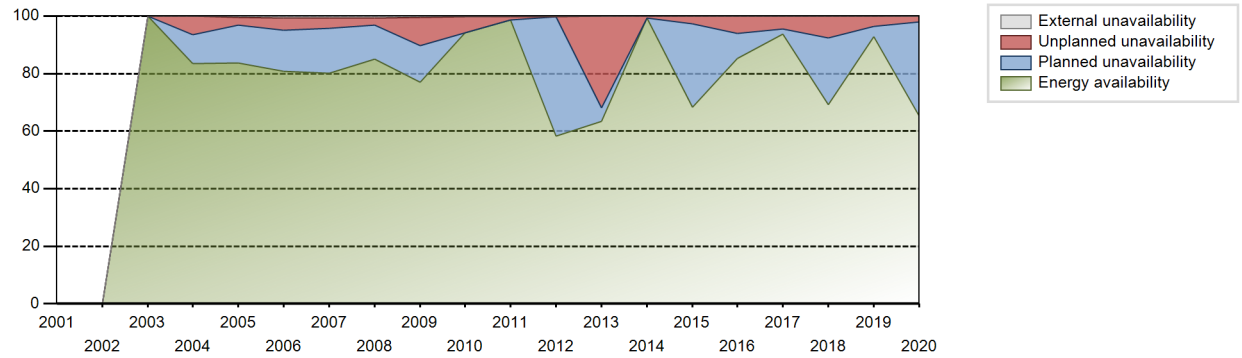


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1979	4966.40	7084	740	84.17	84.17	79.65	84.18	15.83	15.83	0.00	0.00
1980	4945.10	6962	740	76.12	76.12	76.08	79.26	14.06	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 - Long-term shutdown										
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

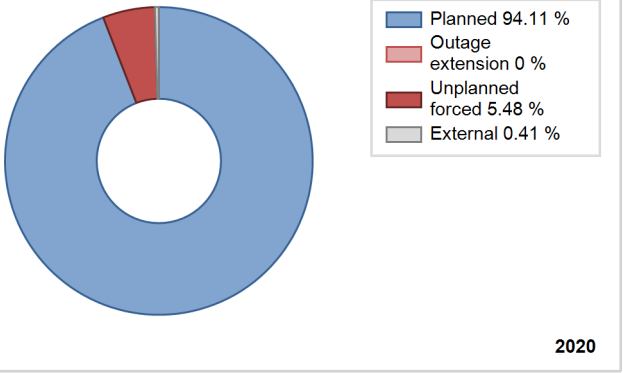
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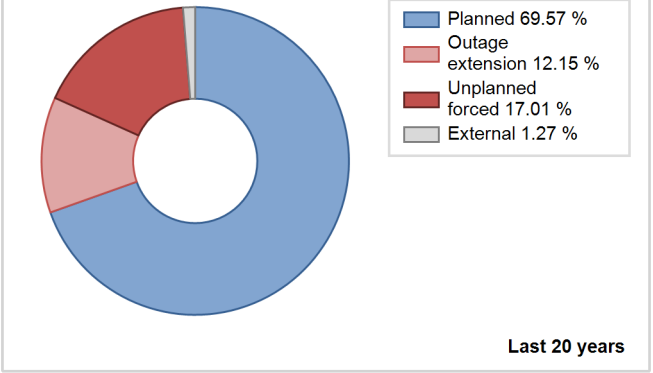
2016	5731.38	7511	750	85.23	85.25	87.00	85.51	6.54	5.96	8.78	0.02
2017	6188.10	8262	750	93.76	93.77	94.19	94.32	4.65	4.58	1.65	0.02
2018	4638.81	6146	750	69.12	69.13	70.61	70.16	4.78	7.58	23.30	0.00
2019	6115.21	8168	750	92.93	92.93	93.08	93.24	3.71	3.58	3.49	0.00
2020	4506.10	5775	769	65.21	65.35	66.71	65.74	2.84	1.91	32.74	0.14

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1979 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		135			782	
C. Inspection, maintenance or repair combined with refuelling				62		
D. Inspection, maintenance or repair without refuelling	2856			865		
E. Testing of plant systems or components				42		
H. Nuclear regulatory requirements					6	
J. Grid limitation, failure or grid unavailability						16
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						3
L. Human factor related					8	
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.)						14
Z. Other					12	2
Subtotal	2856	135		969	808	37
Total	**2991**			**1814**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1979 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		106
12. Reactor I&C Systems		43
14. Safety Systems		45
15. Reactor Cooling Systems		70
16. Steam generation systems		172
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		19
31. Turbine and auxiliaries	57	65
32. Feedwater and Main Steam System		35
33. Circulating Water System		7
34. Miscellaneous Systems		33
35. All other I&C Systems		95
41. Main Generator Systems	78	79
42. Electrical Power Supply Systems		34
Total	**135**	**804**

RUP revision during the year (2020) due to power uprate

RUP at the end of previous year : 750 [MWe]

Month	Capacity [MWe]	Power Uprate	Main modifications	Description
January	769	Stretch power uprate (2-7%)	Balance of plant	Reference Unit Power revised to 769MWs. Increase from 750MW (2019) due to HX5A/5B bypass project and engineering analysis performed on conducted on excitation limitations allowing increase to net average output. Change in RUP retroactive to 1 Jan 2

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2020 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	:	1978-06-01
Grid Date	:	1984-12-02
Commercial Date	:	1985-03-01
Age at end of year	:	36 years

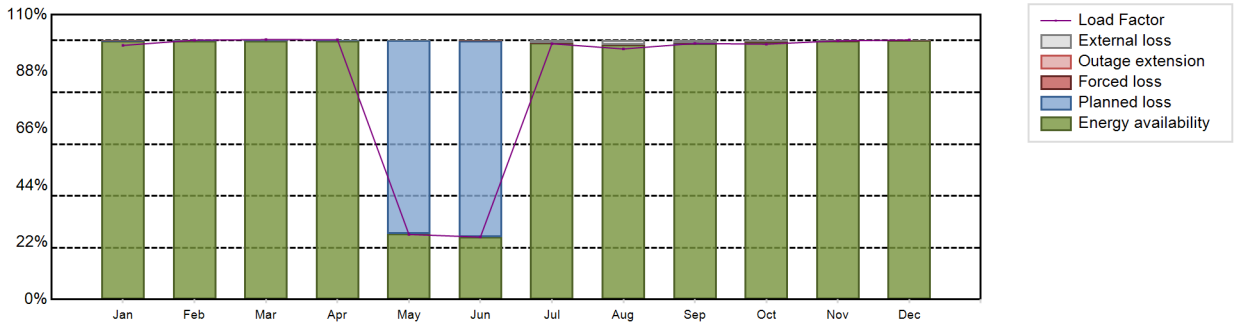
Design Characteristics

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	:	-
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.88
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]	:	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	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	6227.87 GW(e).h	Forced Loss Rate (FLR)	:	0.08 %
Energy Availability Factor (EAF)	:	87.06 %	Unplanned Capability Loss Factor (UCL)	:	0.07 %
Unit Capability Factor (UCF)	:	87.37 %	Planned Unavailability Factor (PUF)	:	12.56 %
Load Factor (LF)	:	86.78 %	Externally cause unavailability (XUF)	:	0.31 %
Operating Factor (OF)	:	87.45 %	Total off-line time	:	1102 hours

Annual Summary



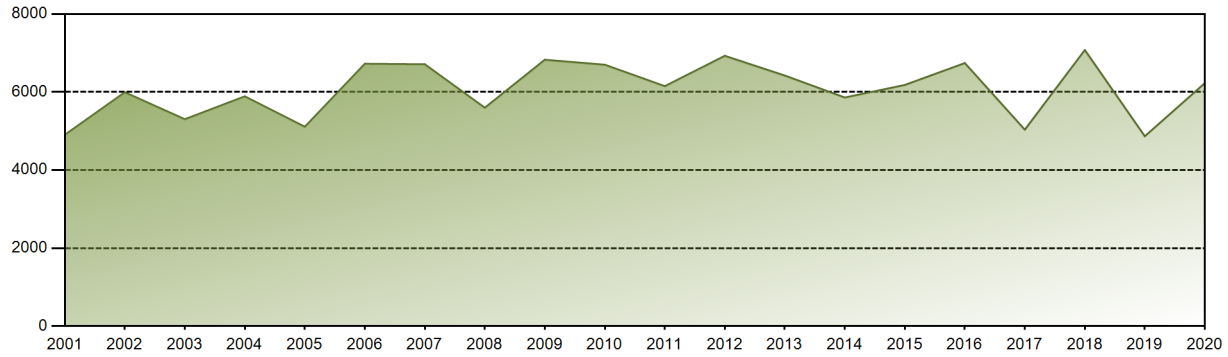
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	596.51	569.57	610.19	590.27	152.70	141.88	600.47	588.24	581.68	599.45	587.63	609.27	6227.87
EAF [%]	99.79	99.95	99.97	99.98	25.30	24.11	99.16	98.34	98.88	99.45	99.82	99.99	87.06
UCF [%]	99.79	99.95	99.97	99.98	25.30	24.11	99.97	99.85	99.87	99.76	99.88	99.99	87.37
LF [%]	98.13	100.17	100.39	100.35	25.12	24.12	98.79	96.77	98.88	98.62	99.90	100.23	86.78
OF [%]	100.00	100.00	100.00	100.00	25.27	24.17	100.00	100.00	100.00	100.00	100.00	100.00	87.45
FLR [%]	0.16	0.00	0.00	0.00	0.00	0.28	0.01	0.15	0.13	0.18	0.12	0.00	0.08
UCL [%]	0.16	0.00	0.00	0.00	0.00	0.07	0.01	0.15	0.13	0.18	0.12	0.00	0.07
PUF [%]	0.05	0.05	0.03	0.02	74.70	75.82	0.02	0.01	0.01	0.06	0.01	0.01	12.56
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.81	1.50	0.98	0.31	0.05	0.00	0.31

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Historical Summary

Lifetime energy generation	:	218180.96 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.89 %
Cumulative Energy Availability Factor (EAF)	:	85.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.8 %
Cumulative Unit Capability Factor (UCF)	:	85.77 %	Cumulative Planned Unavailability Factor (PUF)	:	9.43 %
Cumulative Load Factor (LF)	:	84.56 %	Cumulative Externally cause unavailability (XUF)	:	0.48 %
Cumulative Operating Factor (OF)	:	87.81 %			

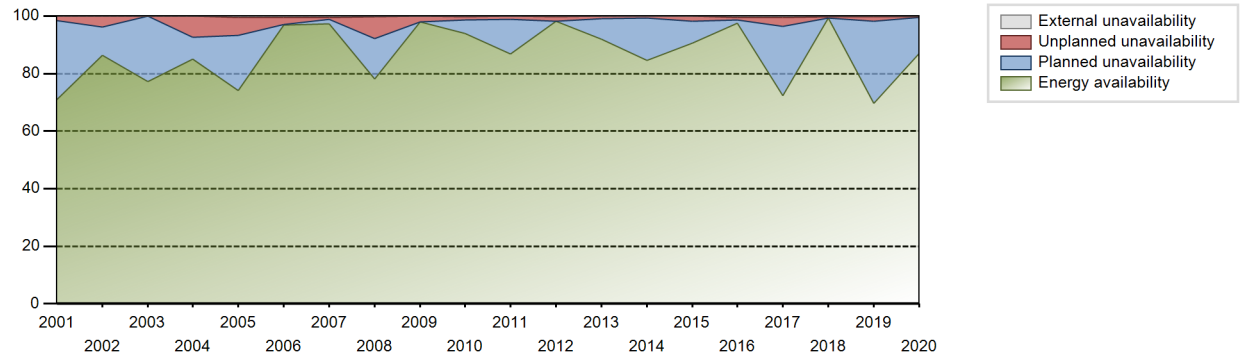
Electricity Production (net) [GWh]



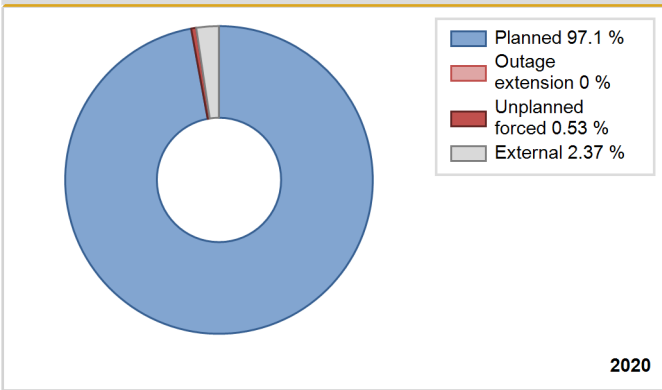
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	5464.16	7163	805	85.86	91.57	84.23	86.11	8.43	8.43	0.00	5.71
1986	7078.03	8675	835	96.67	98.43	96.77	99.03	1.57	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

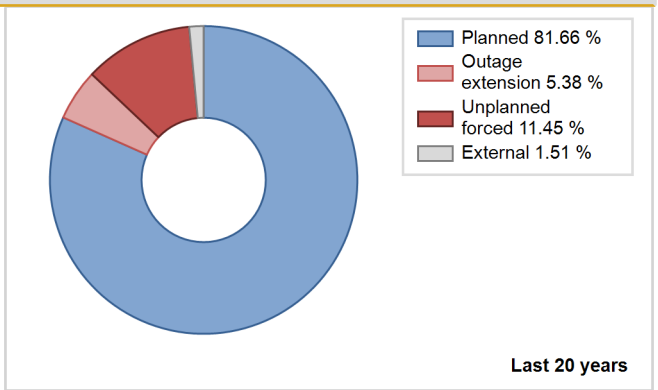
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 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				18		
D. Inspection, maintenance or repair without refuelling	1084			783	7	
E. Testing of plant systems or components				6	0	
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					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.)						13
Z. Other					1	
Subtotal	1084			807	238	17
Total	**1084**			**1062**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		25
13. Reactor Auxiliary Systems		9
14. Safety Systems		17
15. Reactor Cooling Systems		76
16. Steam generation systems		21
21. Fuel Handling and Storage Facilities		22
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		20
33. Circulating Water System		3
34. Miscellaneous Systems		2
41. Main Generator Systems		14
42. Electrical Power Supply Systems		11
Total		**238**

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2020 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	:	36 years

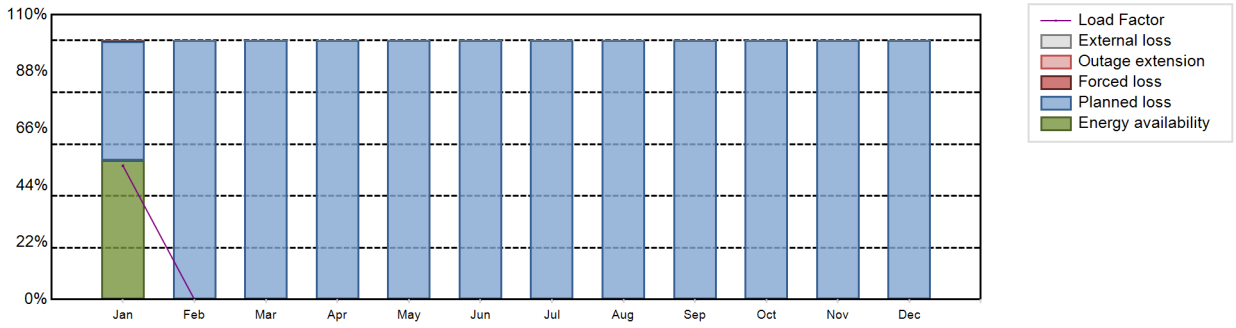
Design Characteristics

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	:	-
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.88
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]	:	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	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	313.8 GW(e).h	Forced Loss Rate (FLR)	:	0.74 %
Energy Availability Factor (EAF)	:	4.74 %	Unplanned Capability Loss Factor (UCL)	:	0.04 %
Unit Capability Factor (UCF)	:	4.74 %	Planned Unavailability Factor (PUF)	:	95.22 %
Load Factor (LF)	:	4.37 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	4.64 %	Total off-line time	:	8376 hours

Annual Summary



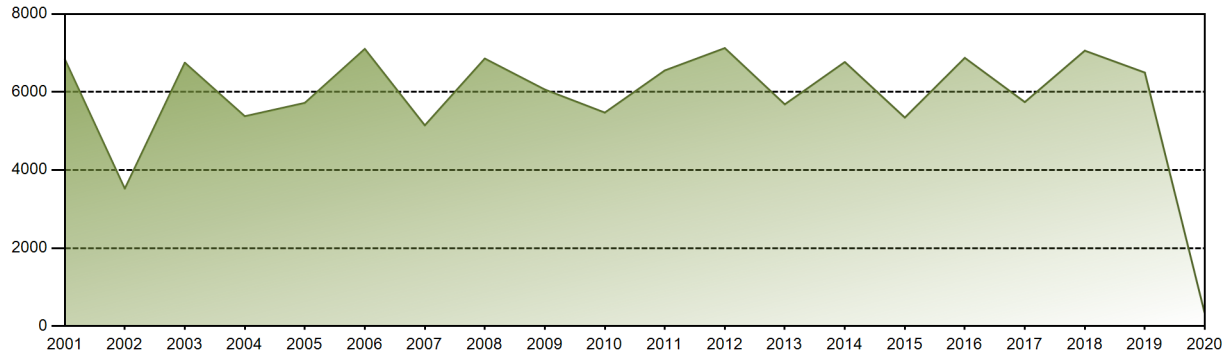
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	313.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.80
EAF [%]	53.72	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	4.74
UCF [%]	53.72	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	4.74
LF [%]	51.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.37
OF [%]	54.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.64
FLR [%]	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74
UCL [%]	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
PUF [%]	45.87	99.79	99.79	99.79	99.79	99.79	99.79	99.79	99.79	99.79	99.79	99.79	95.22
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

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Historical Summary

Lifetime energy generation	:	204577.48 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.03 %
Cumulative Energy Availability Factor (EAF)	:	81.2 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.86 %
Cumulative Unit Capability Factor (UCF)	:	81.79 %	Cumulative Planned Unavailability Factor (PUF)	:	11.35 %
Cumulative Load Factor (LF)	:	80.5 %	Cumulative Externally cause unavailability (XUF)	:	0.59 %
Cumulative Operating Factor (OF)	:	83.76 %			

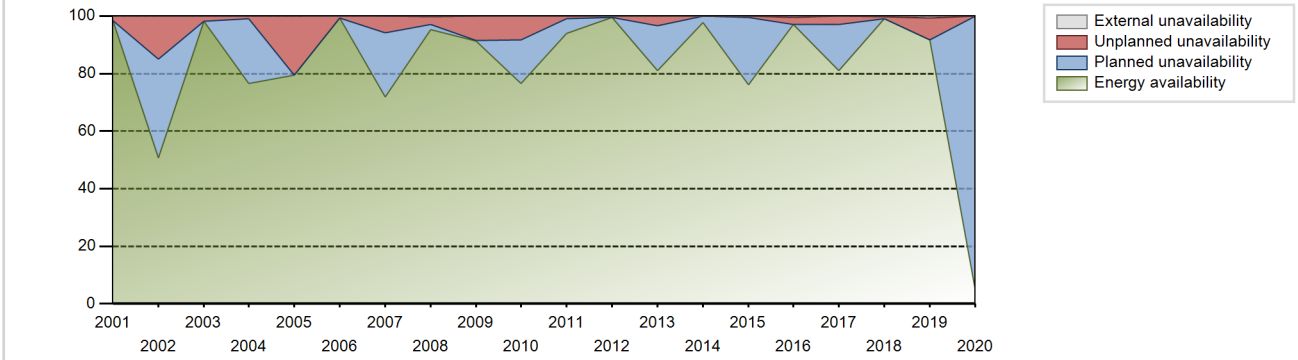
Electricity Production (net) [GWh]



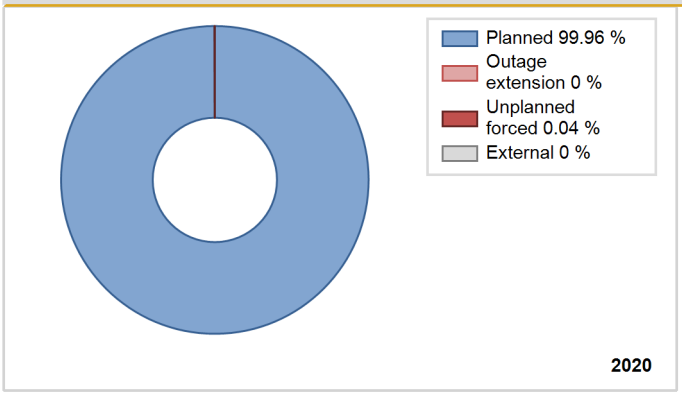
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	3068.32	4230	822	98.80	99.38	98.85	99.93	0.46	0.46	0.17	0.58
1985	5900.13	7369	805	84.04	88.69	83.66	84.12	10.23	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

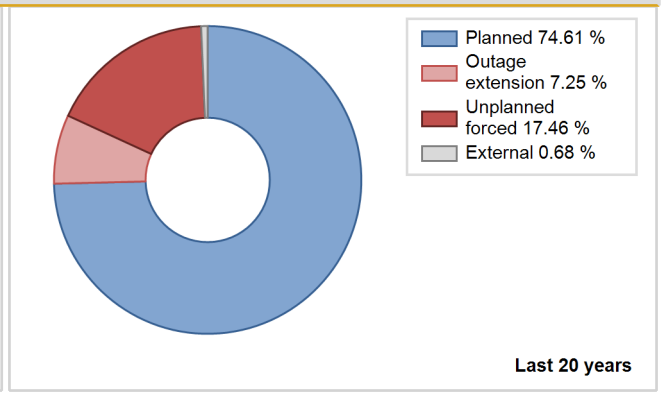
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					355	
C. Inspection, maintenance or repair combined with refuelling	8040			313		
D. Inspection, maintenance or repair without refuelling				660	4	
E. Testing of plant systems or components				0	17	
F. Major backfitting, refurbishment or upgrading activities with refuelling	342			9		
J. Grid limitation, failure or grid unavailability						3
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						15
L. Human factor related					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.)						12
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					11	
Z. Other					13	
Subtotal	8382			982	417	30
Total	**8382**			**1429**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		87
12. Reactor I&C Systems		55
13. Reactor Auxiliary Systems		1
14. Safety Systems		24
15. Reactor Cooling Systems		98
16. Steam generation systems		55
21. Fuel Handling and Storage Facilities		10
31. Turbine and auxiliaries		13
32. Feedwater and Main Steam System		15
33. Circulating Water System		8
34. Miscellaneous Systems		2
35. All other I&C Systems		7
41. Main Generator Systems		3
42. Electrical Power Supply Systems		20
Total		**398**

Highlights (2020)

Major component replacement outage start Jan 2020 (pressure tubes, steam generators, feeder piping, calendria tubes)

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2020 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

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	:	1979-05-01
Grid Date	:	1986-02-22
Commercial Date	:	1986-04-10
Age at end of year	:	34 years

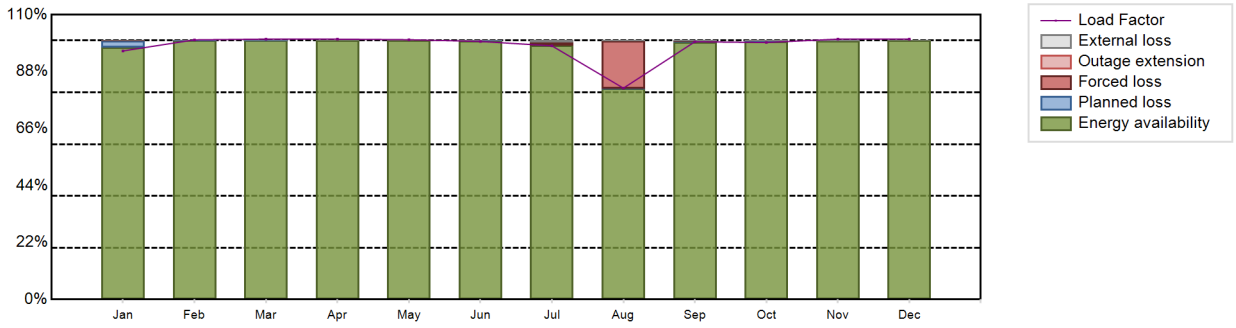
Design Characteristics

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	:	-
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.88
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]	:	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	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	7036.81 GW(e).h	Forced Loss Rate (FLR)	:	1.71 %
Energy Availability Factor (EAF)	:	97.96 %	Unplanned Capability Loss Factor (UCL)	:	1.71 %
Unit Capability Factor (UCF)	:	98.04 %	Planned Unavailability Factor (PUF)	:	0.25 %
Load Factor (LF)	:	98.05 %	Externally cause unavailability (XUF)	:	0.08 %
Operating Factor (OF)	:	98.63 %	Total off-line time	:	120 hours

Annual Summary



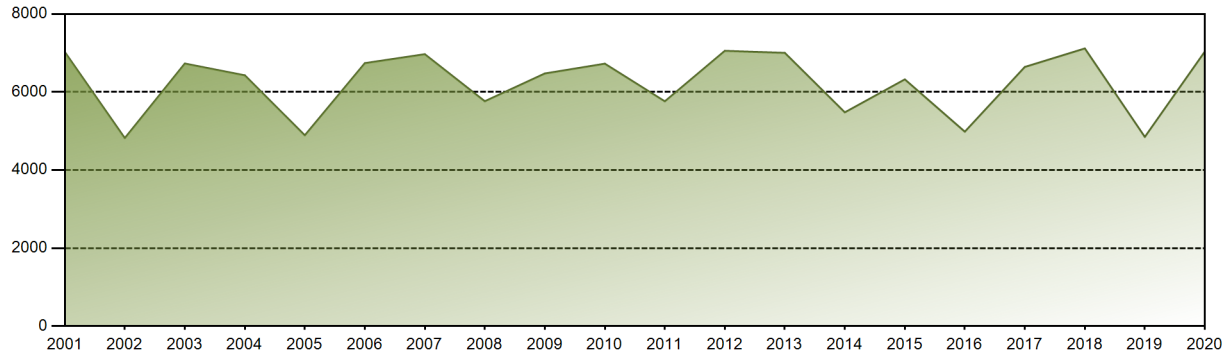
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	583.59	570.29	611.40	591.46	609.95	586.33	595.57	496.24	585.58	603.42	591.60	611.39	7036.81
EAF [%]	97.40	100.00	100.00	100.00	100.00	99.97	98.04	81.46	99.43	99.58	99.98	100.00	97.96
UCF [%]	97.40	100.00	100.00	100.00	100.00	99.97	98.62	81.70	99.57	99.59	99.99	100.00	98.04
LF [%]	96.01	100.29	100.58	100.55	100.35	99.68	97.98	81.64	99.55	99.27	100.57	100.58	98.05
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	83.87	100.00	100.00	100.00	100.00	98.63
FLR [%]	0.08	0.00	0.00	0.00	0.00	0.00	1.38	18.29	0.29	0.13	0.00	0.00	1.71
UCL [%]	0.08	0.00	0.00	0.00	0.00	0.00	1.38	18.29	0.28	0.13	0.00	0.00	1.71
PUF [%]	2.52	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.15	0.28	0.01	0.00	0.25
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.24	0.14	0.01	0.01	0.00	0.08

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Historical Summary

Lifetime energy generation	:	212422.84 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.16 %
Cumulative Energy Availability Factor (EAF)	:	85.8 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.42 %
Cumulative Unit Capability Factor (UCF)	:	86.49 %	Cumulative Planned Unavailability Factor (PUF)	:	8.09 %
Cumulative Load Factor (LF)	:	84.83 %	Cumulative Externally cause unavailability (XUF)	:	0.69 %
Cumulative Operating Factor (OF)	:	88.72 %			

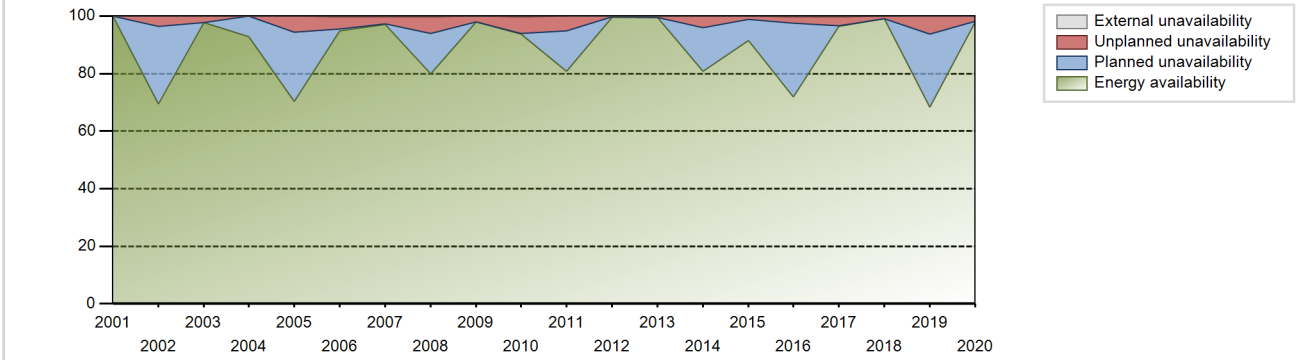
Electricity Production (net) [GWh]



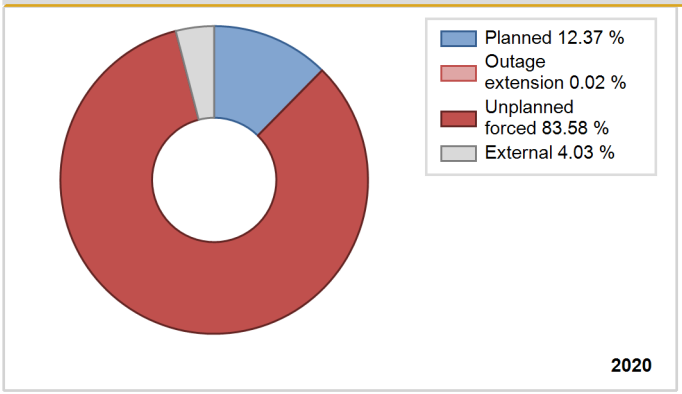
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	5256.62	6957	838	89.83	96.68	89.66	97.55	3.31	3.30	0.02	6.85
1987	6288.05	8489	837	85.91	96.87	85.76	96.91	2.80	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

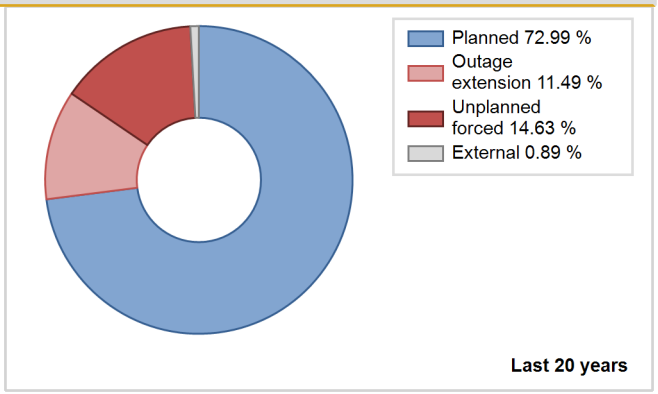
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1986 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		117			247	
C. Inspection, maintenance or repair combined with refuelling				18		
D. Inspection, maintenance or repair without refuelling				603	8	
E. Testing of plant systems or components				8		
G. Major backfitting, refurbishment or upgrading activities without refuelling				65		
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						19
L. Human factor related					4	
Z. Other					10	3
Subtotal		117		694	269	22
Total		**117**			**985**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		14
12. Reactor I&C Systems		32
13. Reactor Auxiliary Systems		2
14. Safety Systems		6
15. Reactor Cooling Systems		40
16. Steam generation systems		25
21. Fuel Handling and Storage Facilities		27
31. Turbine and auxiliaries		31
32. Feedwater and Main Steam System		30
33. Circulating Water System		5
34. Miscellaneous Systems		30
41. Main Generator Systems	117	10
42. Electrical Power Supply Systems		16
Total	**117**	**268**

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2020 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	:	1979-08-01
Grid Date	:	1987-03-09
Commercial Date	:	1987-05-22
Age at end of year	:	33 years

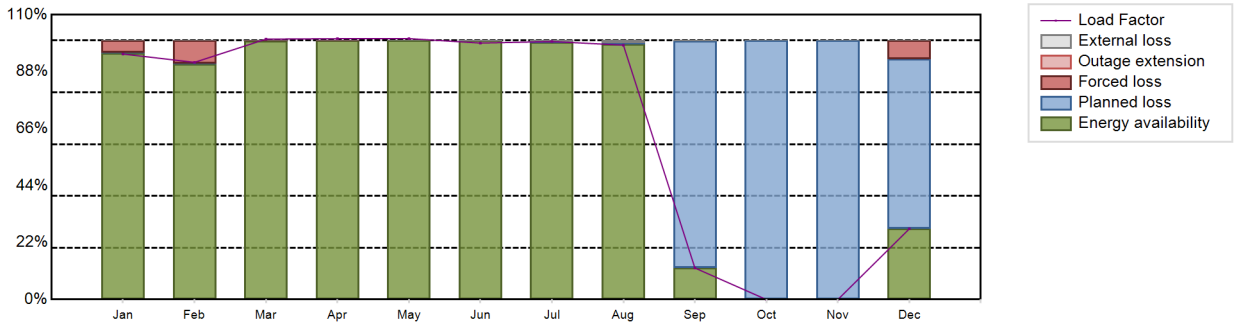
Design Characteristics

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	:	-
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.88
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]	:	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	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	4936.59 GW(e).h	Forced Loss Rate (FLR)	:	2.4 %
Energy Availability Factor (EAF)	:	68.69 %	Unplanned Capability Loss Factor (UCL)	:	1.69 %
Unit Capability Factor (UCF)	:	68.82 %	Planned Unavailability Factor (PUF)	:	29.49 %
Load Factor (LF)	:	68.79 %	Externally cause unavailability (XUF)	:	0.13 %
Operating Factor (OF)	:	69.91 %	Total off-line time	:	2643 hours

Annual Summary



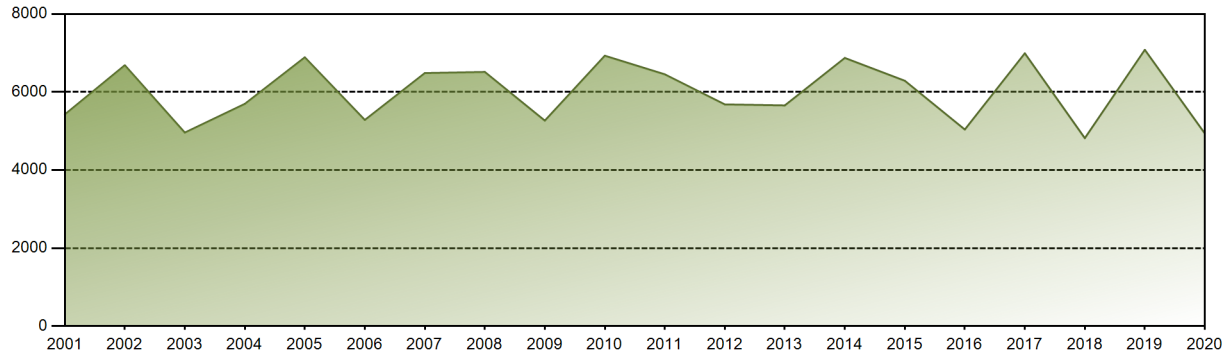
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	576.33	520.85	611.27	592.56	612.57	582.66	605.61	597.11	71.68	0.00	0.00	165.95	4936.59
EAF [%]	95.08	91.05	99.96	100.00	100.00	99.99	99.48	98.69	12.19	0.00	0.00	27.30	68.69
UCF [%]	95.08	91.05	99.96	100.00	100.00	99.99	99.94	99.59	12.35	0.00	0.00	27.30	68.82
LF [%]	94.82	91.60	100.56	100.73	100.78	99.05	99.63	98.23	12.19	0.00	0.00	27.30	68.79
OF [%]	95.83	99.57	100.00	100.00	100.00	100.00	100.00	100.00	12.92	0.00	0.00	30.38	69.91
FLR [%]	4.61	8.85	0.04	0.00	0.00	0.01	0.05	0.00	0.00	0.00	0.00	20.40	2.40
UCL [%]	4.60	8.84	0.04	0.00	0.00	0.01	0.05	0.00	0.00	0.00	0.00	6.99	1.69
PUF [%]	0.32	0.11	0.00	0.00	0.00	0.00	0.01	0.41	87.65	100.00	100.00	65.70	29.49
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.90	0.17	0.00	0.00	0.00	0.13

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Historical Summary

Lifetime energy generation	:	199013.96 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.88 %
Cumulative Energy Availability Factor (EAF)	:	83.65 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.1 %
Cumulative Unit Capability Factor (UCF)	:	84.52 %	Cumulative Planned Unavailability Factor (PUF)	:	9.39 %
Cumulative Load Factor (LF)	:	82.76 %	Cumulative Externally cause unavailability (XUF)	:	0.87 %
Cumulative Operating Factor (OF)	:	86.76 %			

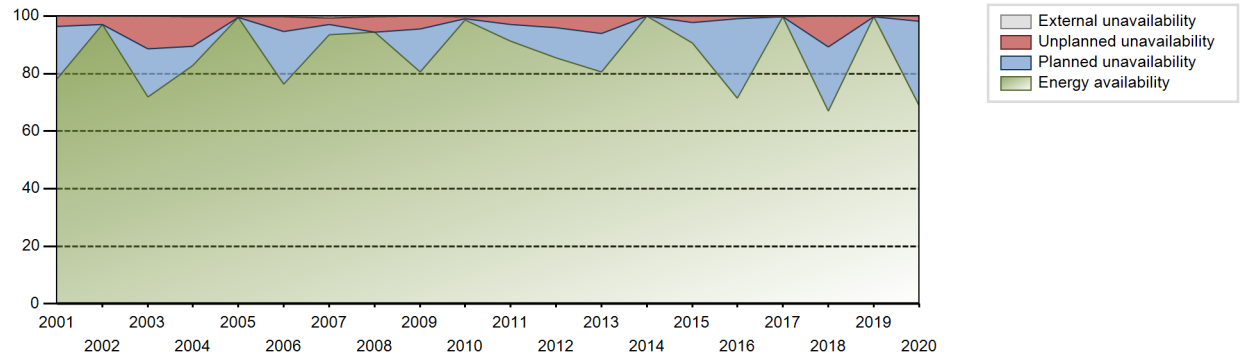
Electricity Production (net) [GWh]



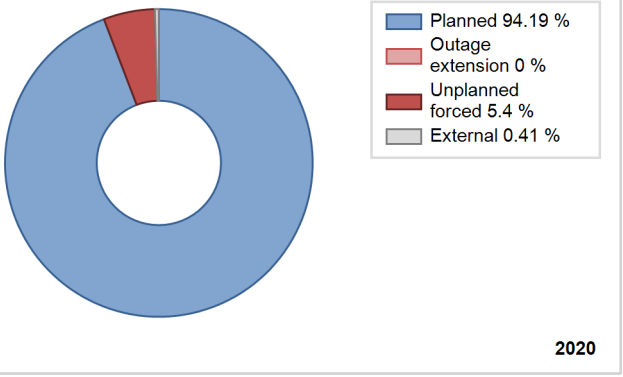
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	3673.23	5849	844	76.58	99.06	76.45	99.90	0.69	0.69	0.25	22.48
1988	5958.52	7659	837	86.53	86.85	81.04	87.19	8.74	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

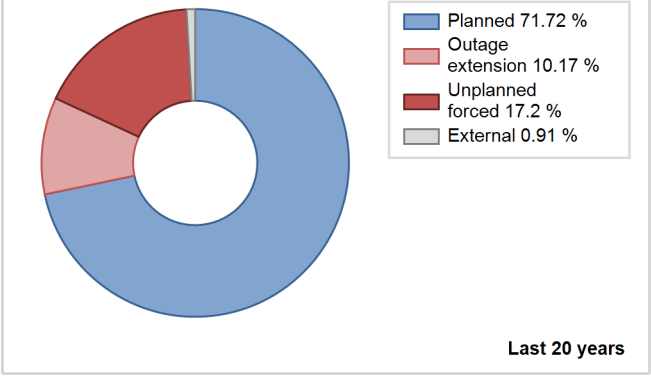
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1987 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		84			296	
C. Inspection, maintenance or repair combined with refuelling				112		
D. Inspection, maintenance or repair without refuelling	2568			698	29	
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)						23
L. Human factor related					5	
Z. Other					1	
Subtotal	2568	84		810	332	23
Total	**2652**			**1165**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		33
12. Reactor I&C Systems		9
13. Reactor Auxiliary Systems		2
14. Safety Systems		18
15. Reactor Cooling Systems		54
16. Steam generation systems		141
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries	33	17
32. Feedwater and Main Steam System	51	13
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		17
Total	**84**	**329**

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2020 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

Reactor type and model	:	PHWR / CANDU 850
Thermal power	:	2776 MWth
Gross electrical power	:	934 MWe
Reference unit power (net)	:	878 MWe

Key Dates

Construction Date	:	1982-04-01
Grid Date	:	1990-12-19
Commercial Date	:	1992-11-14
Age at end of year	:	30 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]	:	8625
Active core diameter [m]	:	7.068
Active core height/length [m]	:	6.06
Number of fissile fuel assemblies/bundles	:	6240
Fuel linear heat generation rate [kW/m]	:	24
Number of control rod assemblies	:	24
Number of external reactor coolant loops	:	2
Coolant type	:	D2O

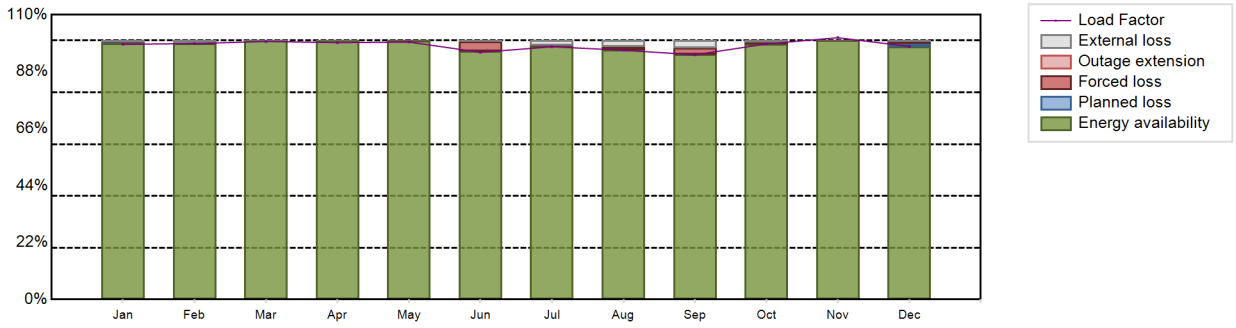
Operating coolant pressure [MPa]	:	10
Reactor outlet temperature [°C]	:	310
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.0965
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	4.93
Output voltage [kV]	:	22
Primary means of condenser cooling	:	Lake (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	:	none

Annual Production Results (2020)

Net Energy Production	:	7565.81 GW(e).h
Energy Availability Factor (EAF)	:	98.22 %
Unit Capability Factor (UCF)	:	99.08 %
Load Factor (LF)	:	98.1 %
Operating Factor (OF)	:	100 %

Forced Loss Rate (FLR)	:	0.81 %
Unplanned Capability Loss Factor (UCL)	:	0.81 %
Planned Unavailability Factor (PUF)	:	0.11 %
Externally cause unavailability (XUF)	:	0.85 %
Total off-line time	:	0 hours

Annual Summary



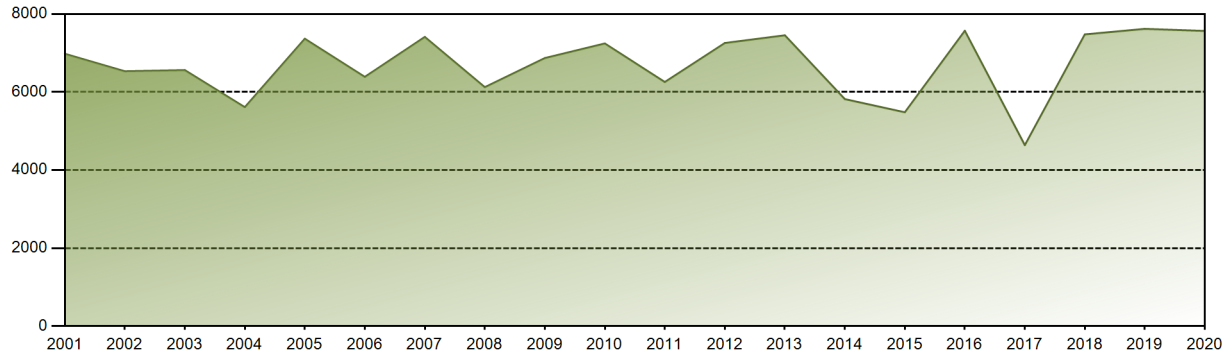
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	643.99	603.99	651.06	627.16	649.54	603.53	637.71	628.90	597.52	644.73	639.25	638.42	7565.81
EAF [%]	98.99	98.84	100.00	100.00	99.96	95.88	97.76	96.27	94.57	98.67	100.00	97.73	98.22
UCF [%]	99.67	99.88	100.00	100.00	99.96	96.27	99.74	98.62	97.32	99.23	100.00	98.23	99.08
LF [%]	98.59	98.84	99.67	99.21	99.44	95.47	97.62	96.27	94.52	98.70	101.12	97.73	98.10
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 [%]	0.22	0.12	0.00	0.00	0.04	3.73	0.26	1.38	2.68	0.77	0.00	0.58	0.81
UCL [%]	0.22	0.12	0.00	0.00	0.04	3.73	0.26	1.38	2.68	0.77	0.00	0.57	0.81
PUF [%]	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.11
XUF [%]	0.68	1.04	0.00	0.00	0.00	0.39	1.98	2.35	2.75	0.56	0.00	0.50	0.85

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Historical Summary

Lifetime energy generation	:	189501.45 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.56 %
Cumulative Energy Availability Factor (EAF)	:	85.54 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.16 %
Cumulative Unit Capability Factor (UCF)	:	86.51 %	Cumulative Planned Unavailability Factor (PUF)	:	8.33 %
Cumulative Load Factor (LF)	:	85.12 %	Cumulative Externally cause unavailability (XUF)	:	0.97 %
Cumulative Operating Factor (OF)	:	89.19 %			

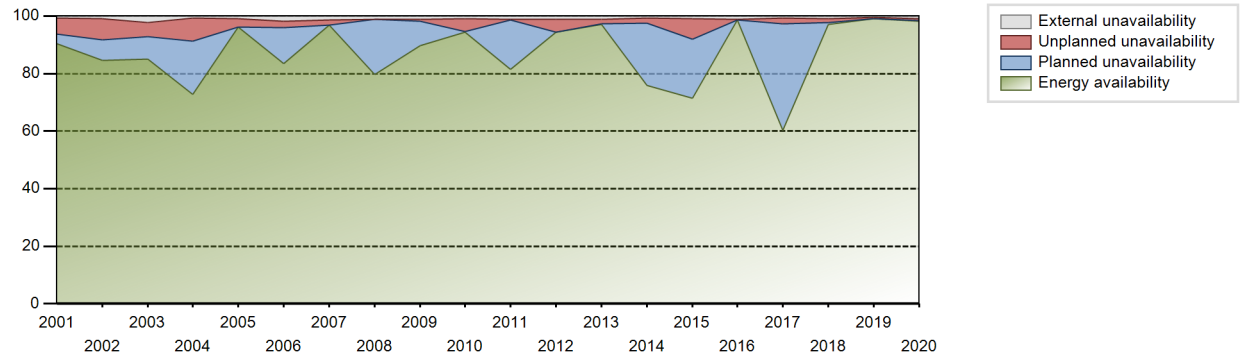
Electricity Production (net) [GWh]



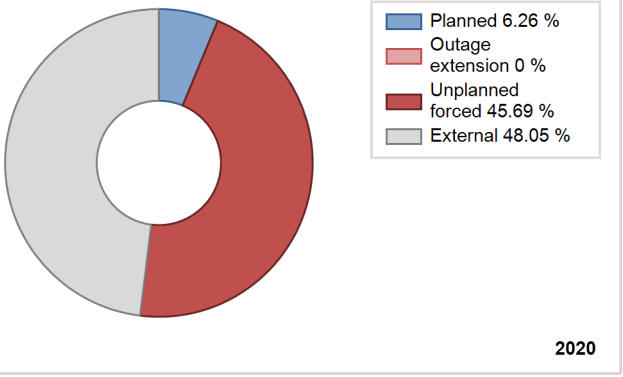
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1992	973.98	1152	881	96.83	96.83	75.51	78.69	3.17	3.17	0.00	0.00
1993	6016.23	7213	881	78.72	79.18	77.96	82.34	9.34	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

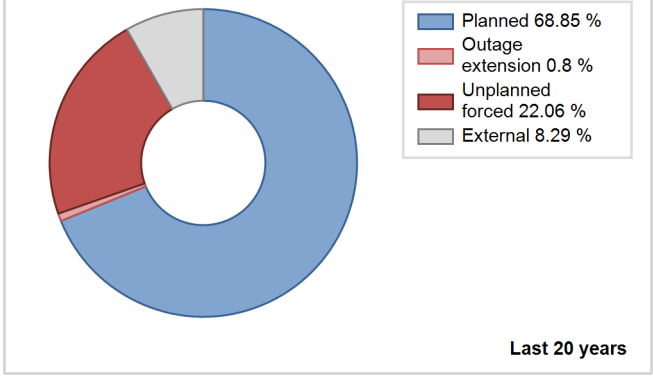
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1992 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					403	
D. Inspection, maintenance or repair without refuelling				705		
F. Major backfitting, refurbishment or upgrading activities with refuelling				38		
J. Grid limitation, failure or grid unavailability						3
L. Human factor related					0	
Z. Other					1	
Subtotal				743	404	3
Total		**0**			**1150**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1992 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		30
12. Reactor I&C Systems		27
13. Reactor Auxiliary Systems		4
14. Safety Systems		13
15. Reactor Cooling Systems		178
21. Fuel Handling and Storage Facilities		24
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		1
34. Miscellaneous Systems		8
35. All other I&C Systems		22
41. Main Generator Systems		46
42. Electrical Power Supply Systems		11
Total		**380**

Highlights (2020)

This Unit hit an international record of the longest CANDU run. It did so safely and reliably. It still continues this run into 2021.

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2020 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

Reactor type and model	:	PHWR / CANDU 850
Thermal power	:	2776 MWth
Gross electrical power	:	934 MWe
Reference unit power (net)	:	878 MWe

Key Dates

Construction Date	:	1981-09-01
Grid Date	:	1990-01-15
Commercial Date	:	1990-10-09
Age at end of year	:	30 years

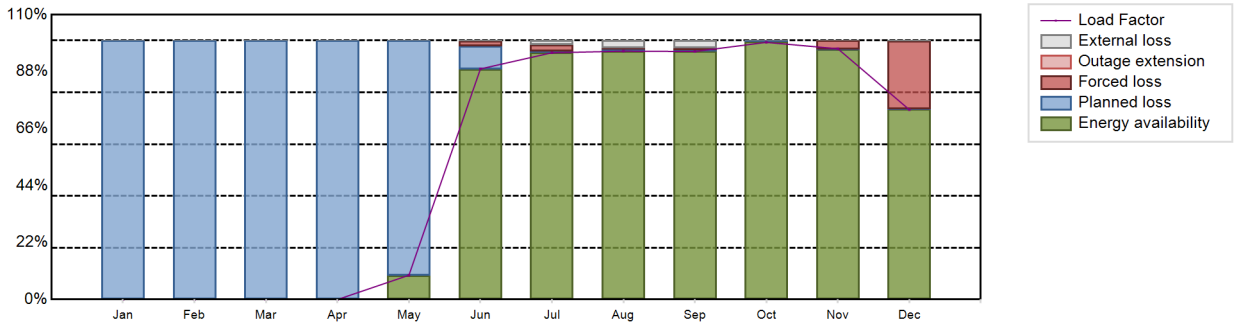
Design Characteristics

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 (2020)

Net Energy Production	:	4218.91 GW(e).h	Forced Loss Rate (FLR)	:	5.06 %
Energy Availability Factor (EAF)	:	54.74 %	Unplanned Capability Loss Factor (UCL)	:	2.95 %
Unit Capability Factor (UCF)	:	55.41 %	Planned Unavailability Factor (PUF)	:	41.64 %
Load Factor (LF)	:	54.7 %	Externally cause unavailability (XUF)	:	0.67 %
Operating Factor (OF)	:	58.56 %	Total off-line time	:	3640 hours

Annual Summary



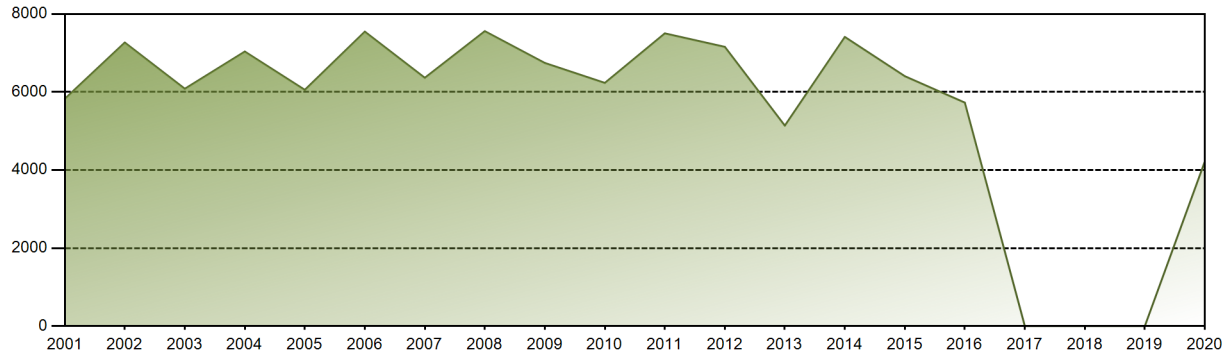
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	61.33	563.05	622.50	626.55	605.54	648.77	612.22	478.95	4218.91
EAF [%]	0.00	0.00	0.00	0.00	9.39	88.89	95.30	95.91	95.83	99.68	96.63	73.67	54.74
UCF [%]	0.00	0.00	0.00	0.00	9.39	89.14	97.04	98.83	98.76	99.68	96.63	73.84	55.41
LF [%]	0.00	0.00	0.00	0.00	9.39	89.07	95.30	95.91	95.79	99.32	96.85	73.32	54.70
OF [%]	0.00	0.00	0.00	0.00	13.31	94.31	100.00	100.00	100.00	100.00	100.00	93.28	58.56
FLR [%]	0.00	0.00	0.00	0.00	0.00	2.14	2.49	0.53	0.67	0.00	3.25	26.16	5.06
UCL [%]	0.00	0.00	0.00	0.00	0.00	1.95	2.48	0.53	0.67	0.00	3.25	26.16	2.95
PUF [%]	100.00	100.00	100.00	100.00	90.61	8.91	0.48	0.64	0.57	0.32	0.12	0.00	41.64
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.25	1.74	2.92	2.92	0.00	0.00	0.17	0.67

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Historical Summary

Lifetime energy generation	:	165550.04 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	12.77 %
Cumulative Energy Availability Factor (EAF)	:	70.49 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	10.78 %
Cumulative Unit Capability Factor (UCF)	:	71.37 %	Cumulative Planned Unavailability Factor (PUF)	:	17.85 %
Cumulative Load Factor (LF)	:	70.32 %	Cumulative Externally cause unavailability (XUF)	:	0.87 %
Cumulative Operating Factor (OF)	:	73.93 %			

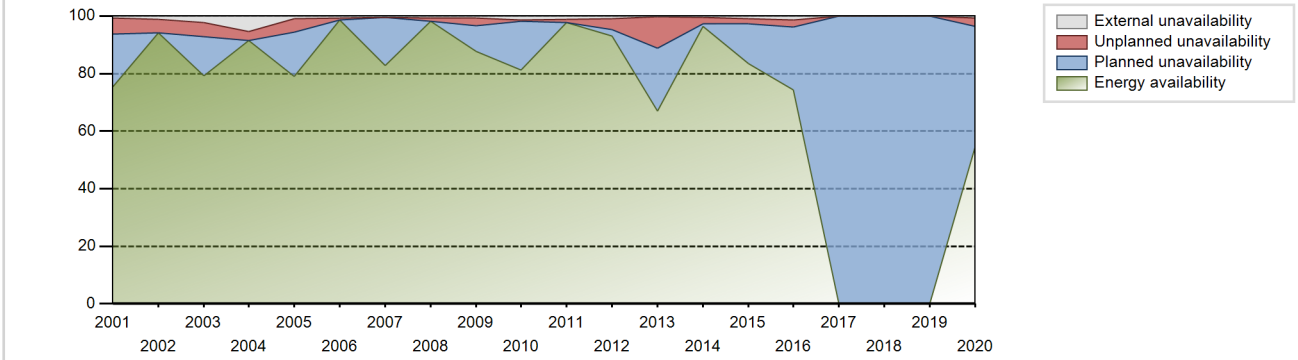
Electricity Production (net) [GWh]



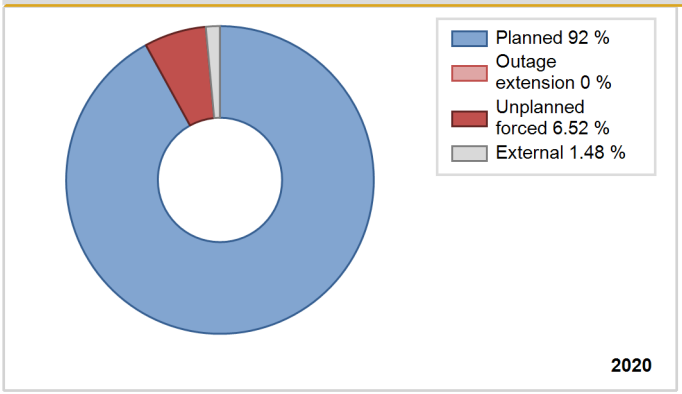
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	1153.47	1608	881	64.94	64.94	65.73	80.72	35.03	35.02	0.04	0.00
1991	51.48	102	881	0.67	0.67	0.67	1.16	99.33	99.33	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

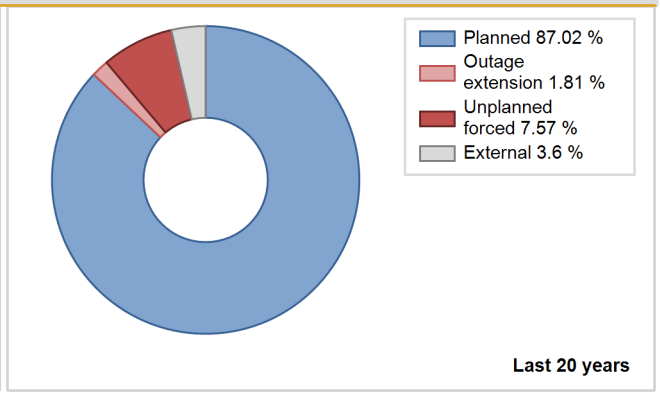
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1990 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		50			501	
D. Inspection, maintenance or repair without refuelling				501	11	
E. Testing of plant systems or components	393			13		
G. Major backfitting, refurbishment or upgrading activities without refuelling	3196			1036		
J. Grid limitation, failure or grid unavailability						2
Z. Other					217	
Subtotal	3589	50		1550	729	2
Total	**3639**			**2281**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1990 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		36
12. Reactor I&C Systems		27
13. Reactor Auxiliary Systems		1
14. Safety Systems		7
15. Reactor Cooling Systems		312
16. Steam generation systems		40
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities	50	16
31. Turbine and auxiliaries		20
32. Feedwater and Main Steam System		9
34. Miscellaneous Systems		6
35. All other I&C Systems		11
41. Main Generator Systems		6
42. Electrical Power Supply Systems		11
Total	**50**	**503**

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Highlights (2020)

This unit was successfully returned to service after a multi-year refurbishment.

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2020 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

Reactor type and model	:	PHWR / CANDU 850
Thermal power	:	2776 MWth
Gross electrical power	:	934 MWe
Reference unit power (net)	:	878 MWe

Key Dates

Construction Date	:	1984-09-01
Grid Date	:	1992-12-07
Commercial Date	:	1993-02-14
Age at end of year	:	28 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]	:	8625
Active core diameter [m]	:	7.068
Active core height/length [m]	:	6.06
Number of fissile fuel assemblies/bundles	:	6240
Fuel linear heat generation rate [kW/m]	:	24
Number of control rod assemblies	:	24
Number of external reactor coolant loops	:	2
Coolant type	:	D2O

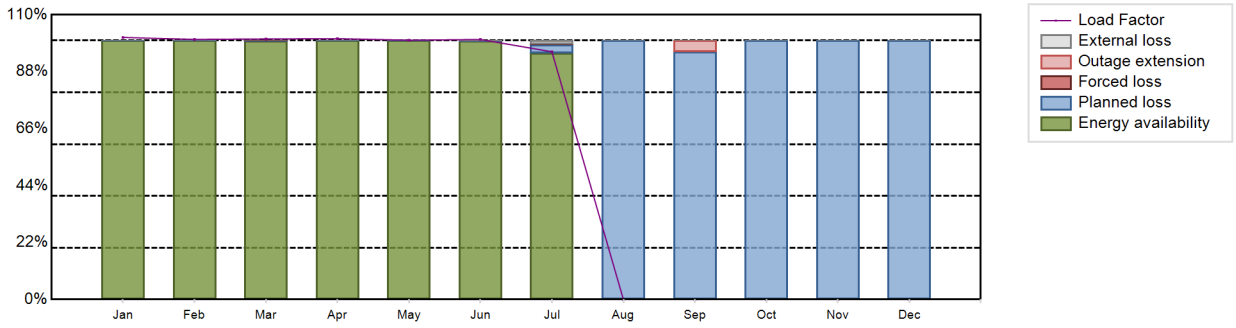
Operating coolant pressure [MPa]	:	10
Reactor outlet temperature [°C]	:	310
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.0965
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	4.93
Output voltage [kV]	:	22
Primary means of condenser cooling	:	Lake (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	:	none

Annual Production Results (2020)

Net Energy Production	:	4483.41 GW(e).h
Energy Availability Factor (EAF)	:	57.75 %
Unit Capability Factor (UCF)	:	57.88 %
Load Factor (LF)	:	58.13 %
Operating Factor (OF)	:	57.91 %

Forced Loss Rate (FLR)	:	0.04 %
Unplanned Capability Loss Factor (UCL)	:	0.37 %
Planned Unavailability Factor (PUF)	:	41.75 %
Externally cause unavailability (XUF)	:	0.13 %
Total off-line time	:	3697 hours

Annual Summary



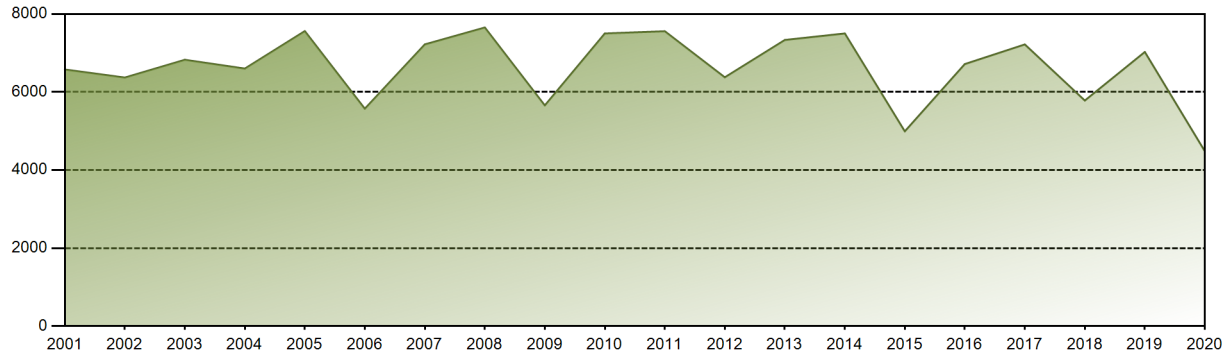
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	661.15	613.91	657.38	636.79	654.30	634.86	625.01	0.00	0.00	0.00	0.00	0.00	4483.41
EAF [%]	99.99	99.99	99.91	100.00	99.99	99.79	95.06	0.00	0.00	0.00	0.00	0.00	57.75
UCF [%]	99.99	99.99	99.91	100.00	99.99	99.99	96.40	0.00	0.00	0.00	0.00	0.00	57.88
LF [%]	101.21	100.46	100.63	100.73	100.16	100.43	95.68	0.00	0.00	0.00	0.00	0.00	58.13
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	96.64	0.00	0.00	0.00	0.00	0.00	57.91
FLR [%]	0.00	0.00	0.09	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.04
UCL [%]	0.00	0.00	0.09	0.00	0.00	0.00	0.17	0.00	4.29	0.00	0.00	0.00	0.37
PUF [%]	0.01	0.01	0.01	0.00	0.01	0.01	3.43	100.00	95.71	100.00	100.00	100.00	41.75
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.20	1.34	0.00	0.00	0.00	0.00	0.00	0.13

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Historical Summary

Lifetime energy generation	:	183258.61 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.94 %
Cumulative Energy Availability Factor (EAF)	:	85.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.87 %
Cumulative Unit Capability Factor (UCF)	:	86.12 %	Cumulative Planned Unavailability Factor (PUF)	:	9.01 %
Cumulative Load Factor (LF)	:	85.02 %	Cumulative Externally cause unavailability (XUF)	:	0.82 %
Cumulative Operating Factor (OF)	:	87.97 %			

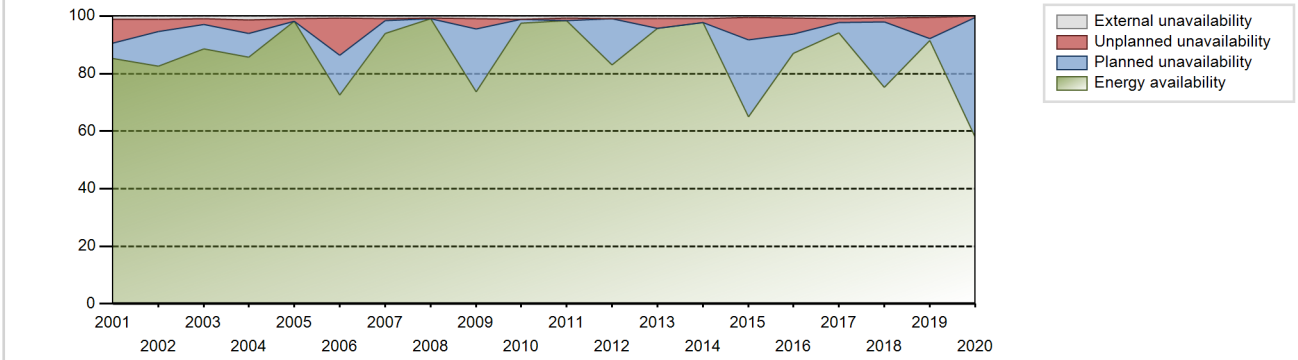
Electricity Production (net) [GWh]



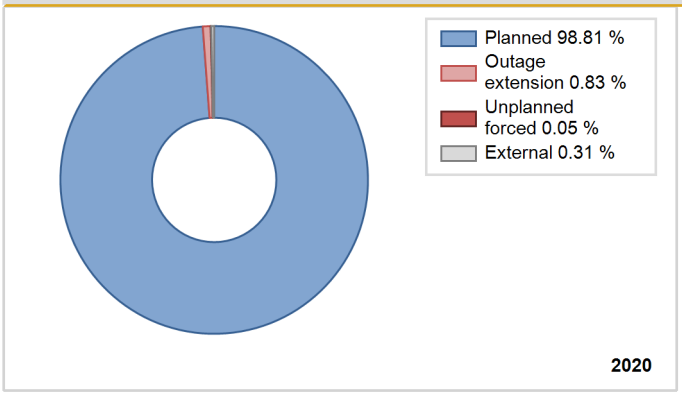
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	6003.39	7141	881	89.24	89.81	85.01	89.08	10.05	10.04	0.15	0.57
1994	6528.54	7642	881	85.26	85.64	84.59	87.24	2.11	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

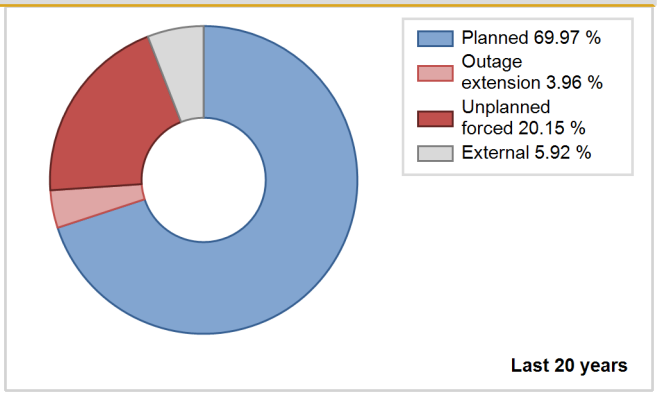
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1993 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		31			261	
C. Inspection, maintenance or repair combined with refuelling				71		
D. Inspection, maintenance or repair without refuelling	792			597		
E. Testing of plant systems or components					5	
G. Major backfitting, refurbishment or upgrading activities without refuelling	2875			103		
L. Human factor related					3	
Subtotal	3667	31		771	269	
Total	**3698**			**1040**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1993 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	31	23
12. Reactor I&C Systems		27
13. Reactor Auxiliary Systems		31
14. Safety Systems		3
15. Reactor Cooling Systems		43
16. Steam generation systems		14
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		19
31. Turbine and auxiliaries		57
32. Feedwater and Main Steam System		15
34. Miscellaneous Systems		9
35. All other I&C Systems		19
42. Electrical Power Supply Systems		8
Total	**31**	**269**

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Highlights (2020)

This unit entered into a long term Refurbishment on September 2020.

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2020 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

Reactor type and model	:	PHWR / CANDU 850
Thermal power	:	2776 MWth
Gross electrical power	:	934 MWe
Reference unit power (net)	:	878 MWe

Key Dates

Construction Date	:	1985-07-01
Grid Date	:	1993-04-17
Commercial Date	:	1993-06-14
Age at end of year	:	27 years

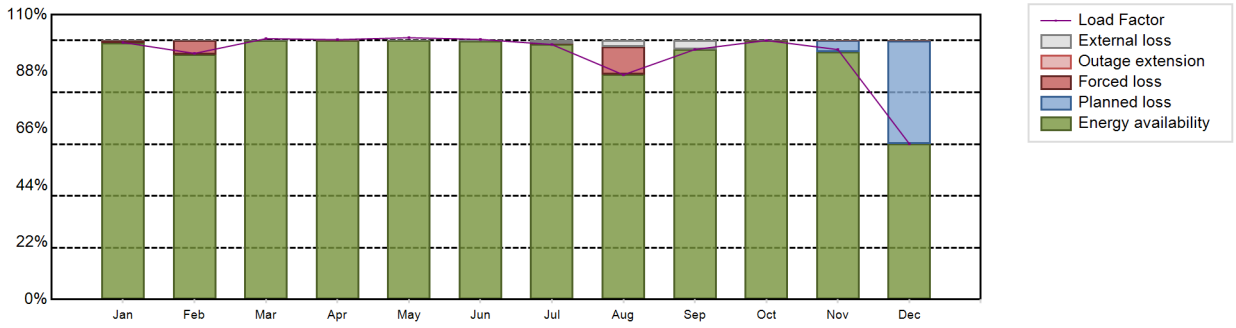
Design Characteristics

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 (2020)

Net Energy Production	:	7294.39 GW(e).h	Forced Loss Rate (FLR)	:	1.46 %
Energy Availability Factor (EAF)	:	94.26 %	Unplanned Capability Loss Factor (UCL)	:	1.41 %
Unit Capability Factor (UCF)	:	94.87 %	Planned Unavailability Factor (PUF)	:	3.72 %
Load Factor (LF)	:	94.58 %	Externally cause unavailability (XUF)	:	0.61 %
Operating Factor (OF)	:	100 %	Total off-line time	:	0 hours

Annual Summary



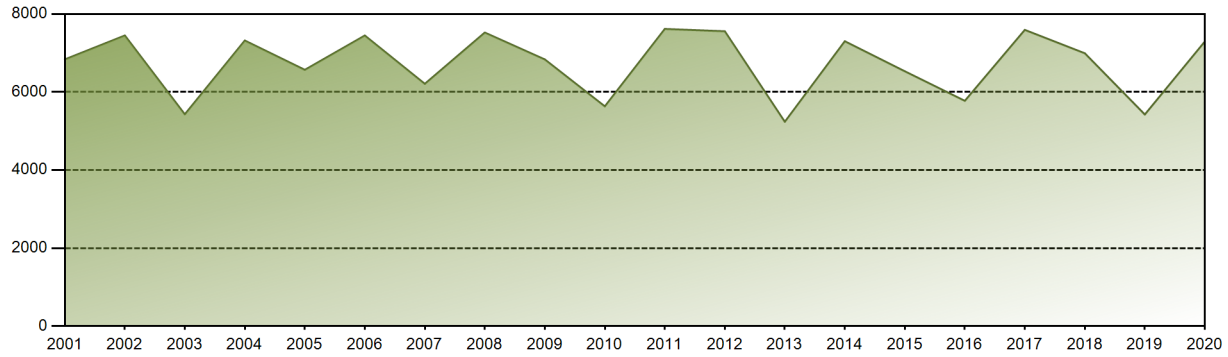
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	648.43	580.80	658.09	634.47	660.53	635.05	643.25	566.85	610.45	653.50	610.18	392.78	7294.39
EAF [%]	99.18	94.74	100.00	99.99	100.00	99.78	98.70	86.89	96.61	100.00	95.59	60.13	94.26
UCF [%]	99.18	94.74	100.00	99.99	100.00	100.00	99.95	89.35	100.00	100.00	95.59	60.13	94.87
LF [%]	99.27	95.04	100.74	100.37	101.12	100.46	98.47	86.78	96.57	100.04	96.52	60.13	94.58
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 [%]	0.82	5.26	0.00	0.01	0.00	0.00	0.05	10.65	0.00	0.00	0.00	0.27	1.46
UCL [%]	0.82	5.26	0.00	0.01	0.00	0.00	0.05	10.65	0.00	0.00	0.00	0.16	1.41
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.41	39.71	3.72
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.22	1.25	2.46	3.39	0.00	0.00	0.00	0.61

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Historical Summary

Lifetime energy generation	:	182991.91 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.94 %
Cumulative Energy Availability Factor (EAF)	:	85.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.92 %
Cumulative Unit Capability Factor (UCF)	:	86.55 %	Cumulative Planned Unavailability Factor (PUF)	:	8.52 %
Cumulative Load Factor (LF)	:	85.74 %	Cumulative Externally cause unavailability (XUF)	:	0.7 %
Cumulative Operating Factor (OF)	:	88.26 %			

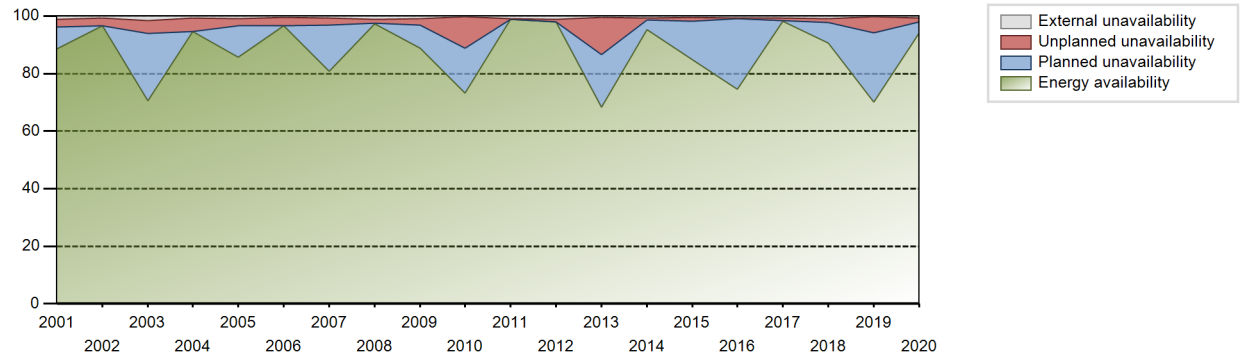
Electricity Production (net) [GWh]



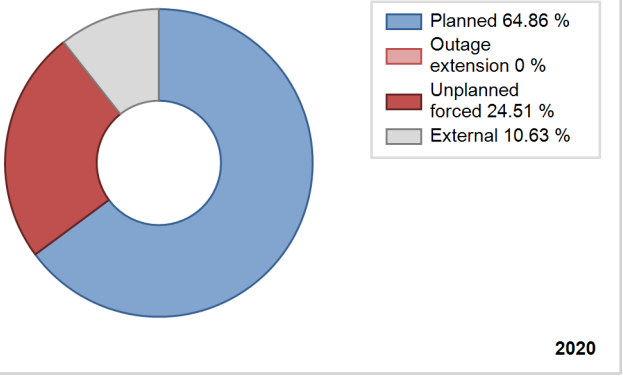
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	3528.78	4447	881	73.87	74.02	67.58	70.40	10.42	8.61	17.37	0.15
1994	7038.67	8143	881	91.85	92.19	91.20	92.96	3.36	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

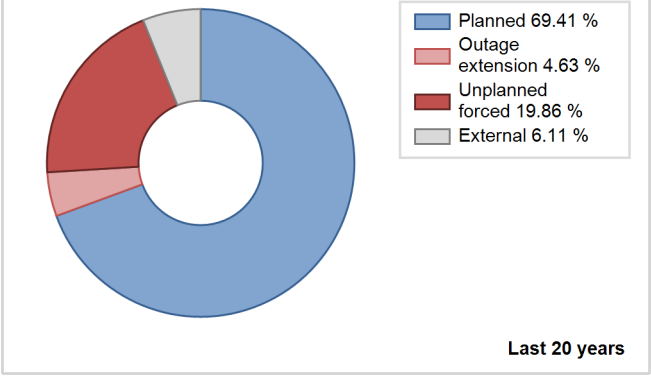
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1993 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					284	
C. Inspection, maintenance or repair combined with refuelling				95		
D. Inspection, maintenance or repair without refuelling				615		
E. Testing of plant systems or components				12	2	
J. Grid limitation, failure or grid unavailability						3
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
Z. Other					10	
Subtotal				722	296	4
Total		**0**			**1022**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1993 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		5
12. Reactor I&C Systems		40
13. Reactor Auxiliary Systems		7
14. Safety Systems		12
15. Reactor Cooling Systems		85
16. Steam generation systems		3
21. Fuel Handling and Storage Facilities		16
31. Turbine and auxiliaries		41
32. Feedwater and Main Steam System		8
33. Circulating Water System		6
34. Miscellaneous Systems		21
35. All other I&C Systems		2
41. Main Generator Systems		19
42. Electrical Power Supply Systems		32
Total		**297**

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2020 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

Reactor type and model	:	PHWR / CANDU 500A
Thermal power	:	1744 MWth
Gross electrical power	:	542 MWe
Reference unit power (net)	:	515 MWe

Key Dates

Construction Date	:	1966-06-01
Grid Date	:	1971-04-04
Commercial Date	:	1971-07-29
Age at end of year	:	49 years

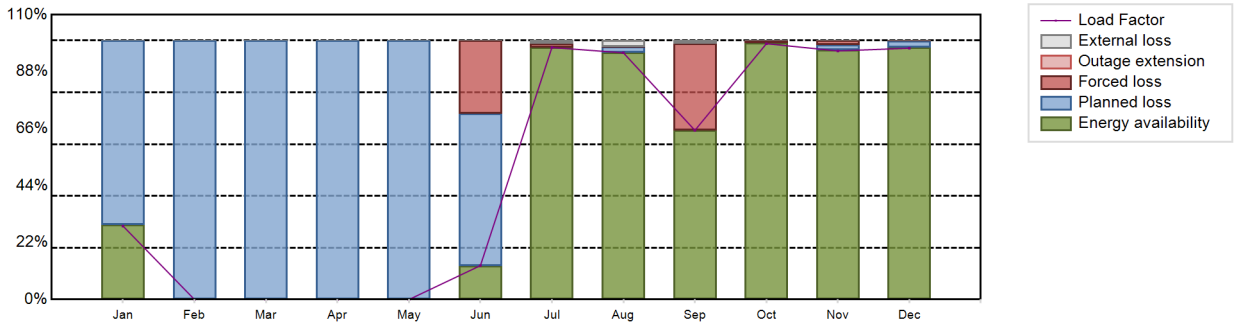
Design Characteristics

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	:	4680	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 (2020)

Net Energy Production	:	2244.06 GW(e).h	Forced Loss Rate (FLR)	:	9.73 %
Energy Availability Factor (EAF)	:	49.73 %	Unplanned Capability Loss Factor (UCL)	:	5.4 %
Unit Capability Factor (UCF)	:	50.11 %	Planned Unavailability Factor (PUF)	:	44.49 %
Load Factor (LF)	:	49.61 %	Externally cause unavailability (XUF)	:	0.38 %
Operating Factor (OF)	:	53.05 %	Total off-line time	:	4124 hours

Annual Summary



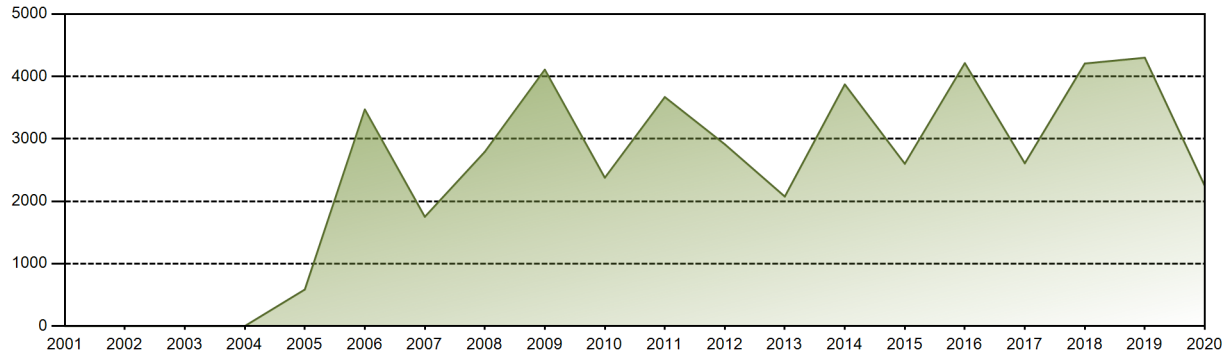
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	108.75	0.00	0.00	0.00	0.00	48.59	372.89	365.07	242.31	378.53	356.00	371.92	2244.06
EAF [%]	28.77	0.00	0.00	0.00	0.00	13.10	97.45	95.34	65.35	99.18	96.29	97.28	49.73
UCF [%]	28.77	0.00	0.00	0.00	0.00	13.10	98.59	97.60	66.50	99.18	96.29	97.28	50.11
LF [%]	28.38	0.00	0.00	0.00	0.00	13.10	97.32	95.28	65.35	98.79	96.01	97.07	49.61
OF [%]	28.76	0.00	0.00	0.00	0.00	27.36	100.00	100.00	76.81	100.00	100.00	100.00	53.05
FLR [%]	0.00	0.00	0.00	0.00	0.00	68.32	1.41	0.04	33.50	0.82	1.65	0.18	9.73
UCL [%]	0.00	0.00	0.00	0.00	0.00	28.25	1.41	0.04	33.50	0.82	1.62	0.18	5.40
PUF [%]	71.23	100.00	100.00	100.00	100.00	58.65	0.00	2.37	0.00	0.00	2.09	2.54	44.49
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	1.14	2.26	1.15	0.00	0.00	0.00	0.38

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Historical Summary

Lifetime energy generation	:	123572.37 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	24 %
Cumulative Energy Availability Factor (EAF)	:	67.4 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	22.42 %
Cumulative Unit Capability Factor (UCF)	:	67.63 %	Cumulative Planned Unavailability Factor (PUF)	:	9.95 %
Cumulative Load Factor (LF)	:	65.34 %	Cumulative Externally cause unavailability (XUF)	:	0.23 %
Cumulative Operating Factor (OF)	:	68.74 %			

Electricity Production (net) [GWh]

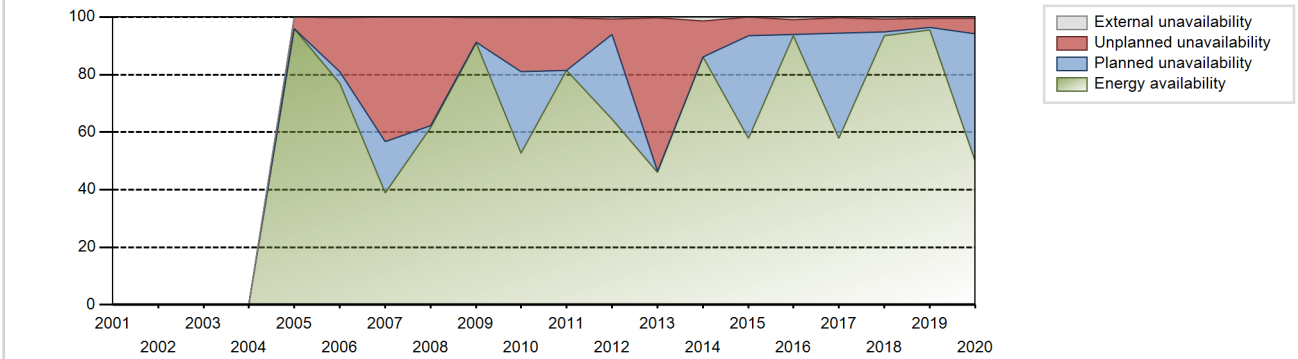


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1971	2302.30	4829	514	100.00	100.00	80.43	78.16	0.00	0.00	0.00	0.00
1972	2207.90	4117	514	100.00	100.00	48.90	46.87	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 - Long-term shutdown										
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

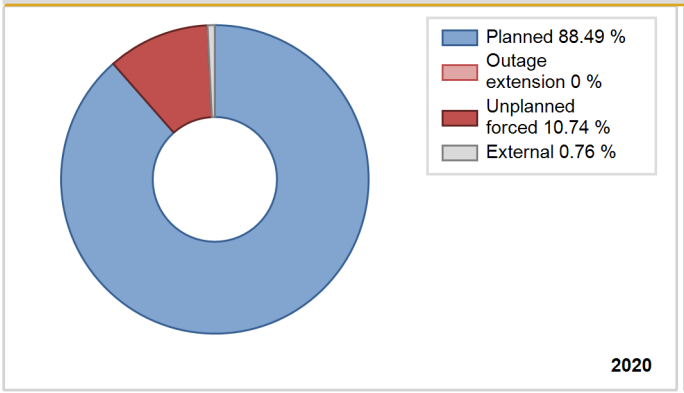
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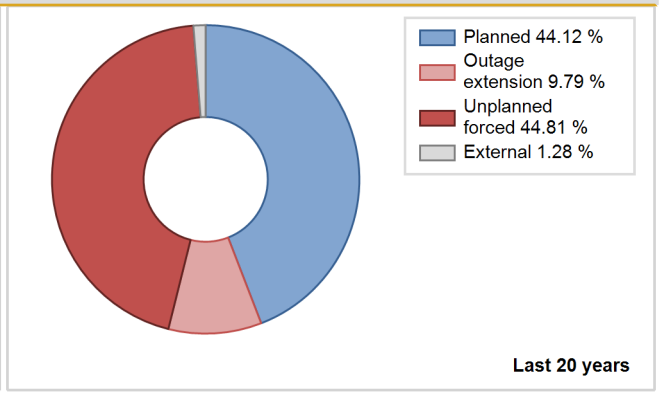
2008	2792.10	6221	515	61.72	61.78	61.72	70.82	37.71	37.70	0.52	0.06
2009	4108.77	8436	515	91.15	91.45	91.08	96.30	8.50	8.50	0.05	0.30
2010	2376.13	4983	515	52.73	52.90	52.67	56.88	22.60	18.82	28.28	0.17
2011	3669.17	7382	515	81.49	81.79	81.33	84.27	18.21	18.21	0.00	0.30
2012	2912.37	5799	515	64.48	65.11	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1971 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		335			1654	
D.	Inspection, maintenance or repair without refuelling	3789			880		
E.	Testing of plant systems or components				5	6	
J.	Grid limitation, failure or grid unavailability						1
L.	Human factor related					56	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						2
P.	Fire					34	
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.)						72
Z.	Other					11	
Subtotal		3789	335		885	1761	75
Total		**4124**			**2721**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1971 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		863
12. Reactor I&C Systems		70
13. Reactor Auxiliary Systems		61
14. Safety Systems		59
15. Reactor Cooling Systems		140
16. Steam generation systems		60
21. Fuel Handling and Storage Facilities	167	76
31. Turbine and auxiliaries	168	119
32. Feedwater and Main Steam System		50
33. Circulating Water System		2
34. Miscellaneous Systems		10
35. All other I&C Systems		7
41. Main Generator Systems		50
42. Electrical Power Supply Systems		116
Total	**335**	**1683**

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2020 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

Reactor type and model	:	PHWR / CANDU 500A
Thermal power	:	1744 MWth
Gross electrical power	:	542 MWe
Reference unit power (net)	:	515 MWe

Key Dates

Construction Date	:	1968-05-01
Grid Date	:	1973-05-21
Commercial Date	:	1973-06-17
Age at end of year	:	47 years

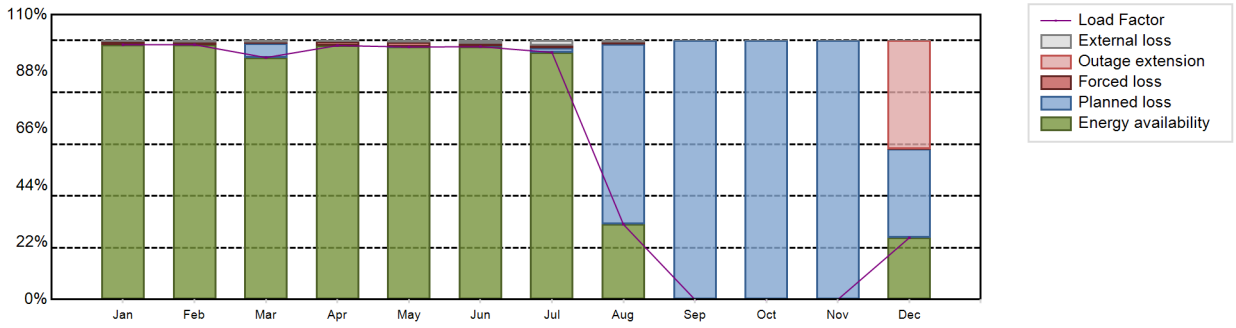
Design Characteristics

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 (2020)

Net Energy Production	:	2755.54 GW(e).h	Forced Loss Rate (FLR)	:	1.2 %
Energy Availability Factor (EAF)	:	60.92 %	Unplanned Capability Loss Factor (UCL)	:	4.29 %
Unit Capability Factor (UCF)	:	61.42 %	Planned Unavailability Factor (PUF)	:	34.29 %
Load Factor (LF)	:	60.91 %	Externally cause unavailability (XUF)	:	0.5 %
Operating Factor (OF)	:	63.24 %	Total off-line time	:	3229 hours

Annual Summary



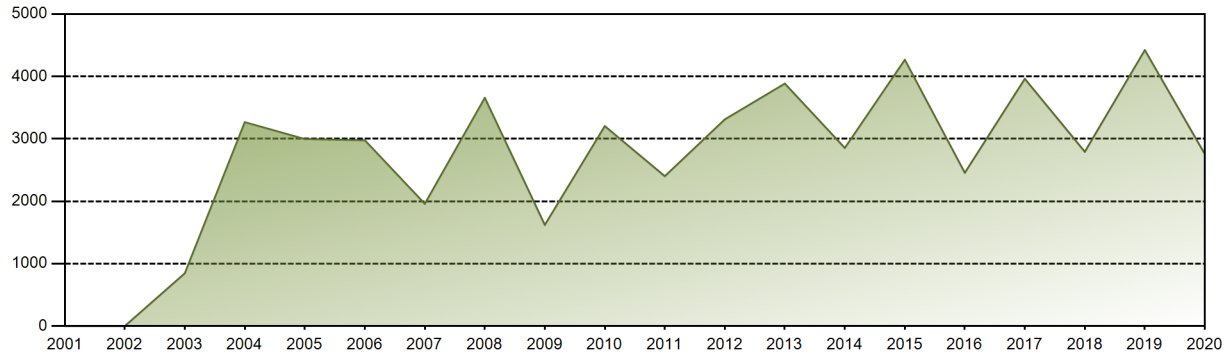
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	377.15	352.81	358.01	363.69	373.62	362.01	365.70	111.20	0.00	0.00	0.00	91.36	2755.54
EAF [%]	98.43	98.43	93.44	98.08	97.51	97.63	95.44	29.02	0.00	0.00	0.00	23.97	60.92
UCF [%]	98.90	98.95	93.95	98.45	98.04	98.65	97.26	29.77	0.00	0.00	0.00	23.97	61.42
LF [%]	98.43	98.43	93.44	98.08	97.51	97.63	95.44	29.02	0.00	0.00	0.00	23.84	60.91
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	32.12	0.00	0.00	0.00	27.42	63.24
FLR [%]	1.10	1.05	0.61	1.55	1.87	1.04	1.13	2.08	0.00	0.00	0.00	0.31	1.20
UCL [%]	1.10	1.05	0.58	1.55	1.86	1.03	1.11	0.63	0.00	0.00	0.00	41.85	4.29
PUF [%]	0.00	0.00	5.48	0.00	0.09	0.31	1.63	69.60	100.00	100.00	100.00	34.18	34.29
XUF [%]	0.47	0.52	0.51	0.37	0.53	1.03	1.81	0.75	0.00	0.00	0.00	0.00	0.50

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Historical Summary

Lifetime energy generation	:	127546.68 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	17.79 %
Cumulative Energy Availability Factor (EAF)	:	67.52 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	16.01 %
Cumulative Unit Capability Factor (UCF)	:	67.91 %	Cumulative Planned Unavailability Factor (PUF)	:	16.08 %
Cumulative Load Factor (LF)	:	67.38 %	Cumulative Externally cause unavailability (XUF)	:	0.39 %
Cumulative Operating Factor (OF)	:	70.47 %			

Electricity Production (net) [GWh]

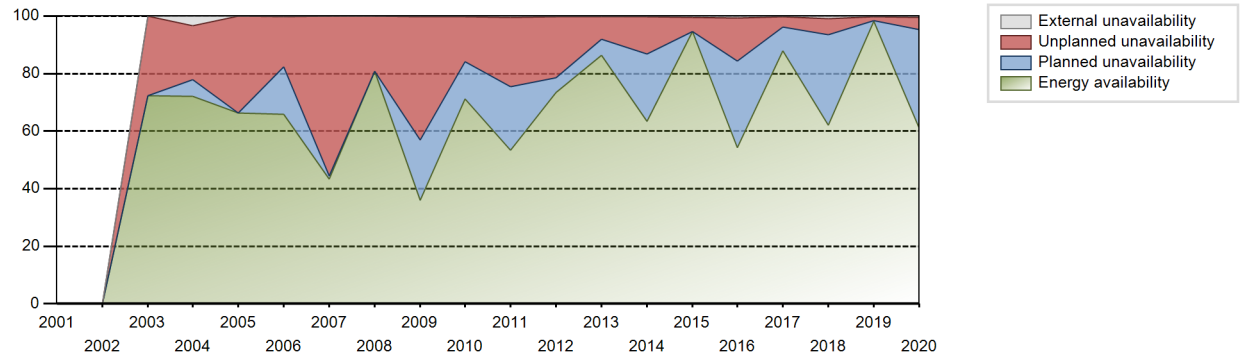


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	2226.60	4402	514	90.59	90.59	90.40	91.75	6.12	5.91	3.50	0.00
1974	4221.00	8356	514	94.00	94.00	94.00	95.65	5.22	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 - Long-term shutdown										
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

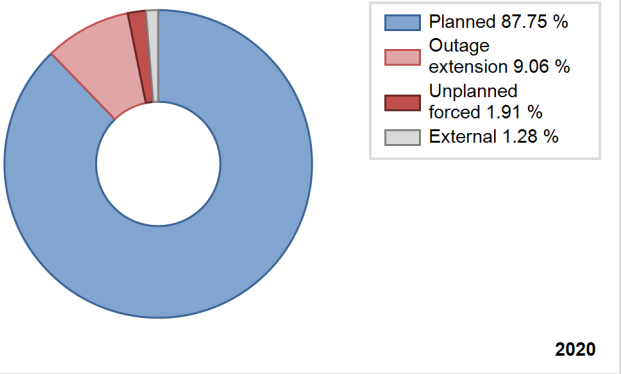
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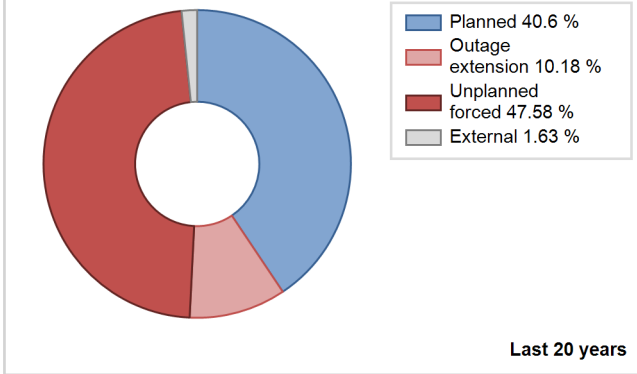
2010	3203.51	6583	515	71.13	71.37	71.01	75.15	17.89	15.55	13.08	0.24
2011	2401.12	4919	515	53.28	53.66	53.22	56.15	29.34	24.15	22.18	0.38
2012	3310.83	6592	515	73.42	73.73	73.19	75.05	20.62	21.17	5.10	0.31
2013	3884.54	7798	515	86.29	86.60	86.10	89.02	7.00	7.76	5.64	0.31
2014	2853.53	5772	515	63.30	63.49	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		311			1153	
C.	Inspection, maintenance or repair combined with refuelling				63		
D.	Inspection, maintenance or repair without refuelling	2919			1291		
E.	Testing of plant systems or components				54		
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					7	
Subtotal		2919	311		1408	1163	17
Total		**3230**			**2588**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		57
12. Reactor I&C Systems		135
13. Reactor Auxiliary Systems		151
14. Safety Systems		17
15. Reactor Cooling Systems		429
16. Steam generation systems		39
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries	311	111
32. Feedwater and Main Steam System		28
34. Miscellaneous Systems		16
35. All other I&C Systems		5
41. Main Generator Systems		45
42. Electrical Power Supply Systems		106
Total	**311**	**1148**

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2020 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

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	:	1974-11-01
Grid Date	:	1982-12-19
Commercial Date	:	1983-05-10
Age at end of year	:	38 years

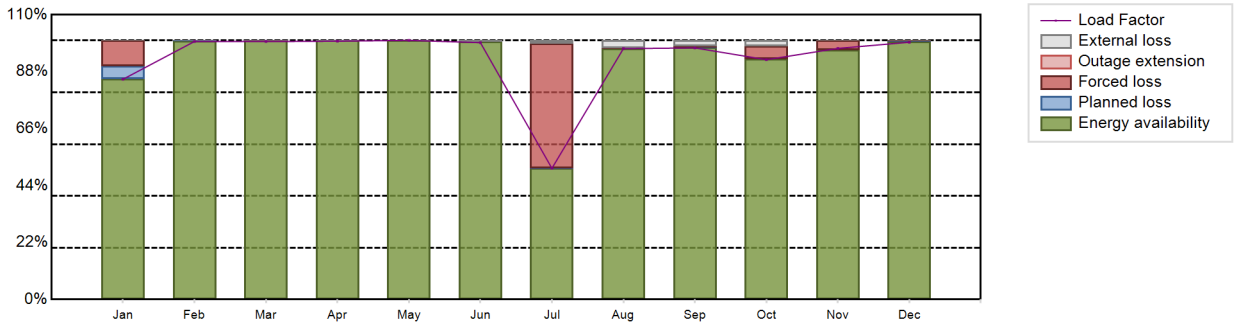
Design Characteristics

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 (2020)

Net Energy Production	:	4215.36 GW(e).h	Forced Loss Rate (FLR)	:	5.72 %
Energy Availability Factor (EAF)	:	93.12 %	Unplanned Capability Loss Factor (UCL)	:	5.7 %
Unit Capability Factor (UCF)	:	93.85 %	Planned Unavailability Factor (PUF)	:	0.45 %
Load Factor (LF)	:	93 %	Externally cause unavailability (XUF)	:	0.73 %
Operating Factor (OF)	:	96.99 %	Total off-line time	:	264 hours

Annual Summary



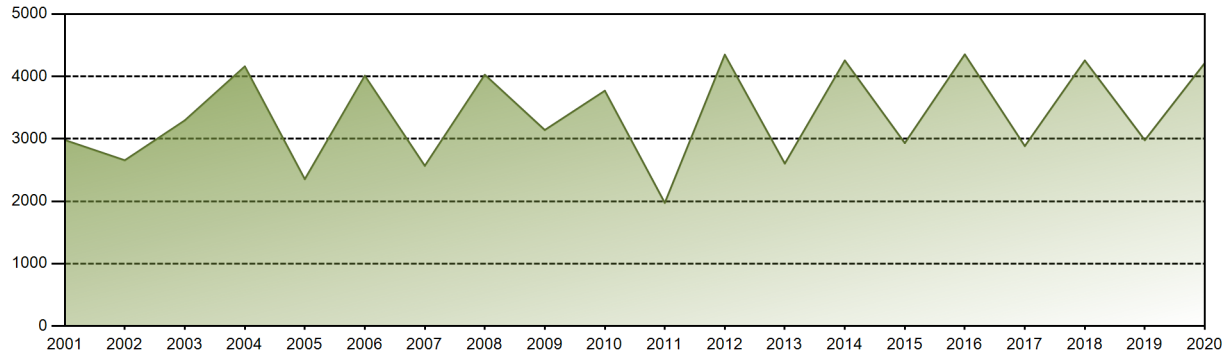
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	326.61	357.91	382.47	370.70	384.25	368.55	194.52	372.04	361.03	355.56	360.30	381.42	4215.36
EAF [%]	85.11	99.93	99.99	100.00	100.00	99.55	50.69	96.99	97.35	92.85	96.38	99.71	93.12
UCF [%]	85.11	99.93	99.99	100.00	100.00	100.00	51.91	99.96	99.40	94.86	96.38	99.71	93.85
LF [%]	85.08	99.66	99.63	99.78	100.09	99.20	50.67	96.91	97.18	92.62	96.98	99.35	93.00
OF [%]	92.74	100.00	100.00	100.00	100.00	100.00	71.77	100.00	100.00	100.00	100.00	100.00	96.99
FLR [%]	10.32	0.00	0.01	0.00	0.00	0.00	48.09	0.04	0.59	5.14	3.62	0.10	5.72
UCL [%]	9.79	0.00	0.01	0.00	0.00	0.00	48.08	0.04	0.59	5.14	3.62	0.10	5.70
PUF [%]	5.10	0.07	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.19	0.45
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.45	1.21	2.97	2.05	2.01	0.00	0.00	0.73

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Historical Summary

Lifetime energy generation	:	127240.42 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	12.13 %
Cumulative Energy Availability Factor (EAF)	:	74.67 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.85 %
Cumulative Unit Capability Factor (UCF)	:	75.37 %	Cumulative Planned Unavailability Factor (PUF)	:	12.78 %
Cumulative Load Factor (LF)	:	74.43 %	Cumulative Externally cause unavailability (XUF)	:	0.7 %
Cumulative Operating Factor (OF)	:	78.29 %			

Electricity Production (net) [GWh]

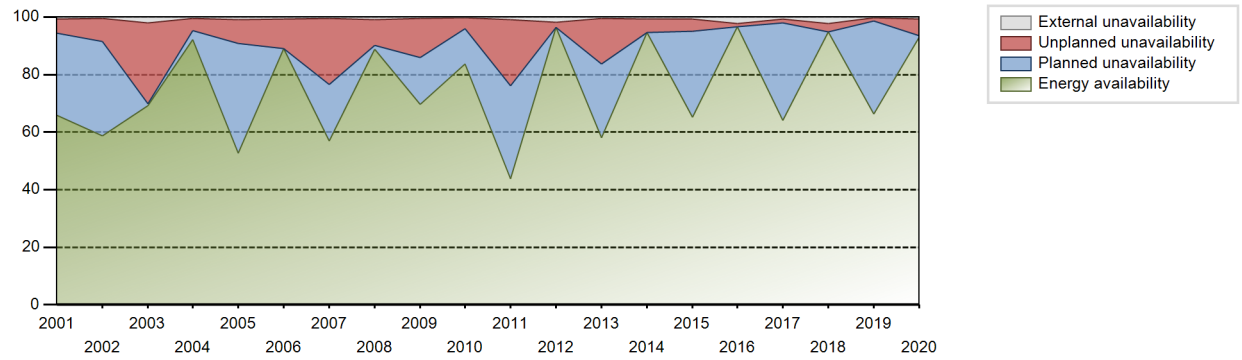


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	3202.40	6968	516	90.29	90.29	89.64	92.62	9.69	9.69	0.02	0.00
1984	3517.52	7035	516	77.75	77.75	77.61	80.09	11.82	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

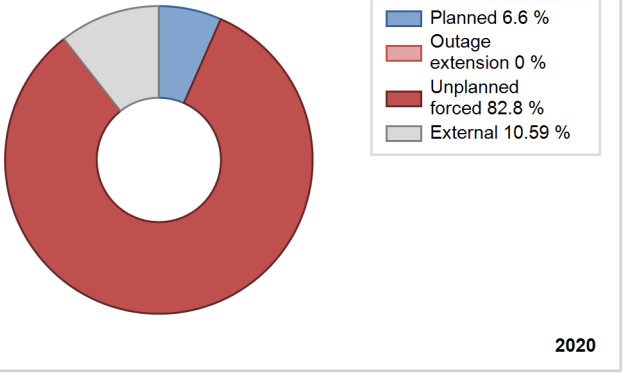
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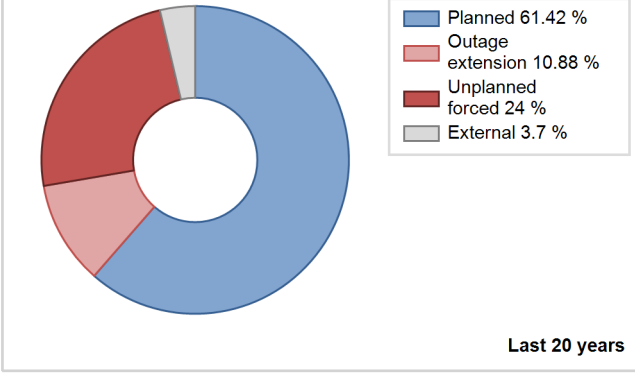
2020	4215.36	8520	516	93.12	93.85	93.00	96.99	5.72	5.70	0.45	0.73

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1983 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		264			778	
D. Inspection, maintenance or repair without refuelling				1031		
E. Testing of plant systems or components				0	2	
L. Human factor related					50	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						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.)						15
Z. Other				25	20	
Subtotal		264		1056	850	21
Total		**264**			**1927**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		55
12. Reactor I&C Systems		64
13. Reactor Auxiliary Systems		52
14. Safety Systems		17
15. Reactor Cooling Systems		112
16. Steam generation systems		259
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries	264	44
32. Feedwater and Main Steam System		8
33. Circulating Water System		9
35. All other I&C Systems		7
41. Main Generator Systems		82
42. Electrical Power Supply Systems		82
Total	**264**	**795**

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2020 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	:	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

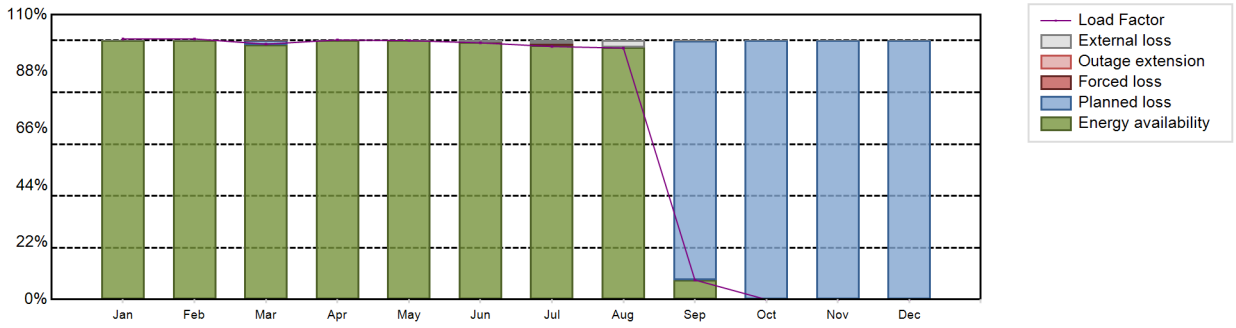
Operating coolant pressure [MPa]	:	9
Reactor outlet temperature [°C]	:	293.4
Number of SG	:	12
Containment type	:	-
Containment design pressure [MPa]	:	1.46
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	3027.01 GW(e).h
Energy Availability Factor (EAF)	:	66.72 %
Unit Capability Factor (UCF)	:	67.1 %
Load Factor (LF)	:	66.78 %
Operating Factor (OF)	:	67.37 %

Forced Loss Rate (FLR)	:	0.07 %
Unplanned Capability Loss Factor (UCL)	:	0.05 %
Planned Unavailability Factor (PUF)	:	32.85 %
Externally cause unavailability (XUF)	:	0.39 %
Total off-line time	:	2866 hours

Annual Summary



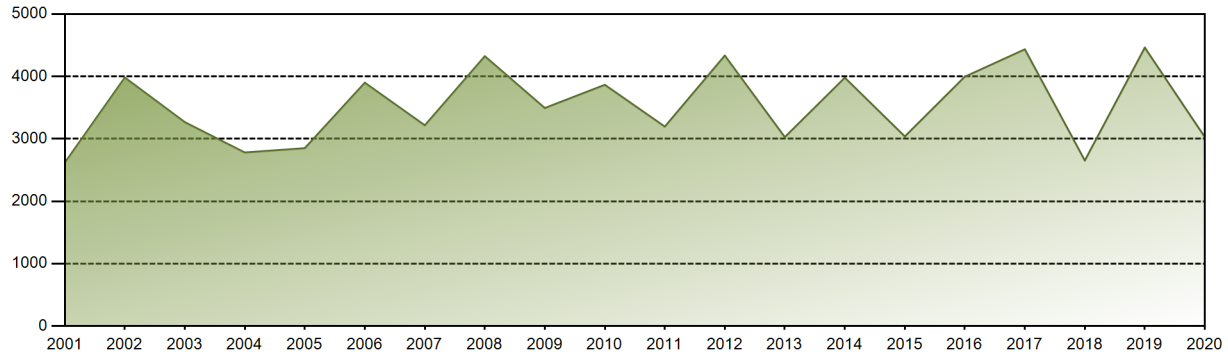
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	386.36	361.46	378.65	372.44	383.89	368.29	375.06	372.83	28.03	0.00	0.00	0.00	3027.01
EAF [%]	100.00	100.00	98.31	100.00	100.00	99.44	98.23	97.29	7.54	0.00	0.00	0.00	66.72
UCF [%]	100.00	100.00	98.31	100.00	100.00	99.99	99.47	100.00	7.63	0.00	0.00	0.00	67.10
LF [%]	100.64	100.65	98.63	100.25	100.00	99.13	97.70	97.11	7.54	0.00	0.00	0.00	66.78
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	8.61	0.00	0.00	0.00	67.37
FLR [%]	0.00	0.00	0.01	0.00	0.00	0.01	0.53	0.00	0.00	0.00	0.00	0.00	0.07
UCL [%]	0.00	0.00	0.01	0.00	0.00	0.01	0.53	0.00	0.00	0.00	0.00	0.00	0.05
PUF [%]	0.00	0.00	1.68	0.00	0.00	0.00	0.00	0.00	92.37	100.00	100.00	100.00	32.85
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.55	1.24	2.71	0.09	0.00	0.00	0.00	0.39

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Historical Summary

Lifetime energy generation	:	131013.02 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	8.99 %
Cumulative Energy Availability Factor (EAF)	:	78.2 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.35 %
Cumulative Unit Capability Factor (UCF)	:	78.91 %	Cumulative Planned Unavailability Factor (PUF)	:	12.74 %
Cumulative Load Factor (LF)	:	78.15 %	Cumulative Externally cause unavailability (XUF)	:	0.71 %
Cumulative Operating Factor (OF)	:	80.94 %			

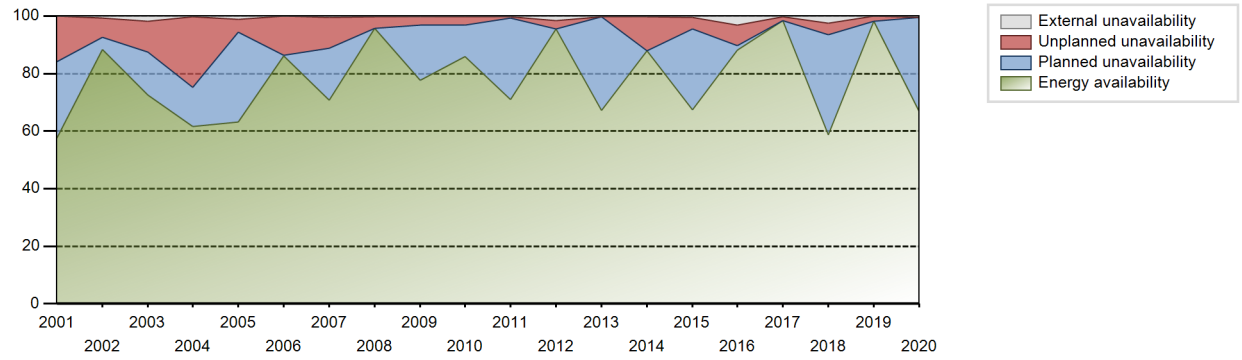
Electricity Production (net) [GWh]



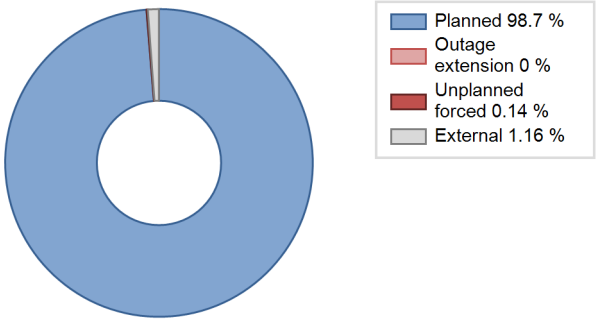
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	3816.08	7636	516	86.09	86.09	85.88	87.66	13.78	13.76	0.16	0.00
1985	3289.09	6540	516	73.11	79.48	72.76	74.66	6.72	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

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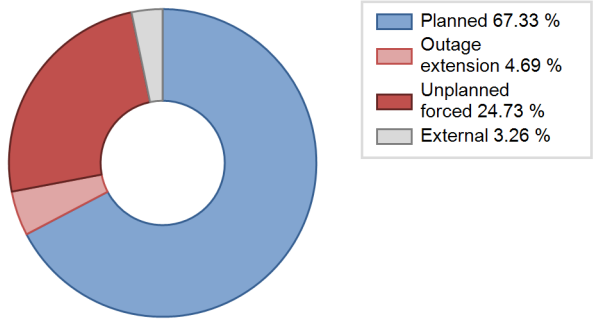
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					518	
C. Inspection, maintenance or repair combined with refuelling				81		
D. Inspection, maintenance or repair without refuelling	2866			1002		
E. Testing of plant systems or components				0	3	
J. Grid limitation, failure or grid unavailability						17
L. Human factor related					36	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						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.)						16
Z. Other					2	
Subtotal	2866			1083	559	42
Total	**2866**			**1684**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		56
12. Reactor I&C Systems		47
13. Reactor Auxiliary Systems		29
14. Safety Systems		38
15. Reactor Cooling Systems		47
16. Steam generation systems		99
21. Fuel Handling and Storage Facilities		13
31. Turbine and auxiliaries		53
32. Feedwater and Main Steam System		34
33. Circulating Water System		13
34. Miscellaneous Systems		20
35. All other I&C Systems		5
41. Main Generator Systems		64
42. Electrical Power Supply Systems		22
Total		**540**

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2020 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

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	:	1976-03-01
Grid Date	:	1984-11-17
Commercial Date	:	1985-01-01
Age at end of year	:	36 years

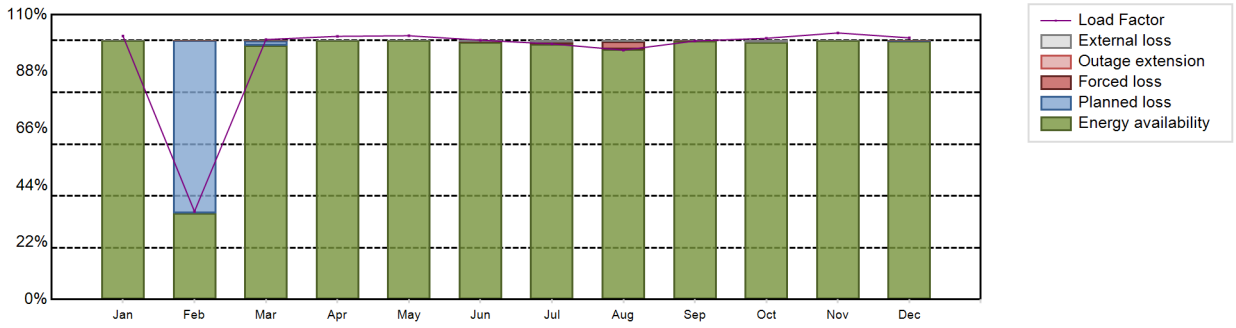
Design Characteristics

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 (2020)

Net Energy Production	:	4316.41 GW(e).h	Forced Loss Rate (FLR)	:	0.35 %
Energy Availability Factor (EAF)	:	94.04 %	Unplanned Capability Loss Factor (UCL)	:	0.33 %
Unit Capability Factor (UCF)	:	94.2 %	Planned Unavailability Factor (PUF)	:	5.47 %
Load Factor (LF)	:	95.23 %	Externally cause unavailability (XUF)	:	0.15 %
Operating Factor (OF)	:	94.73 %	Total off-line time	:	463 hours

Annual Summary



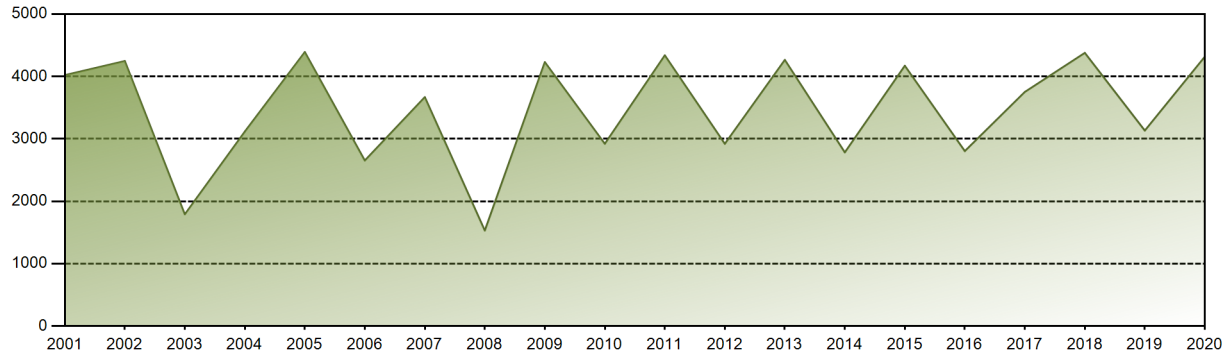
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	390.56	122.16	385.42	377.68	391.06	372.15	378.98	369.76	370.89	387.33	382.48	387.95	4316.41
EAF [%]	100.00	33.34	98.05	100.00	100.00	99.30	98.55	96.73	99.98	99.44	100.00	99.98	94.04
UCF [%]	100.00	33.34	98.05	100.00	100.00	99.64	99.14	97.06	99.98	100.00	100.00	99.98	94.20
LF [%]	101.73	34.01	100.39	101.66	101.86	100.17	98.72	96.32	99.83	100.89	102.95	101.05	95.23
OF [%]	100.00	33.48	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.73
FLR [%]	0.00	0.02	0.02	0.00	0.00	0.01	0.86	2.94	0.02	0.00	0.00	0.02	0.35
UCL [%]	0.00	0.01	0.02	0.00	0.00	0.01	0.86	2.94	0.02	0.00	0.00	0.02	0.33
PUF [%]	0.00	66.66	1.93	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	5.47
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.34	0.59	0.33	0.00	0.56	0.00	0.00	0.15

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Historical Summary

Lifetime energy generation	:	127628.6 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	10.42 %
Cumulative Energy Availability Factor (EAF)	:	78.36 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	10.05 %
Cumulative Unit Capability Factor (UCF)	:	78.97 %	Cumulative Planned Unavailability Factor (PUF)	:	10.97 %
Cumulative Load Factor (LF)	:	78.15 %	Cumulative Externally cause unavailability (XUF)	:	0.61 %
Cumulative Operating Factor (OF)	:	81.14 %			

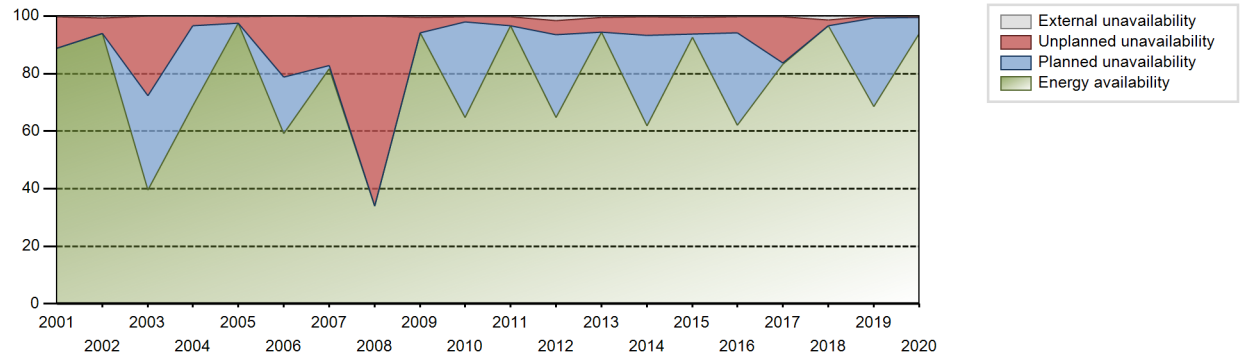
Electricity Production (net) [GWh]



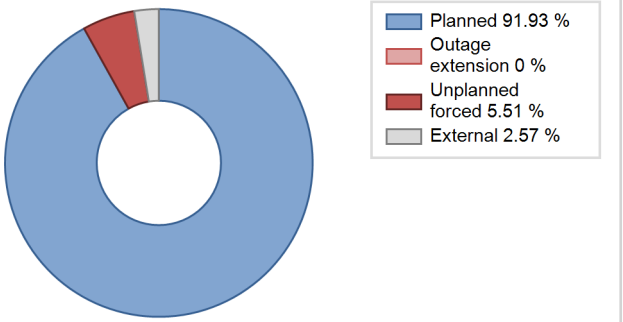
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	4093.95	8277	516	92.65	99.03	90.57	94.49	0.86	0.86	0.11	6.39
1986	3373.30	7002	516	75.20	75.45	74.63	79.93	8.27	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

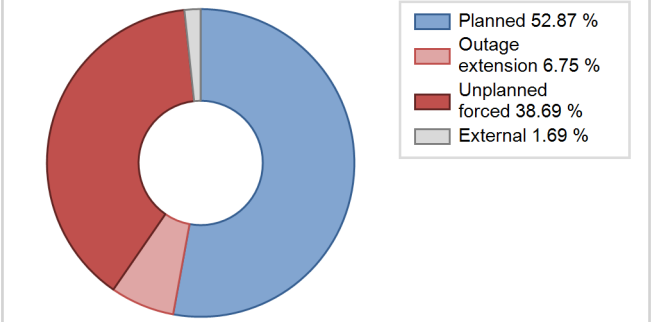
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					554	
D. Inspection, maintenance or repair without refuelling	463			925		
E. Testing of plant systems or components				1	9	
J. Grid limitation, failure or grid unavailability						3
L. Human factor related					118	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						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					33	
Subtotal	463			926	714	20
Total	**463**			**1660**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		98
12. Reactor I&C Systems		56
13. Reactor Auxiliary Systems		14
14. Safety Systems		32
15. Reactor Cooling Systems		87
16. Steam generation systems		56
21. Fuel Handling and Storage Facilities		22
31. Turbine and auxiliaries		34
32. Feedwater and Main Steam System		19
33. Circulating Water System		13
34. Miscellaneous Systems		45
41. Main Generator Systems		67
42. Electrical Power Supply Systems		49
Total		**592**

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2020 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	:	34 years

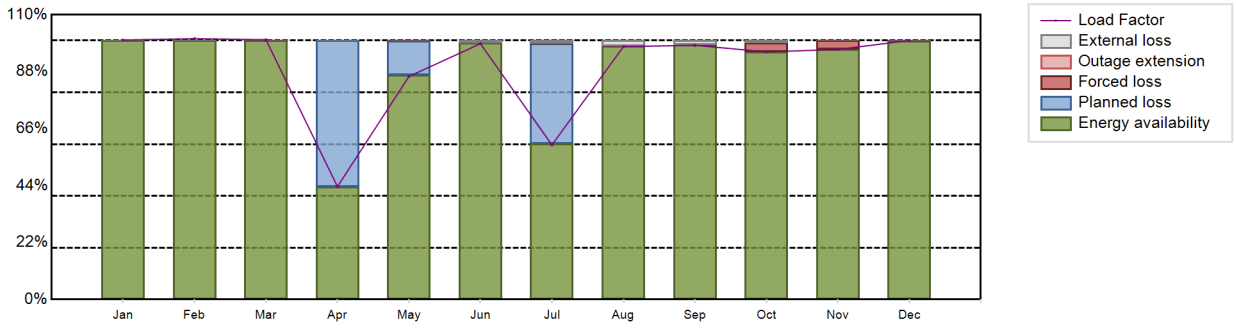
Design Characteristics

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 (2020)

Net Energy Production	:	4070.63 GW(e).h	Forced Loss Rate (FLR)	:	0.65 %
Energy Availability Factor (EAF)	:	89.87 %	Unplanned Capability Loss Factor (UCL)	:	0.59 %
Unit Capability Factor (UCF)	:	90.41 %	Planned Unavailability Factor (PUF)	:	9 %
Load Factor (LF)	:	89.81 %	Externally cause unavailability (XUF)	:	0.54 %
Operating Factor (OF)	:	91.33 %	Total off-line time	:	762 hours

Annual Summary



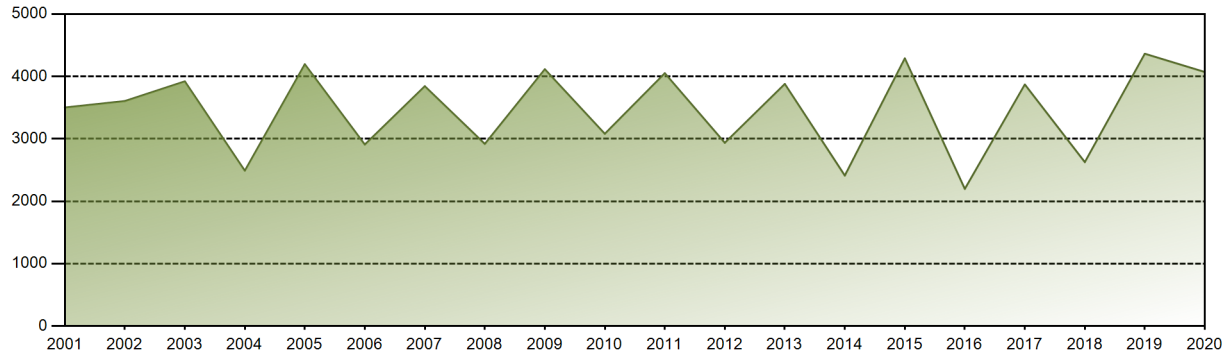
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	384.77	361.79	385.27	162.03	330.72	367.10	229.15	375.00	364.78	367.16	358.76	384.09	4070.63
EAF [%]	100.00	100.00	99.99	43.64	86.73	99.23	60.23	97.81	98.44	95.74	96.55	99.98	89.87
UCF [%]	100.00	100.00	99.99	43.64	86.73	100.00	61.27	99.99	99.96	96.71	96.55	99.98	90.41
LF [%]	100.23	100.74	100.36	43.61	86.15	98.81	59.69	97.68	98.19	95.64	96.56	100.05	89.81
OF [%]	100.00	100.00	100.00	43.61	89.25	100.00	62.90	100.00	100.00	100.00	100.00	100.00	91.33
FLR [%]	0.00	0.00	0.01	0.00	0.25	0.00	0.06	0.01	0.04	3.29	3.45	0.02	0.65
UCL [%]	0.00	0.00	0.01	0.00	0.21	0.00	0.04	0.01	0.04	3.29	3.45	0.02	0.59
PUF [%]	0.00	0.00	0.00	56.36	13.06	0.00	38.69	0.00	0.00	0.00	0.00	0.00	9.00
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.77	1.04	2.18	1.53	0.97	0.00	0.00	0.54

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Historical Summary

Lifetime energy generation	:	119937.68 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.98 %
Cumulative Energy Availability Factor (EAF)	:	76.14 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.43 %
Cumulative Unit Capability Factor (UCF)	:	76.77 %	Cumulative Planned Unavailability Factor (PUF)	:	13.8 %
Cumulative Load Factor (LF)	:	76 %	Cumulative Externally cause unavailability (XUF)	:	0.62 %
Cumulative Operating Factor (OF)	:	79.37 %			

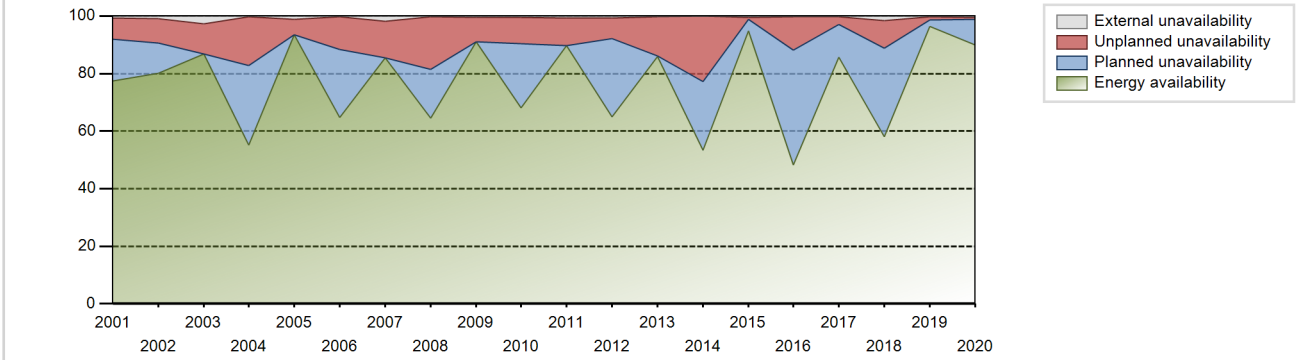
Electricity Production (net) [GWh]



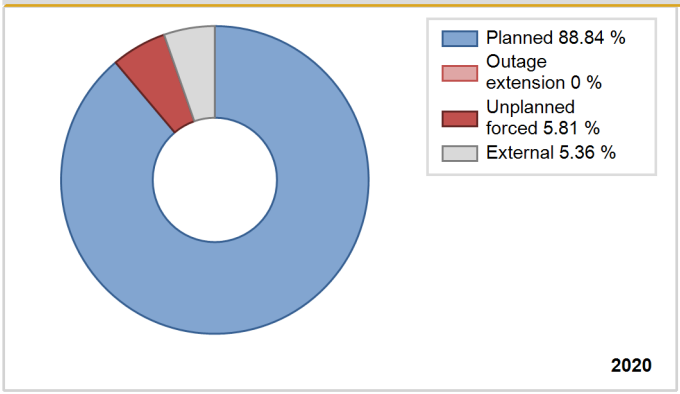
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	3792.31	8086	516	96.32	96.67	95.69	97.69	3.33	3.33	0.00	0.35
1987	3759.36	7585	516	83.31	84.70	83.17	86.59	2.09	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

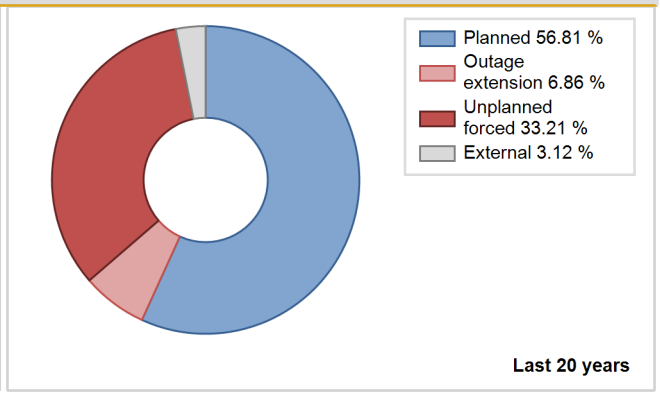
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					464	
C. Inspection, maintenance or repair combined with refuelling				76		
D. Inspection, maintenance or repair without refuelling	762			950		
E. Testing of plant systems or components				1		
J. Grid limitation, failure or grid unavailability						4
L. Human factor related					303	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						9
Z. Other					1	
Subtotal	762			1027	768	13
Total	**762**			**1808**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		34
12. Reactor I&C Systems		34
13. Reactor Auxiliary Systems		3
14. Safety Systems		37
15. Reactor Cooling Systems		85
16. Steam generation systems		30
21. Fuel Handling and Storage Facilities		96
31. Turbine and auxiliaries		48
32. Feedwater and Main Steam System		27
33. Circulating Water System		23
34. Miscellaneous Systems		13
35. All other I&C Systems		1
41. Main Generator Systems		10
42. Electrical Power Supply Systems		30
Total		**471**

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2020 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	:	38 years

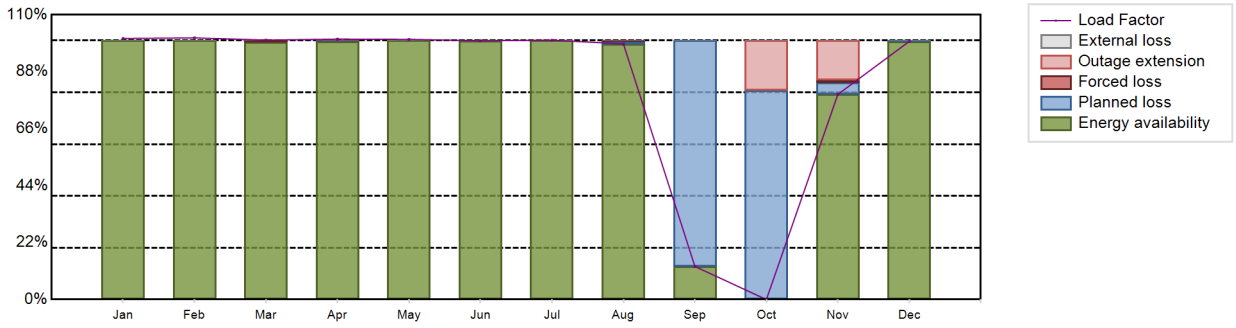
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	11.55
Reactor vessel centreline orientation	:	Horizontal	Reactor outlet temperature [°C]	:	310
Fuel material	:	UO2	Number of SG	:	4
Refuelling type	:	ON-line	Containment type	:	-
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.3
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]	:	8000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	6.28	HP cylinder inlet steam pressure [MPa]	:	4.64
Active core height/length [m]	:	5.94	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	4560	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	59.5	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 (2020)

Net Energy Production	:	4801 GW(e).h	Forced Loss Rate (FLR)	:	0.23 %
Energy Availability Factor (EAF)	:	82.46 %	Unplanned Capability Loss Factor (UCL)	:	3.08 %
Unit Capability Factor (UCF)	:	82.46 %	Planned Unavailability Factor (PUF)	:	14.45 %
Load Factor (LF)	:	82.81 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	83.13 %	Total off-line time	:	1482 hours

Annual Summary



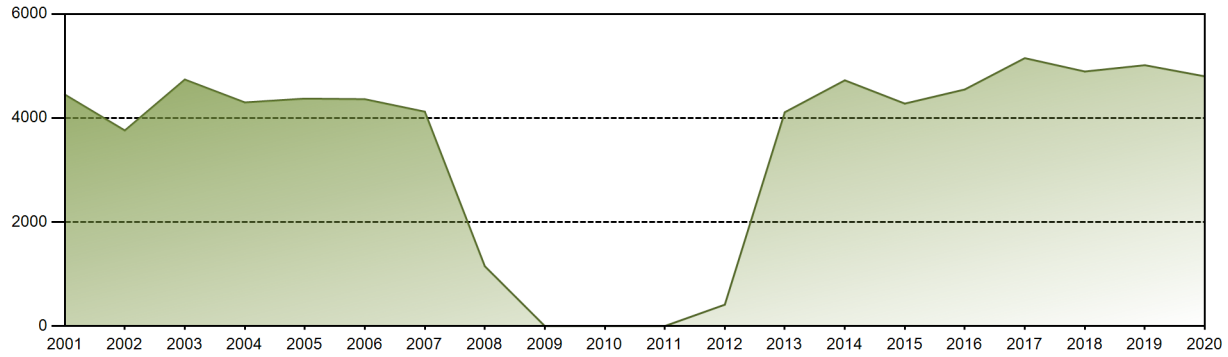
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	495.10	464.18	491.97	477.90	493.41	474.95	491.83	484.75	60.72	0.00	376.56	489.63	4801.00
EAF [%]	100.00	100.00	99.39	99.68	100.00	99.95	100.00	98.72	12.78	0.00	79.24	99.71	82.46
UCF [%]	100.00	100.00	99.39	99.68	100.00	99.95	100.00	98.72	12.78	0.00	79.24	99.71	82.46
LF [%]	100.83	101.05	100.19	100.57	100.48	99.95	100.16	98.72	12.78	0.00	79.24	99.71	82.81
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	12.78	0.00	84.72	100.00	83.13
FLR [%]	0.00	0.00	0.61	0.18	0.00	0.00	0.00	0.46	0.00	0.00	1.27	0.00	0.23
UCL [%]	0.00	0.00	0.61	0.18	0.00	0.00	0.00	0.46	0.00	19.35	16.30	0.00	3.08
PUF [%]	0.00	0.00	0.00	0.14	0.00	0.05	0.00	0.82	87.22	80.65	4.46	0.29	14.45
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

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Historical Summary

Lifetime energy generation	:	152874.84 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.81 %
Cumulative Energy Availability Factor (EAF)	:	72.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.4 %
Cumulative Unit Capability Factor (UCF)	:	73.06 %	Cumulative Planned Unavailability Factor (PUF)	:	20.55 %
Cumulative Load Factor (LF)	:	71.67 %	Cumulative Externally cause unavailability (XUF)	:	0.76 %
Cumulative Operating Factor (OF)	:	74.41 %			

Electricity Production (net) [GWh]

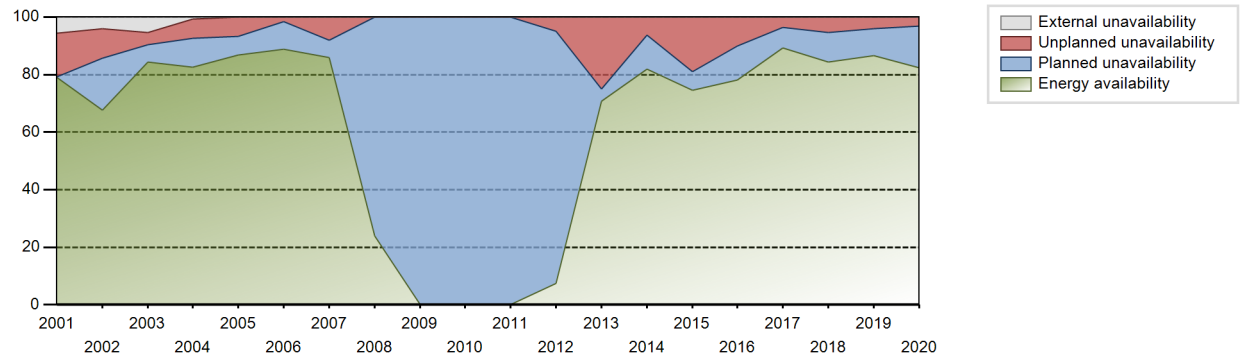


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	4742.90	7875	640	86.03	86.03	85.85	89.37	8.10	7.58	6.39	0.00
1984	5000.94	7927	635	88.94	88.97	89.66	90.24	3.03	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

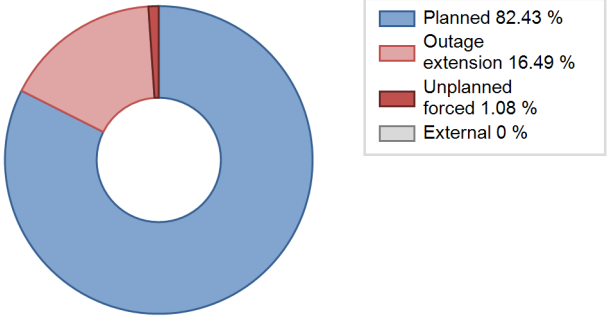
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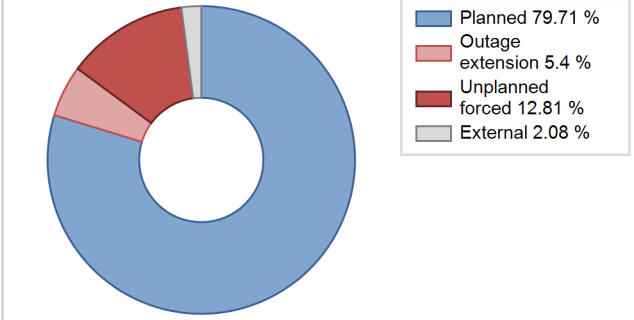
2020	4801.00	7302	660	82.46	82.46	82.81	83.13	0.23	3.08	14.45	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1983 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					297	
C.	Inspection, maintenance or repair combined with refuelling				74		
D.	Inspection, maintenance or repair without refuelling				414		
E.	Testing of plant systems or components	1228	254		32	8	
F.	Major backfitting, refurbishment or upgrading activities with refuelling				1070		
G.	Major backfitting, refurbishment or upgrading activities without refuelling				23		
H.	Nuclear regulatory requirements					2	
J.	Grid limitation, failure or grid unavailability						1
L.	Human factor related					57	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						3
Z.	Other					24	
Subtotal		1228	254		1613	388	4
Total		**1482**			**2005**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	254	20
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		11
14. Safety Systems		22
15. Reactor Cooling Systems		98
16. Steam generation systems		41
17. Safety I&C Systems (excluding reactor I&C)		4
21. Fuel Handling and Storage Facilities		24
31. Turbine and auxiliaries		56
32. Feedwater and Main Steam System		25
34. Miscellaneous Systems		17
41. Main Generator Systems		6
42. Electrical Power Supply Systems		19
Total	**254**	**361**

Highlights (2020)

Due to Covid-19 our station's Outage had been pushed from April 2020 to September 2020. During this time, our station further proved it's reliability as there were minimal forced losses and no forced outages. This allowed us to have at total of 417 consecutive days online which was the first time the station has done this in multiple decades.

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2020 Operating Experience

CN-901 CEFR CHINA



Status at end of year	:	**Operational**
Operator	:	CIAE (CHINA INSTITUTE OF ATOMIC ENERGY)
Owner	:	CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
Reactor Supplier	:	IZ (Izhorskiye Zavody)
Turbine Supplier	:	LMZ (JOINT-STOCK COMPANY "LENINGRADSKIY METALLICHESKIY ZAVOD")

Reactor Unit Details

Reactor type and model	:	FBR / BN-20
Thermal power	:	65 MWth
Gross electrical power	:	25 MWe
Reference unit power (net)	:	20 MWe

Key Dates

Construction Date	:	2000-05-10
Grid Date	:	2011-07-21
Commercial Date	:	
Age at end of year	:	9 years

Design Characteristics

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

Annual Production Results (2020)

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

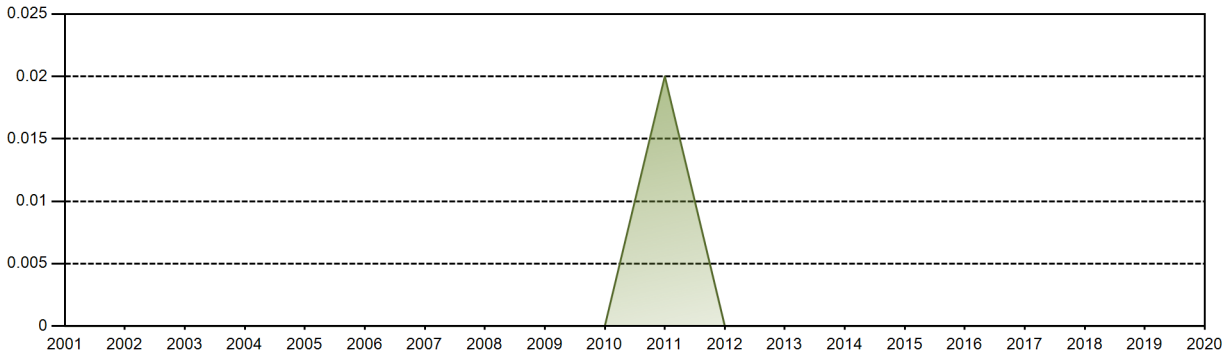
	Jan	Oct	Nov	Dec	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
GW(e)-h												
EAF [%]												
UCF [%]												
LF [%]												
OF [%]												
FLR [%]												
UCL [%]												
PUF [%]												
XUF [%]												

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Historical Summary

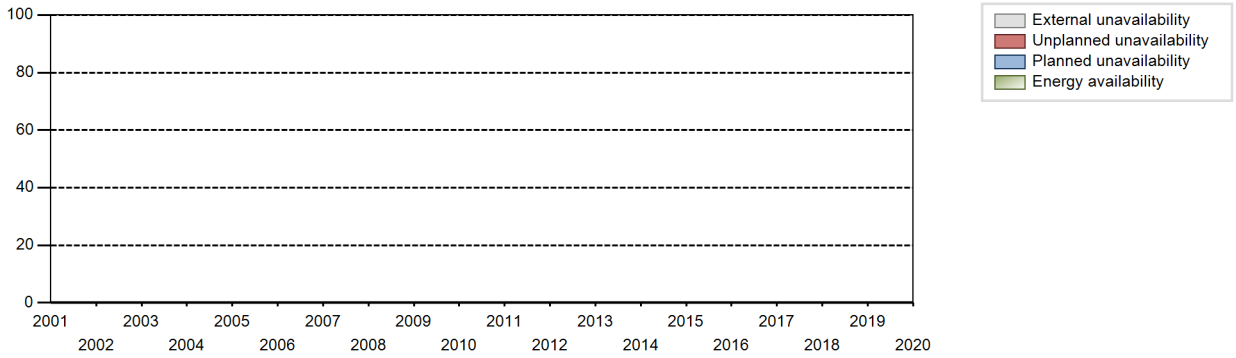
Lifetime energy generation	:	0 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	0 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	0 %	Cumulative Planned Unavailability Factor (PUF)	:	0 %
Cumulative Load Factor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

Electricity Production (net) [GWh]

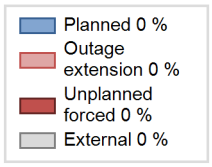


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]

Key Factors in Last 20 Years [%]



Energy Losses by Type



2020

No Data Available

Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			1 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
Subtotal						
Total	0			0		

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Equipment Related Unplanned Full Outages, Analysis by System		
System	2020	1 to 2020
	Hours Lost	Average hours lost per reactor-year
Total		

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2020 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	:	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]	:	2.53
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

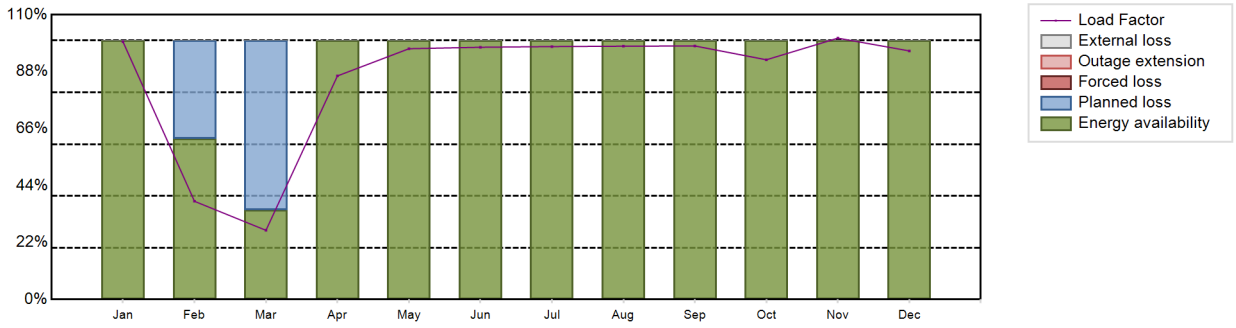
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	326.6
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.35
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	4519.05 GW(e).h
Energy Availability Factor (EAF)	:	91.48 %
Unit Capability Factor (UCF)	:	91.48 %
Load Factor (LF)	:	85.86 %
Operating Factor (OF)	:	90.31 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.52 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	851 hours

Annual Summary



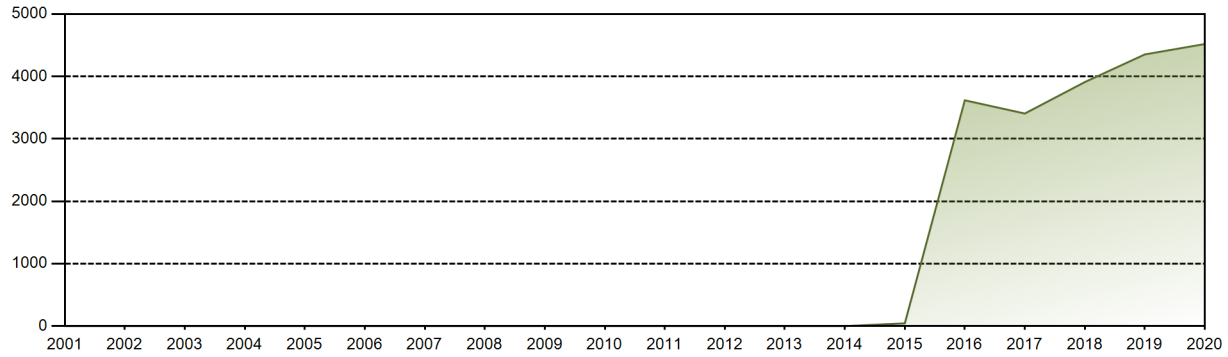
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	437.01	155.83	119.53	373.72	433.11	421.64	436.81	437.45	423.76	414.04	436.83	429.32	4519.05
EAF [%]	100.00	62.07	34.52	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.48
UCF [%]	100.00	62.07	34.52	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.48
LF [%]	99.56	37.95	26.73	86.36	96.86	97.44	97.69	97.83	97.93	92.60	100.95	96.01	85.86
OF [%]	100.00	42.39	39.52	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.31
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	37.93	65.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.52
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

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Historical Summary

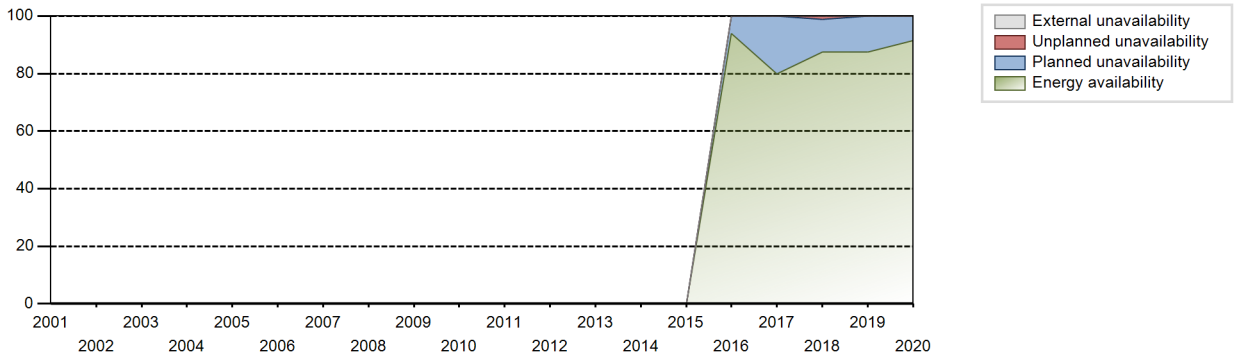
Lifetime energy generation	:	19847.05 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.27 %
Cumulative Energy Availability Factor (EAF)	:	88.08 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.24 %
Cumulative Unit Capability Factor (UCF)	:	88.08 %	Cumulative Planned Unavailability Factor (PUF)	:	11.68 %
Cumulative Load Factor (LF)	:	75.19 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	87.98 %			

Electricity Production (net) [GWh]

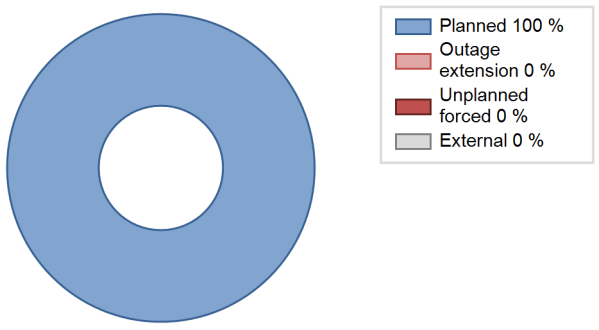


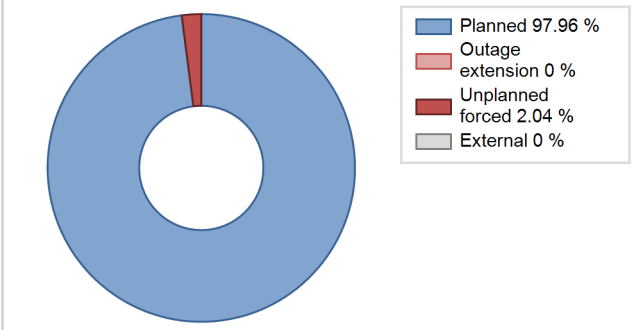
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2015	43.73	1006	610	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2016	3617.23	8185	601	93.96	93.96	68.52	93.18	0.00	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2015 to 2020		
	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	714			851		
D. Inspection, maintenance or repair without refuelling				123		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			137			74
Subtotal	714		137	974	6	74
Total	**851**			**1054**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2015 to 2020
	Hours Lost	Average hours lost per reactor-year
33. Circulating Water System		6
34. Miscellaneous Systems	137	27
Total	**137**	**33**

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2020 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

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	:	2010-11-21
Grid Date	:	2016-06-20
Commercial Date	:	2016-08-12
Age at end of year	:	4 years

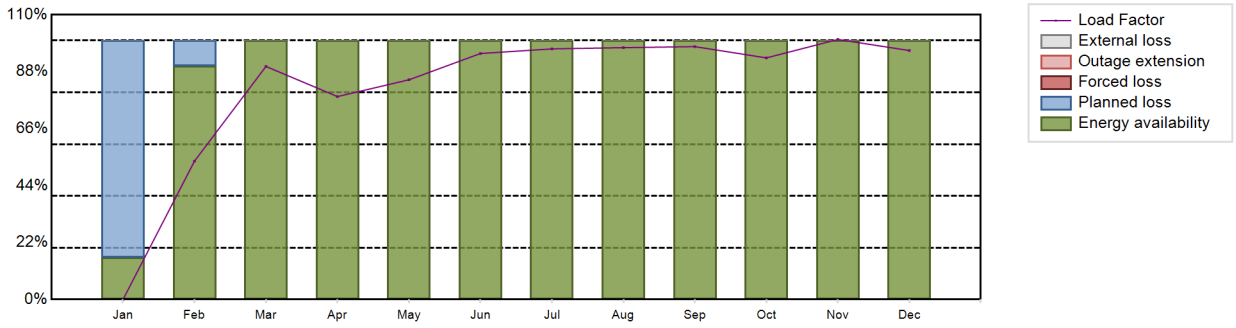
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	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 (2020)

Net Energy Production	:	4328.28 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	92.11 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	92.11 %	Planned Unavailability Factor (PUF)	:	7.89 %
Load Factor (LF)	:	81.99 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	87.53 %	Total off-line time	:	1095 hours

Annual Summary



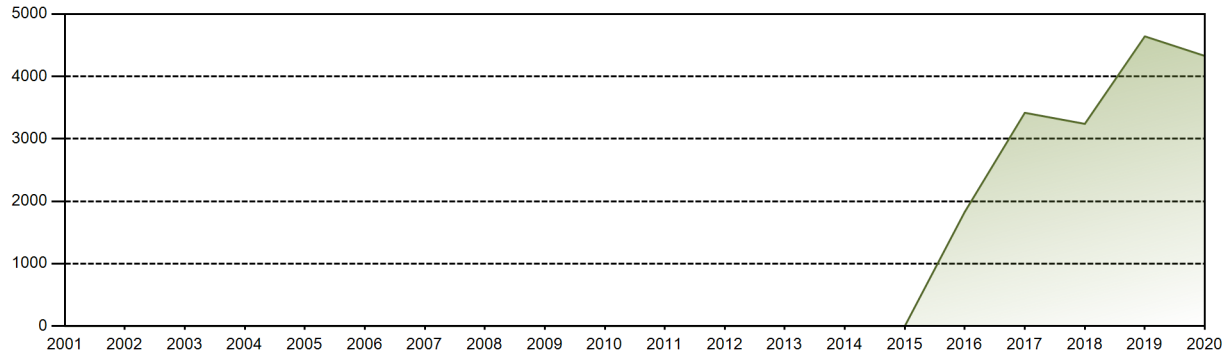
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	223.60	402.52	339.19	379.44	411.14	432.85	435.01	422.64	417.29	434.63	429.97	4328.28
EAF [%]	16.13	90.06	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.11
UCF [%]	16.13	90.06	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.11
LF [%]	0.00	53.45	90.02	78.39	84.86	95.01	96.80	97.29	97.67	93.32	100.44	96.16	81.99
OF [%]	0.00	61.21	100.00	100.00	89.11	100.00	100.00	100.00	100.00	100.00	100.00	100.00	87.53
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 [%]	83.87	9.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.89
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

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Historical Summary

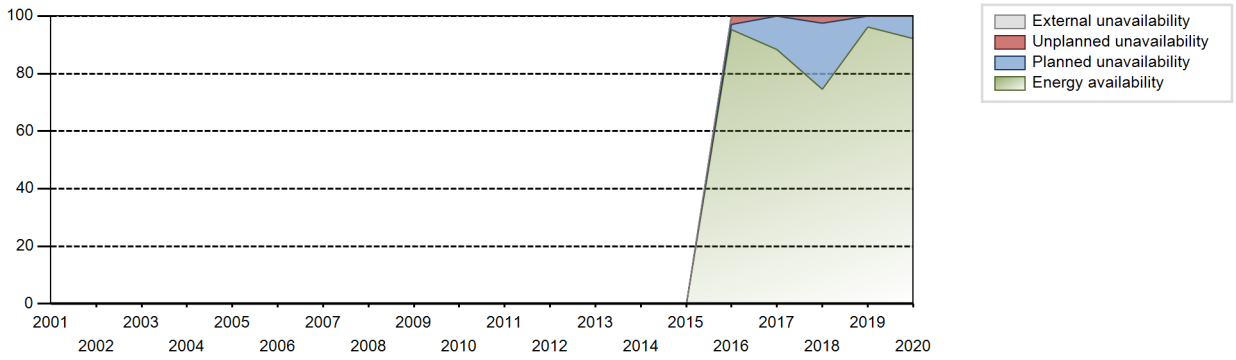
Lifetime energy generation	:	17457.13 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.67 %
Cumulative Energy Availability Factor (EAF)	:	88.53 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.83 %
Cumulative Unit Capability Factor (UCF)	:	88.53 %	Cumulative Planned Unavailability Factor (PUF)	:	10.64 %
Cumulative Load Factor (LF)	:	74.04 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	87.12 %			

Electricity Production (net) [GWh]

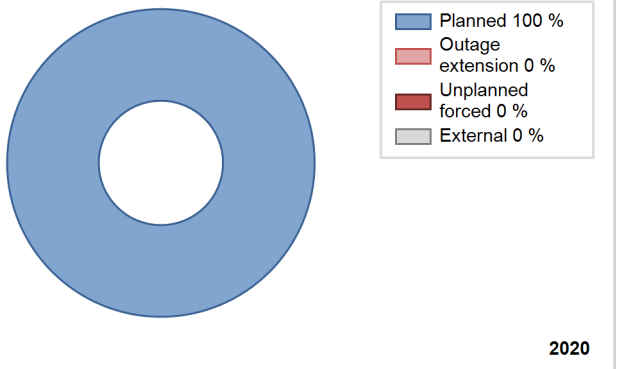


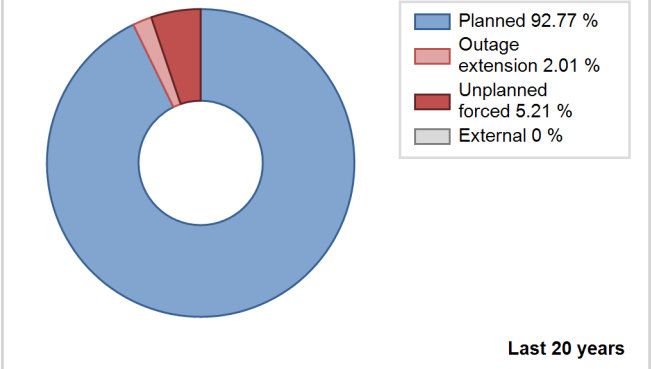
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	1831.25	4180	601	95.30	95.30	72.98	95.89	3.07	3.02	1.68	0.00
2017	3417.22	7524	601	88.44	88.44	64.91	85.89	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2016 to 2020 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	624			889		
E. Testing of plant systems or components				73		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			471			179
Subtotal	624		471	962	67	179
Total	**1095**			**1208**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2016 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		6
14. Safety Systems		20
16. Steam generation systems		9
31. Turbine and auxiliaries	81	18
33. Circulating Water System		31
34. Miscellaneous Systems	390	85
Total	**471**	**169**

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2020 Operating Experience

CN-2 DAYA BAY-1 CHINA



Status at end of year	:	**Operational**
Operator	:	DNMC (Daya Bay Nuclear Power Operations and Management Co, Ltd.)
Owner	:	GNPJVC (GUANDONG NUCLEAR POWER JOINT VENTURE COMPANY LIMITED)
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	:	984 MWe
Reference unit power (net)	:	944 MWe

Key Dates

Construction Date	:	1987-08-07
Grid Date	:	1993-08-31
Commercial Date	:	1994-02-01
Age at end of year	:	27 years

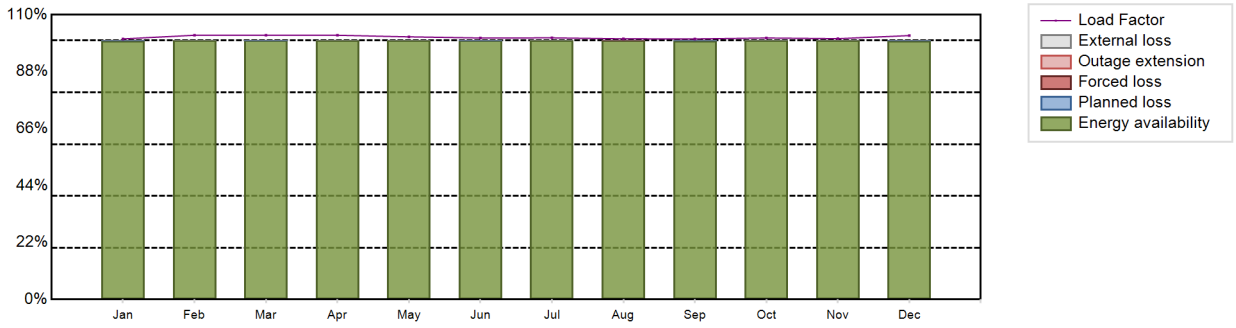
Design Characteristics

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 (2020)

Net Energy Production	:	8398.23 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)	:	101.28 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	100 %	Total off-line time	:	0 hours

Annual Summary



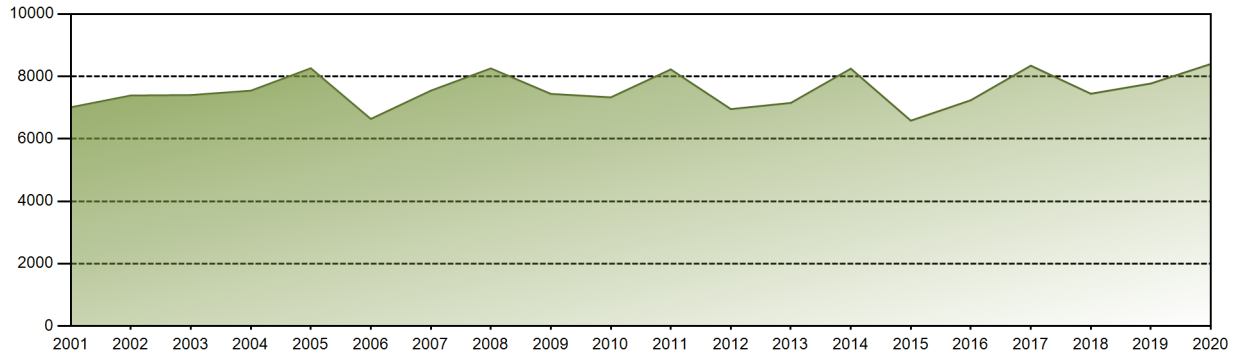
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	706.99	670.50	716.76	693.70	712.59	686.44	709.76	707.16	684.06	709.53	684.82	715.90	8398.23
EAF [%]	99.98	100.00	99.99	100.00	100.00	99.99	100.00	99.99	99.97	100.00	100.00	99.91	99.99
UCF [%]	99.98	100.00	99.99	100.00	100.00	99.99	100.00	99.99	99.97	100.00	100.00	99.91	99.99
LF [%]	100.66	102.05	102.05	102.06	101.46	100.99	101.06	100.69	100.65	101.02	100.76	101.93	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	0.01	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 [%]	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.09	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

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Historical Summary

Lifetime energy generation	:	192462.14 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.28 %
Cumulative Energy Availability Factor (EAF)	:	86.45 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.31 %
Cumulative Unit Capability Factor (UCF)	:	88.87 %	Cumulative Planned Unavailability Factor (PUF)	:	9.82 %
Cumulative Load Factor (LF)	:	86.73 %	Cumulative Externally cause unavailability (XUF)	:	2.42 %
Cumulative Operating Factor (OF)	:	88.19 %			

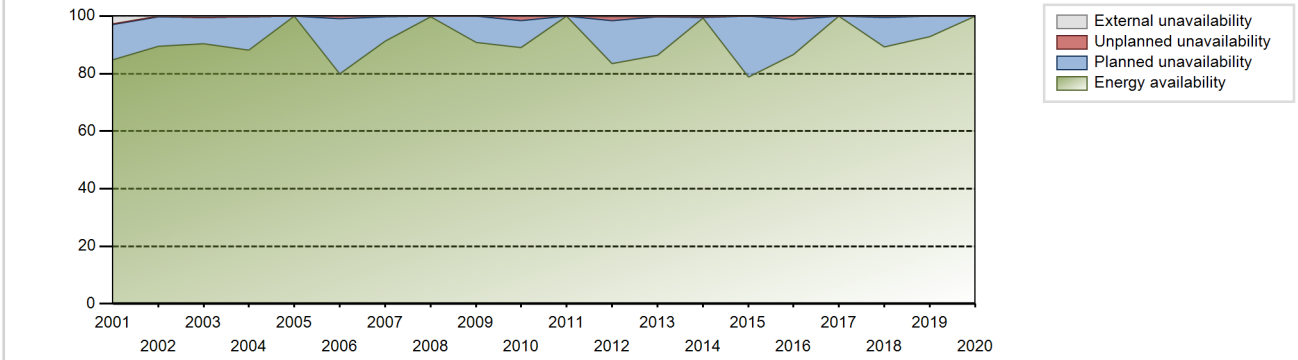
Electricity Production (net) [GWh]



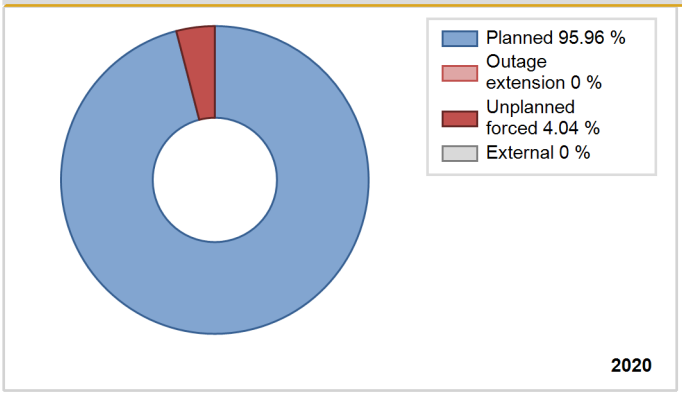
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1994	5917.39	6539	944	76.26	77.44	76.76	79.65	18.87	18.01	4.55	1.18
1995	3723.63	4088	944	46.21	84.61	45.03	46.67	0.45	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

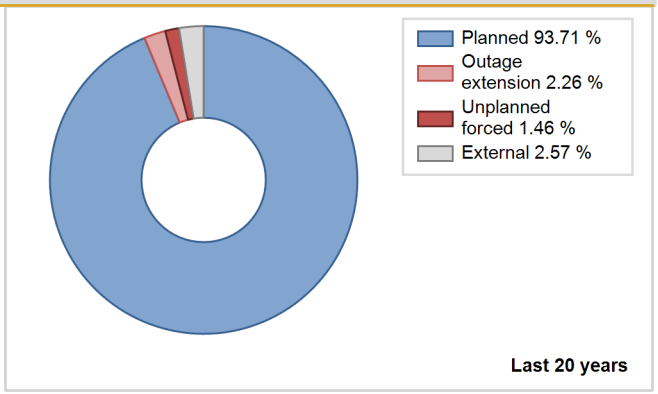
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1994 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					93	
C. Inspection, maintenance or repair combined with refuelling				810		
D. Inspection, maintenance or repair without refuelling				11		
E. Testing of plant systems or components					0	
J. Grid limitation, failure or grid unavailability						11
Z. Other						114
Subtotal				821	93	125
Total		**0**			**1039**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1994 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		3
15. Reactor Cooling Systems		10
31. Turbine and auxiliaries		2
32. Feedwater and Main Steam System		12
33. Circulating Water System		2
41. Main Generator Systems		36
42. Electrical Power Supply Systems		21
Total		**94**

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2020 Operating Experience

CN-3 DAYA BAY-2 CHINA



Status at end of year	:	**Operational**
Operator	:	DNMC (Daya Bay Nuclear Power Operations and Management Co, Ltd.)
Owner	:	GNPJVC (GUANDONG NUCLEAR POWER JOINT VENTURE COMPANY LIMITED)
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	:	984 MWe
Reference unit power (net)	:	944 MWe

Key Dates

Construction Date	:	1988-04-07
Grid Date	:	1994-02-07
Commercial Date	:	1994-05-06
Age at end of year	:	26 years

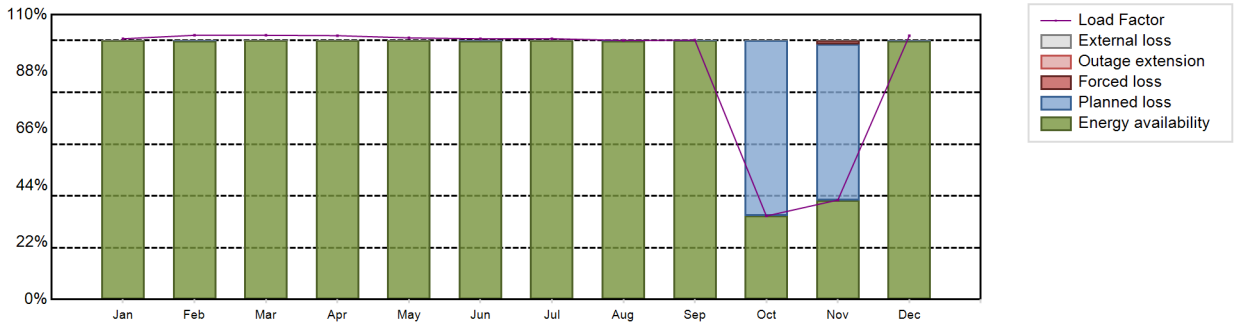
Design Characteristics

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 [%]	:	46
Average discharge burnup [MWd/t]	:	43000
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 (2020)

Net Energy Production	:	7475.32 GW(e).h
Energy Availability Factor (EAF)	:	89.21 %
Unit Capability Factor (UCF)	:	89.21 %
Load Factor (LF)	:	90.15 %
Operating Factor (OF)	:	89.81 %
Forced Loss Rate (FLR)	:	0.13 %
Unplanned Capability Loss Factor (UCL)	:	0.12 %
Planned Unavailability Factor (PUF)	:	10.67 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	895 hours

Annual Summary



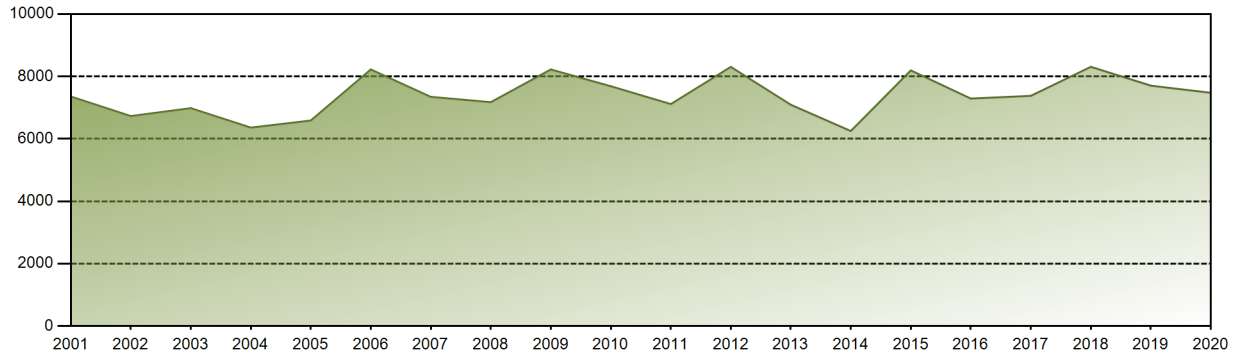
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	707.31	670.39	716.69	692.62	709.66	684.53	707.36	702.76	680.93	226.50	261.21	715.38	7475.32
EAF [%]	100.00	99.97	100.00	100.00	100.00	99.98	100.00	99.91	100.00	32.36	38.40	99.98	89.21
UCF [%]	100.00	99.97	100.00	100.00	100.00	99.98	100.00	99.91	100.00	32.36	38.40	99.98	89.21
LF [%]	100.71	102.03	102.04	101.90	101.04	100.71	100.71	100.06	100.18	32.25	38.43	101.86	90.15
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	32.66	45.28	100.00	89.81
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.66	0.00	0.13
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.46	0.00	0.12
PUF [%]	0.00	0.03	0.00	0.00	0.00	0.02	0.00	0.09	0.00	67.64	60.14	0.02	10.67
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

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Historical Summary

Lifetime energy generation	:	189748.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.57 %
Cumulative Energy Availability Factor (EAF)	:	86.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.21 %
Cumulative Unit Capability Factor (UCF)	:	87.23 %	Cumulative Planned Unavailability Factor (PUF)	:	10.56 %
Cumulative Load Factor (LF)	:	86.25 %	Cumulative Externally cause unavailability (XUF)	:	1.13 %
Cumulative Operating Factor (OF)	:	87.63 %			

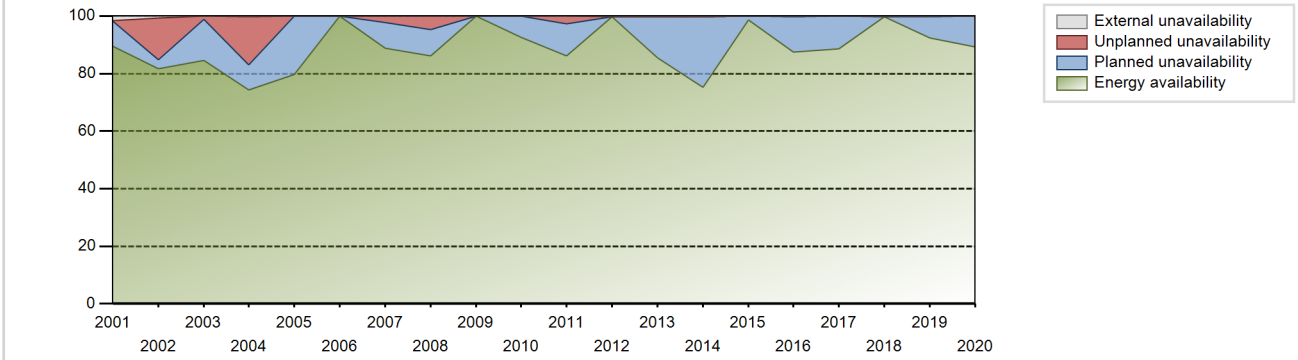
Electricity Production (net) [GWh]



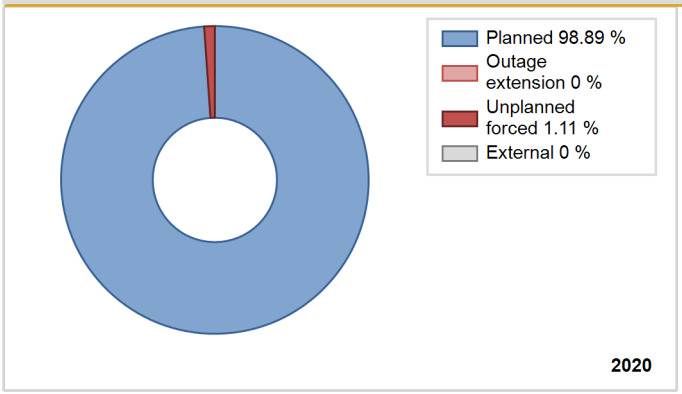
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1994	5741.21	6889	944	92.32	99.39	90.33	97.98	0.60	0.60	0.01	7.07
1995	6343.33	7146	944	77.48	81.09	76.71	81.58	1.35	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

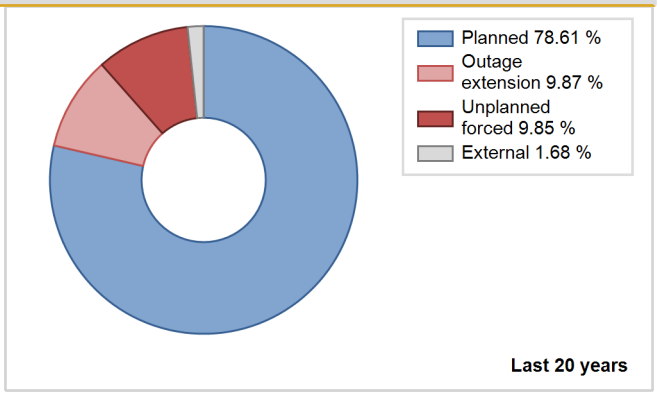
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1994 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					104	
C. Inspection, maintenance or repair combined with refuelling	895			852	8	
D. Inspection, maintenance or repair without refuelling				10		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						12
L. Human factor related					16	
Subtotal	895			862	128	12
Total	**895**			**1002**		

Equipment Related Unplanned Full Outages, Analysis by System

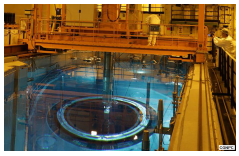
System	2020 Hours Lost	1994 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		5
14. Safety Systems		0
15. Reactor Cooling Systems		1
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		40
31. Turbine and auxiliaries		2
32. Feedwater and Main Steam System		1
35. All other I&C Systems		1
41. Main Generator Systems		48
42. Electrical Power Supply Systems		17
Total		**117**

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2020 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	:	5 years

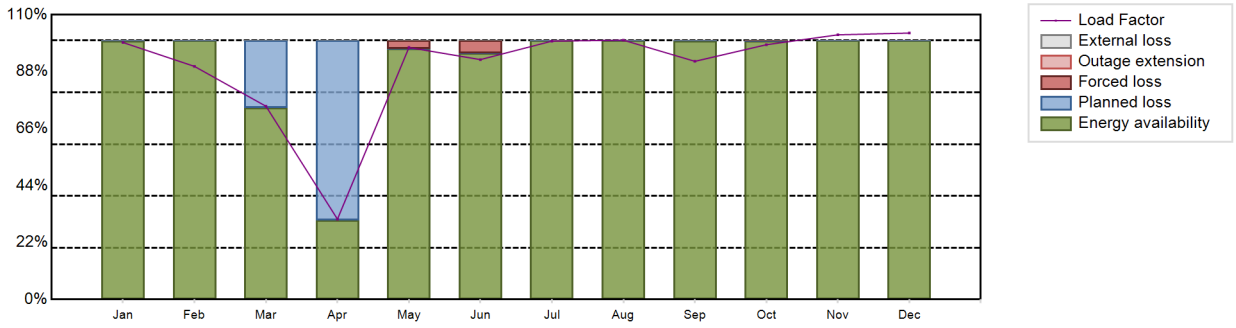
Design Characteristics

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]	:	NA	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 (2020)

Net Energy Production	:	7919.2 GW(e).h	Forced Loss Rate (FLR)	:	0.72 %
Energy Availability Factor (EAF)	:	91.43 %	Unplanned Capability Loss Factor (UCL)	:	0.66 %
Unit Capability Factor (UCF)	:	91.43 %	Planned Unavailability Factor (PUF)	:	7.91 %
Load Factor (LF)	:	90.15 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	92.67 %	Total off-line time	:	644 hours

Annual Summary



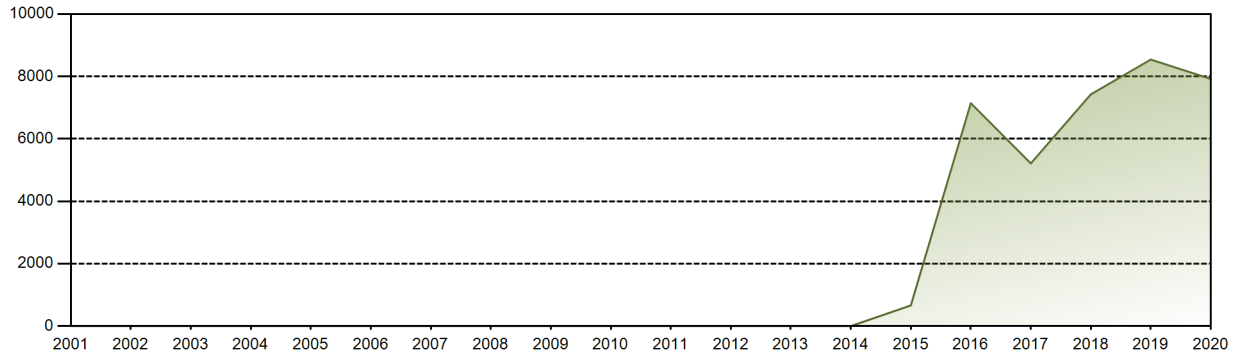
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	738.50	626.69	555.43	223.51	724.07	667.16	742.45	745.23	662.33	732.12	736.03	765.68	7919.20
EAF [%]	99.87	99.99	73.94	30.68	96.89	95.09	100.00	100.00	99.98	99.98	100.00	100.00	91.43
UCF [%]	99.87	99.99	73.94	30.68	96.89	95.09	100.00	100.00	99.98	99.98	100.00	100.00	91.43
LF [%]	99.26	90.04	74.65	31.04	97.32	92.66	99.79	100.17	91.99	98.40	102.23	102.91	90.15
OF [%]	100.00	100.00	74.60	36.81	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.67
FLR [%]	0.00	0.00	0.00	0.00	3.10	4.87	0.00	0.00	0.00	0.02	0.00	0.00	0.72
UCL [%]	0.00	0.00	0.00	0.00	3.10	4.86	0.00	0.00	0.00	0.02	0.00	0.00	0.66
PUF [%]	0.13	0.01	26.06	69.32	0.00	0.05	0.00	0.00	0.02	0.00	0.00	0.00	7.91
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

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Historical Summary

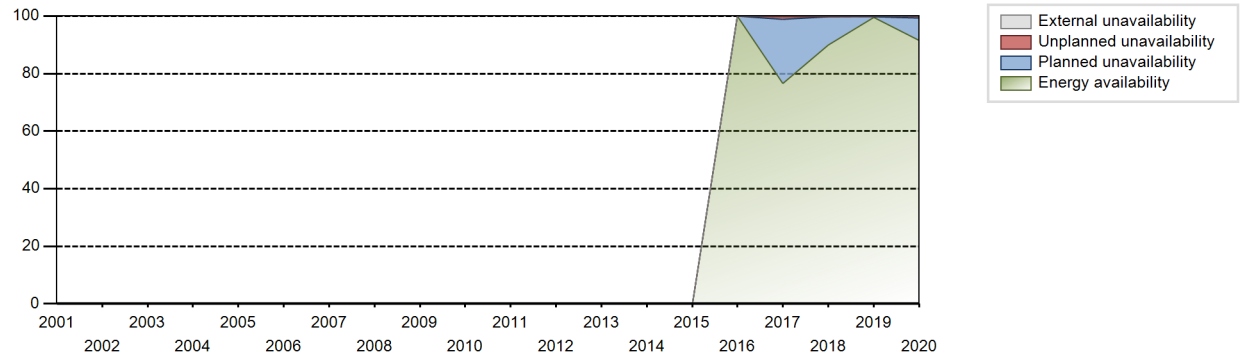
Lifetime energy generation	:	36901.2 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.23 %
Cumulative Energy Availability Factor (EAF)	:	91.54 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.39 %
Cumulative Unit Capability Factor (UCF)	:	91.61 %	Cumulative Planned Unavailability Factor (PUF)	:	8 %
Cumulative Load Factor (LF)	:	82.65 %	Cumulative Externally cause unavailability (XUF)	:	0.07 %
Cumulative Operating Factor (OF)	:	86.78 %			

Electricity Production (net) [GWh]

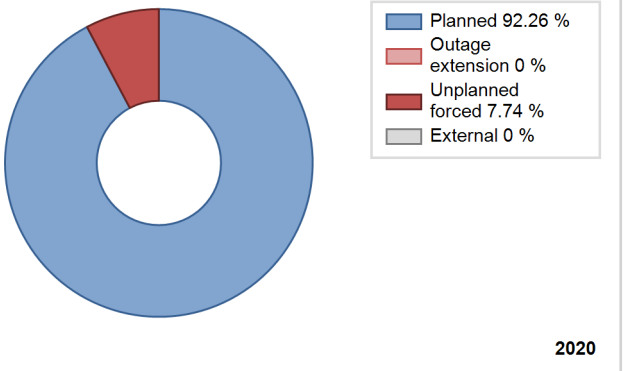


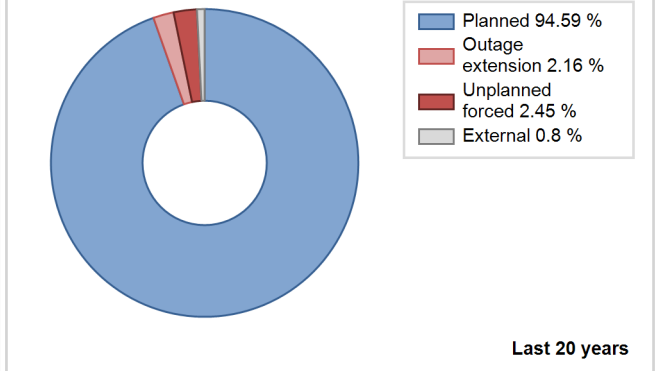
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	7141.83	7761	1000	99.97	99.97	81.30	88.35	0.00	0.00	0.03	0.01
2017	5212.98	5794	1000	76.66	76.82	59.51	66.14	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	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	644			668		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						471
Subtotal	644			668	21	471
Total	**644**			**1160**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
14. Safety Systems		16
31. Turbine and auxiliaries		5
Total		**21**

Highlights (2020)

1.CN38 was basically operated in base-load mode. There was no scram in 2020.
2.According to the requirements of grid, CN38 deloaded for some holidays,weekends and other reasons.

3.CN38 was bearing its third refuelling outage from Mar 24 to Apr 19, lasting 26.54 days.

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2020 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	:	4 years

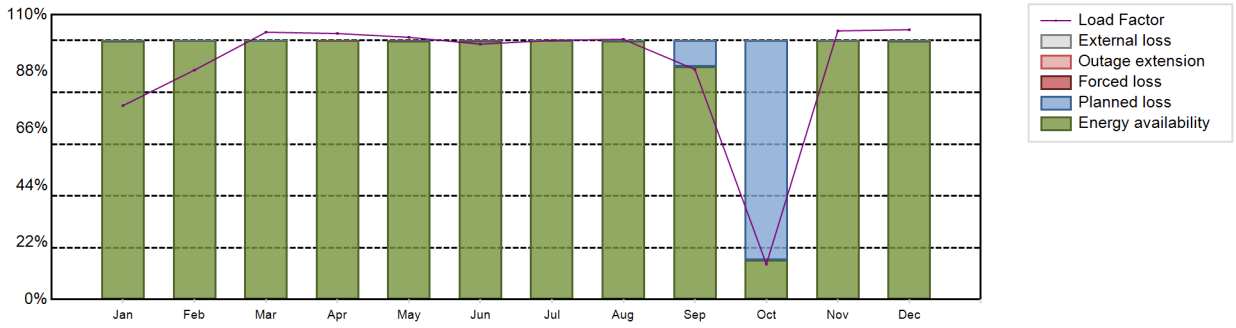
Design Characteristics

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]	:	NA	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 (2020)

Net Energy Production	:	7901 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	91.98 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	91.98 %	Planned Unavailability Factor (PUF)	:	8.02 %
Load Factor (LF)	:	89.95 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	90.06 %	Total off-line time	:	873 hours

Annual Summary



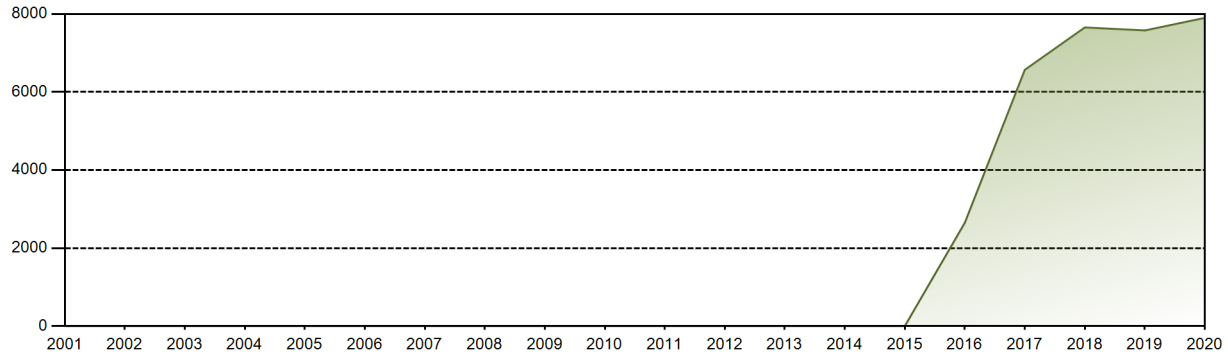
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	557.05	616.66	768.02	739.64	753.43	709.99	744.65	747.72	639.82	101.73	747.02	775.27	7901.00
EAF [%]	99.98	99.99	100.00	99.99	99.95	99.98	100.00	99.93	89.98	15.19	100.00	99.93	91.98
UCF [%]	99.98	99.99	100.00	99.99	99.95	99.98	100.00	99.93	89.98	15.19	100.00	99.93	91.98
LF [%]	74.87	88.60	103.23	102.73	101.27	98.61	100.09	100.50	88.86	13.67	103.75	104.20	89.95
OF [%]	73.66	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.42	18.28	100.00	100.00	90.06
FLR [%]	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCL [%]	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PUF [%]	0.02	0.01	0.00	0.01	0.03	0.00	0.00	0.07	10.02	84.81	0.00	0.07	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

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Historical Summary

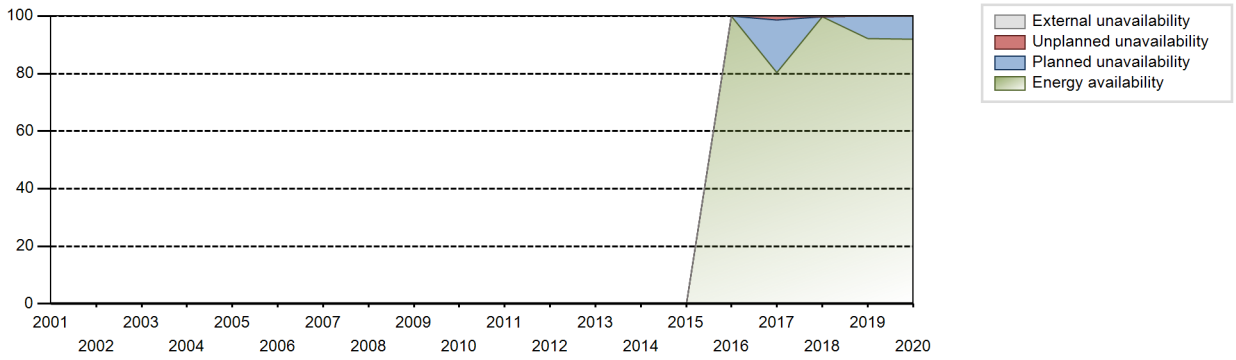
Lifetime energy generation	:	32258 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.36 %
Cumulative Energy Availability Factor (EAF)	:	91.58 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.33 %
Cumulative Unit Capability Factor (UCF)	:	91.65 %	Cumulative Planned Unavailability Factor (PUF)	:	8.02 %
Cumulative Load Factor (LF)	:	85.1 %	Cumulative Externally cause unavailability (XUF)	:	0.07 %
Cumulative Operating Factor (OF)	:	86.2 %			

Electricity Production (net) [GWh]

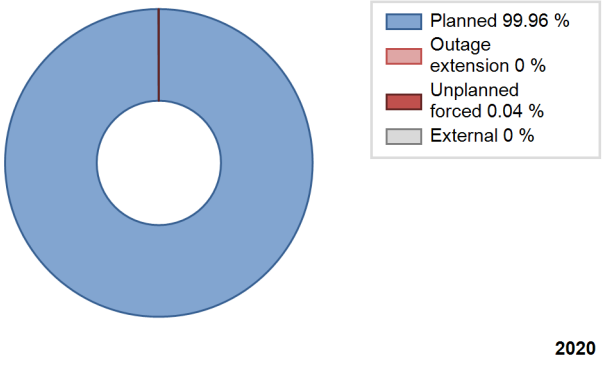


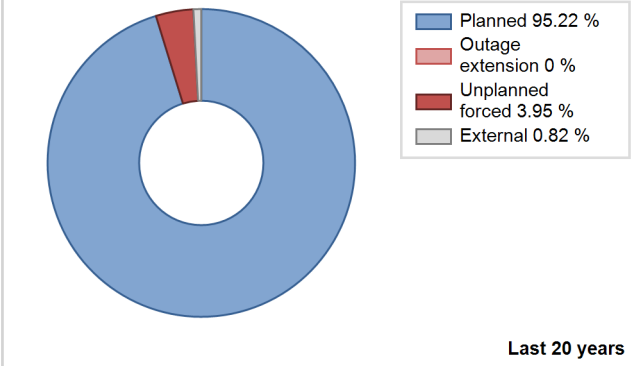
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	2648.30	3297	1000	100.00	100.00	91.13	88.22	0.00	0.00	0.00	0.00
2017	6569.07	6827	1000	80.27	80.38	74.99	77.93	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	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	668			669		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			205			513
Subtotal	668		205	669	28	513
Total	**873**			**1210**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
31. Turbine and auxiliaries		27
34. Miscellaneous Systems	205	152
Total	**205**	**179**

Highlights (2020)

1.CN39 was basically operated in base-load mode. There was no scram in 2020.
2.According to the requirements of grid, CN39 deloaded for some holidays,weekends and other reasons.

3.CN39 was bearing its third refuelling outage from Sep 28 to Oct 26, lasting 27.29 days.

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2020 Operating Experience

CN-24 FANGJIASHAN-1 CHINA

Status at end of year	:	**Operational**
Operator	:	QNPC (QINSHAN NUCLEAR POWER COMPANY)
Owner	:	CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
Reactor Supplier	:	NPIC (Nuclear Power Institute of China)
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)	:	1012 MWe

Key Dates

Construction Date	:	2008-12-26
Grid Date	:	2014-11-04
Commercial Date	:	2014-12-15
Age at end of year	:	6 years

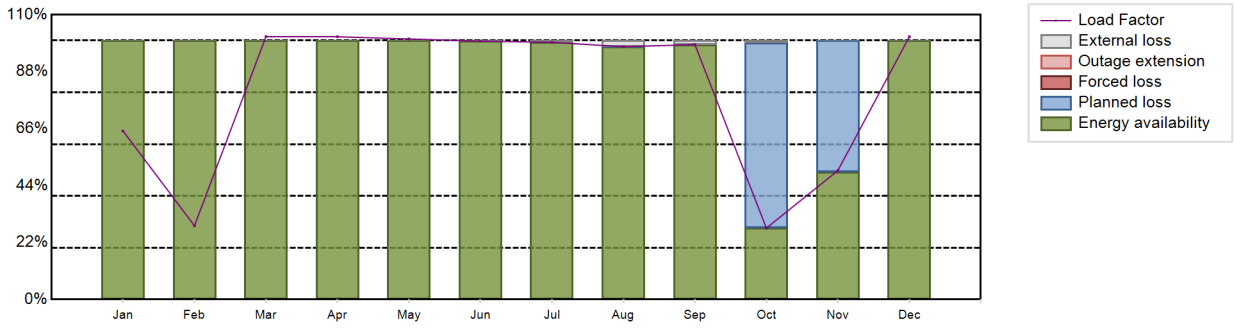
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.4
Refuelling frequency [month]	:	12
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]	:	18.6
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 (2020)

Net Energy Production	:	7214.92 GW(e).h
Energy Availability Factor (EAF)	:	89.3 %
Unit Capability Factor (UCF)	:	89.77 %
Load Factor (LF)	:	81.16 %
Operating Factor (OF)	:	82.17 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	10.23 %
Externally cause unavailability (XUF)	:	0.46 %
Total off-line time	:	1566 hours

Annual Summary



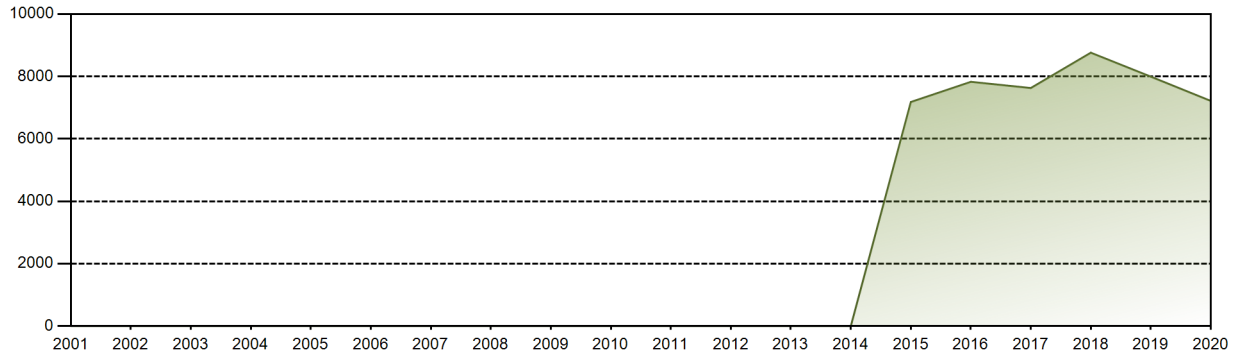
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	490.21	200.60	764.54	739.49	757.61	727.21	747.81	735.08	717.54	207.69	362.89	764.25	7214.92
EAF [%]	100.00	100.00	100.00	100.00	100.00	99.80	99.32	97.63	98.48	27.58	49.19	100.00	89.30
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.94	100.00	28.40	49.19	100.00	89.77
LF [%]	65.11	28.48	101.54	101.49	100.62	99.80	99.32	97.63	98.48	27.58	49.80	101.50	81.16
OF [%]	65.32	32.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	29.17	56.67	100.00	82.17
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	0.00	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	0.06	0.00	71.60	50.81	0.00	10.23
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.20	0.68	2.31	1.52	0.82	0.00	0.00	0.46

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Historical Summary

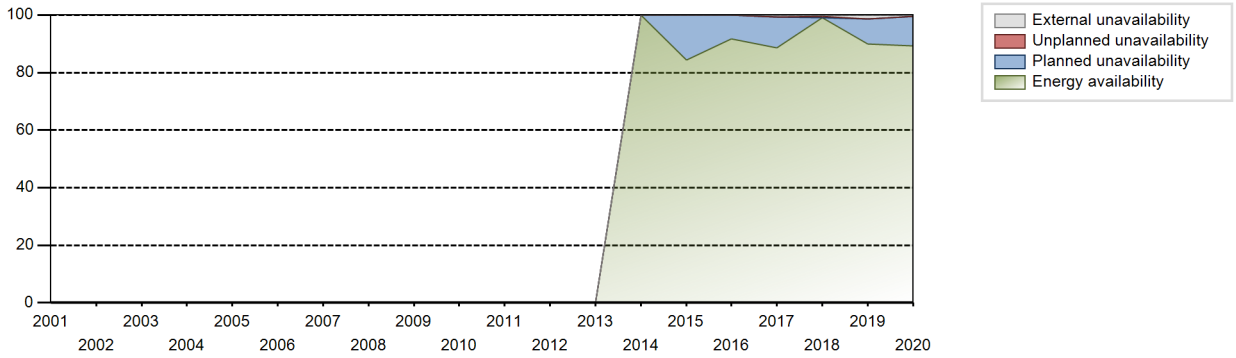
Lifetime energy generation	:	46605.12 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.09 %
Cumulative Energy Availability Factor (EAF)	:	90.62 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.08 %
Cumulative Unit Capability Factor (UCF)	:	91.09 %	Cumulative Planned Unavailability Factor (PUF)	:	8.83 %
Cumulative Load Factor (LF)	:	86.33 %	Cumulative Externally cause unavailability (XUF)	:	0.47 %
Cumulative Operating Factor (OF)	:	87.86 %			

Electricity Production (net) [GWh]

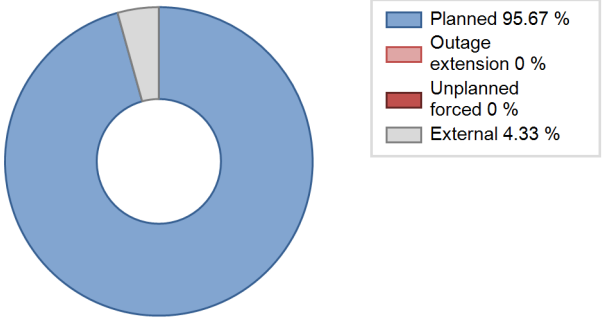


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2014	0.00	0	1000	100.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
2015	7180.23	7289	1012	84.47	84.47	80.99	83.21	0.00	0.00	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

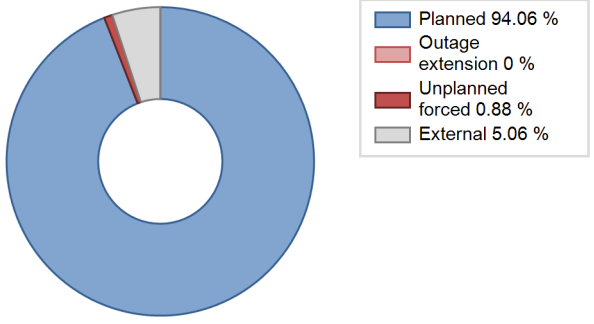
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2014 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling	839			748		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			727			203
L. Human factor related					5	
Subtotal	839		727	748	5	203
Total	**1566**			**956**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2014 to 2020
	Hours Lost	Average hours lost per reactor-year
34. Miscellaneous Systems	727	121
Total	**727**	**121**

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2020 Operating Experience

CN-25 FANGJIASHAN-2 CHINA

Status at end of year	:	**Operational**
Operator	:	QNPC (QINSHAN NUCLEAR POWER COMPANY)
Owner	:	CNNC (CHINA NATIONAL NUCLEAR CORPORATION)
Reactor Supplier	:	NPIC (Nuclear Power Institute of China)
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)	:	1012 MWe

Key Dates

Construction Date	:	2009-07-17
Grid Date	:	2015-01-12
Commercial Date	:	2015-02-12
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]	:	2.4
Refuelling frequency [month]	:	12
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]	:	18.6
Number of control rod assemblies	:	61
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

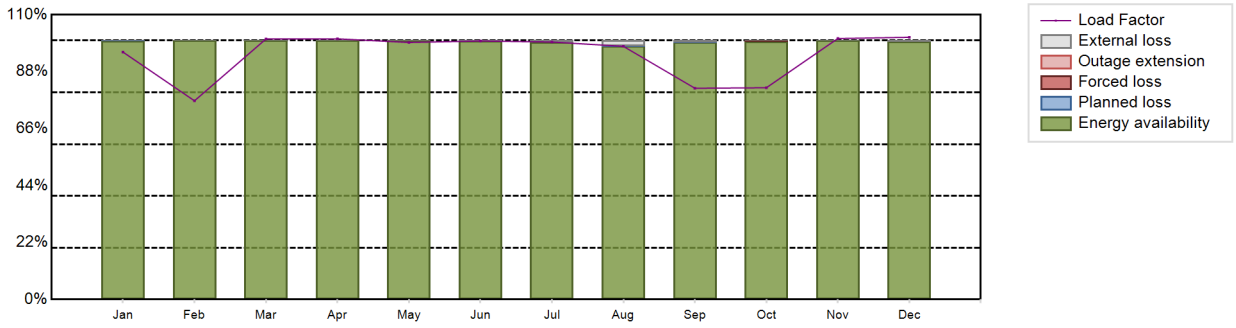
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.6
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	0.52
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP 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 (2020)

Net Energy Production	:	8418.73 GW(e).h
Energy Availability Factor (EAF)	:	99.62 %
Unit Capability Factor (UCF)	:	99.93 %
Load Factor (LF)	:	94.71 %
Operating Factor (OF)	:	95.36 %

Forced Loss Rate (FLR)	:	0.04 %
Unplanned Capability Loss Factor (UCL)	:	0.04 %
Planned Unavailability Factor (PUF)	:	0.03 %
Externally cause unavailability (XUF)	:	0.31 %
Total off-line time	:	408 hours

Annual Summary



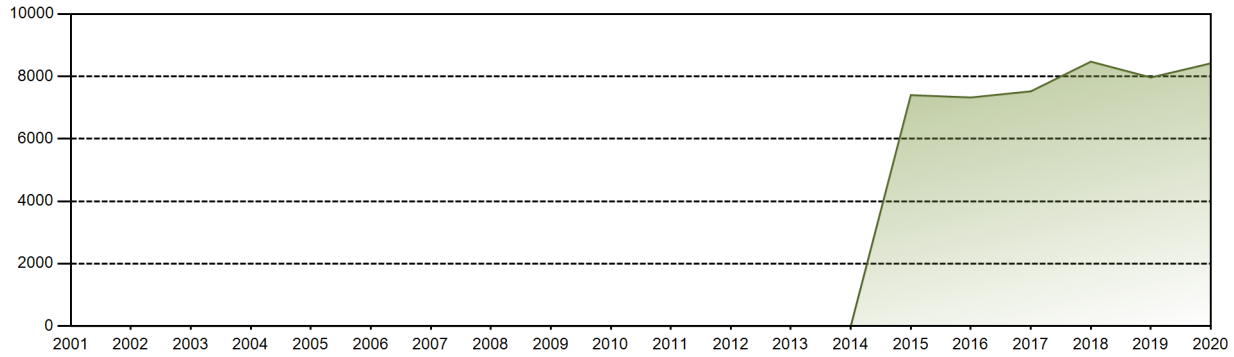
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	719.52	540.61	757.60	733.54	747.49	727.62	748.81	736.13	594.61	615.83	734.53	762.45	8418.73
EAF [%]	99.91	100.00	100.00	100.00	100.00	99.86	99.45	97.77	99.25	99.54	100.00	99.69	99.62
UCF [%]	99.91	100.00	100.00	100.00	100.00	100.00	100.00	99.89	99.77	99.54	100.00	100.00	99.93
LF [%]	95.56	76.75	100.62	100.67	99.28	99.86	99.45	97.77	81.61	81.79	100.81	101.26	94.71
OF [%]	100.00	80.46	100.00	100.00	100.00	100.00	100.00	100.00	83.33	79.57	100.00	100.00	95.36
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.04
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.04
PUF [%]	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.23	0.00	0.00	0.00	0.03
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.14	0.55	2.12	0.52	0.00	0.00	0.31	0.31

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Historical Summary

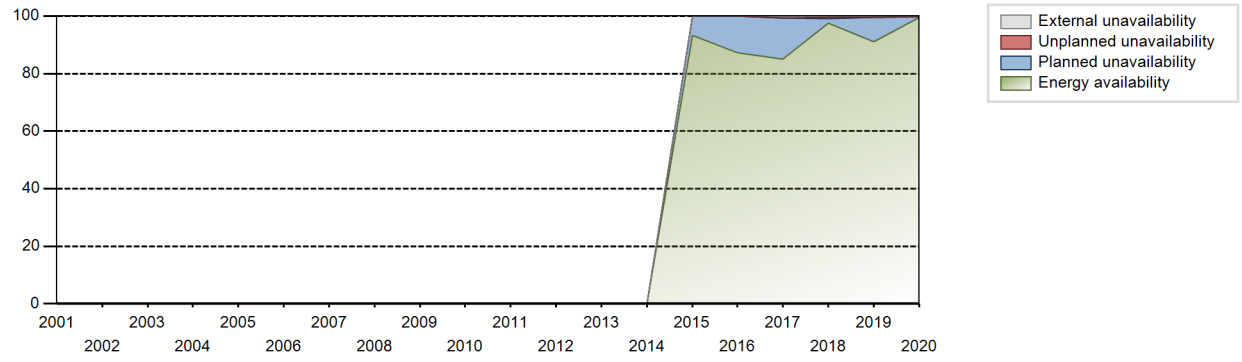
Lifetime energy generation	:	47104.1 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.1 %
Cumulative Energy Availability Factor (EAF)	:	92.27 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.09 %
Cumulative Unit Capability Factor (UCF)	:	92.61 %	Cumulative Planned Unavailability Factor (PUF)	:	7.3 %
Cumulative Load Factor (LF)	:	89.55 %	Cumulative Externally cause unavailability (XUF)	:	0.34 %
Cumulative Operating Factor (OF)	:	91.32 %			

Electricity Production (net) [GWh]

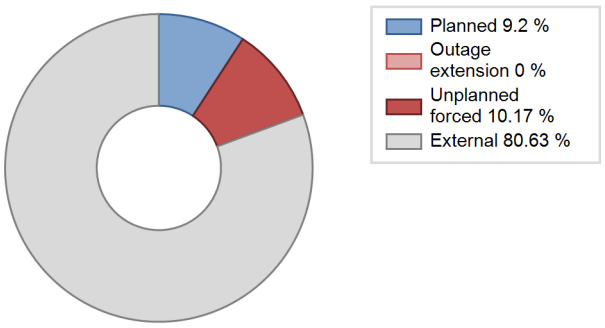


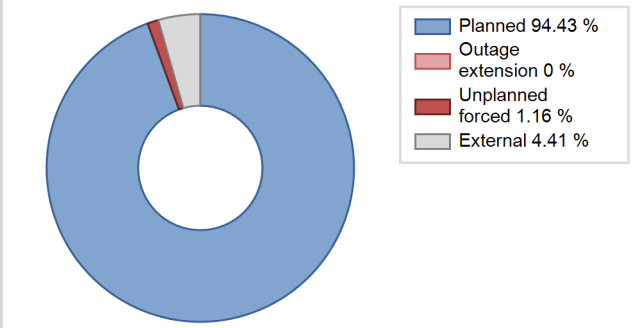
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2015	7400.55	7747	1012	93.22	93.22	89.98	92.90	0.02	0.02	6.76	0.00
2016	7324.84	7529	1012	87.29	87.29	82.40	85.71	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2015 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		3			5	
C. Inspection, maintenance or repair combined with refuelling				615		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			381			132
Subtotal		3	381	615	5	132
Total		**384**			**752**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2015 to 2020
	Hours Lost	Average hours lost per reactor-year
31. Turbine and auxiliaries		4
32. Feedwater and Main Steam System	3	1
34. Miscellaneous Systems	381	63
Total	**384**	**68**

Highlights (2020)

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2020 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

Reactor type and model	:	PWR / CNP-1000
Thermal power	:	2905 MWth
Gross electrical power	:	1089 MWe
Reference unit power (net)	:	1000 MWe

Key Dates

Construction Date	:	2008-11-21
Grid Date	:	2014-08-20
Commercial Date	:	2014-11-22
Age at end of year	:	6 years

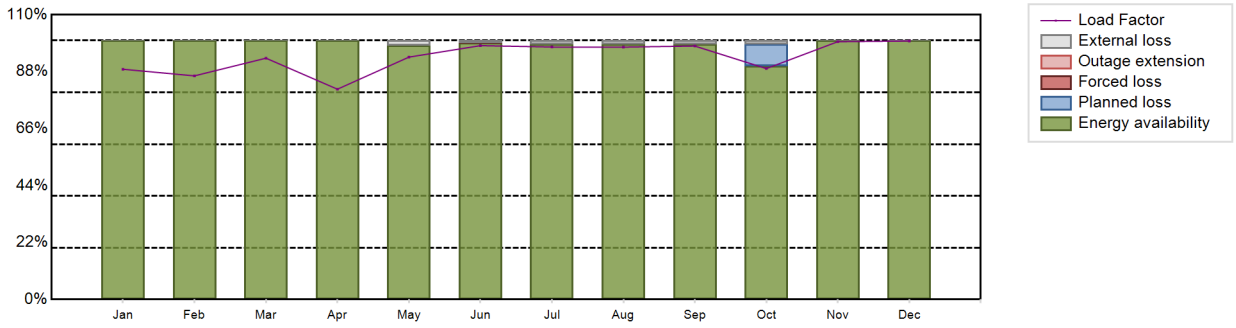
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.4
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	33
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]	:	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	:	4
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	8222.85 GW(e).h
Energy Availability Factor (EAF)	:	98.58 %
Unit Capability Factor (UCF)	:	99.3 %
Load Factor (LF)	:	93.61 %
Operating Factor (OF)	:	99.11 %
Forced Loss Rate (FLR)	:	0.01 %
Unplanned Capability Loss Factor (UCL)	:	0.01 %
Planned Unavailability Factor (PUF)	:	0.7 %
Externally cause unavailability (XUF)	:	0.72 %
Total off-line time	:	78 hours

Annual Summary



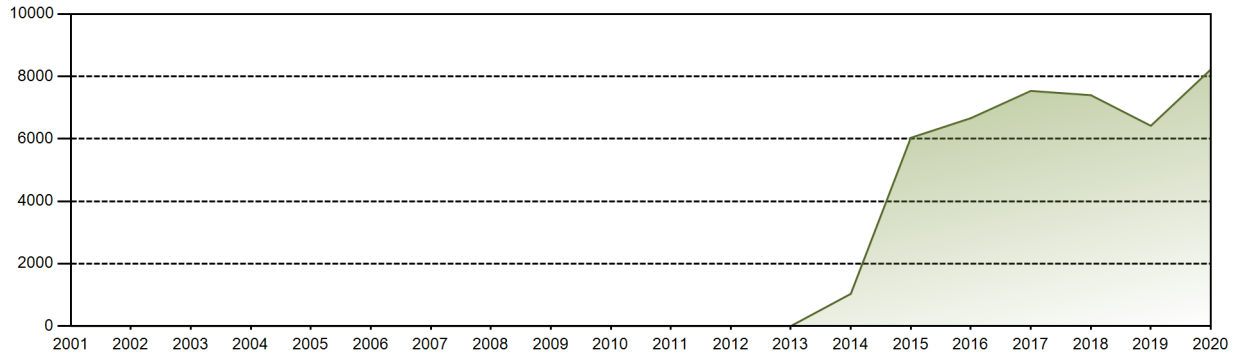
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	661.69	601.21	693.52	584.85	696.58	705.97	725.52	725.22	704.83	663.59	717.05	742.83	8222.85
EAF [%]	100.00	100.00	100.00	100.00	98.14	99.14	98.53	98.53	98.53	90.30	100.00	100.00	98.58
UCF [%]	100.00	100.00	100.00	100.00	100.00	99.92	100.00	100.00	100.00	91.77	100.00	100.00	99.30
LF [%]	88.94	86.38	93.22	81.23	93.63	98.05	97.52	97.48	97.89	89.19	99.59	99.84	93.61
OF [%]	100.00	100.00	100.00	89.17	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.11
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.01
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.08	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	8.23	0.00	0.00	0.70
XUF [%]	0.00	0.00	0.00	0.00	1.86	0.78	1.47	1.47	1.47	1.47	0.00	0.00	0.72

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Historical Summary

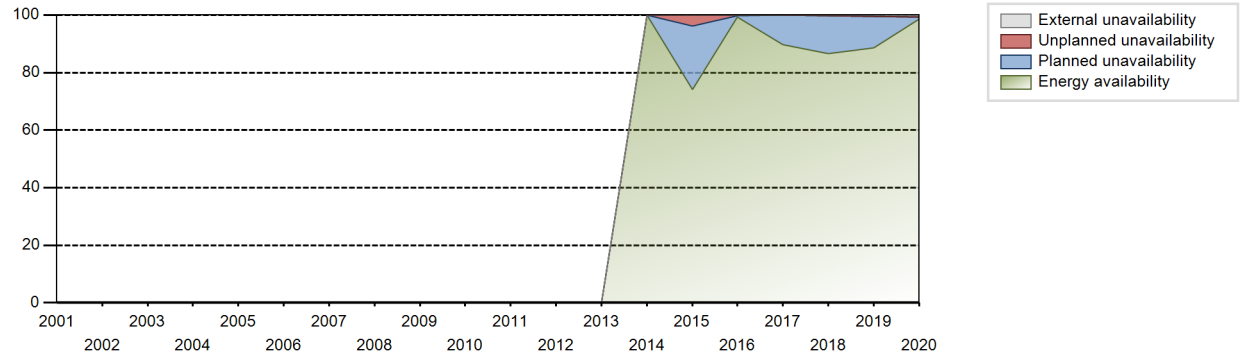
Lifetime energy generation	:	43301.49 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.31 %
Cumulative Energy Availability Factor (EAF)	:	89.66 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.65 %
Cumulative Unit Capability Factor (UCF)	:	89.87 %	Cumulative Planned Unavailability Factor (PUF)	:	9.47 %
Cumulative Load Factor (LF)	:	80.75 %	Cumulative Externally cause unavailability (XUF)	:	0.21 %
Cumulative Operating Factor (OF)	:	86.56 %			

Electricity Production (net) [GWh]

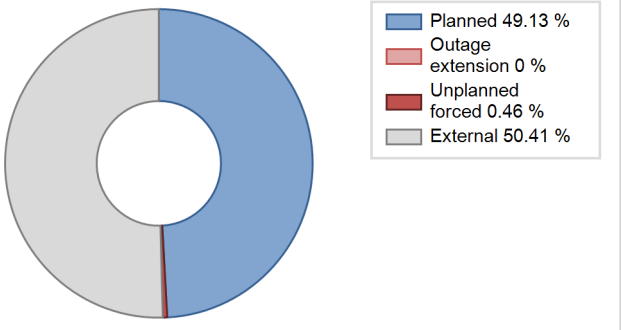


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2014	1033.07	949	1000	100.00	100.00	109.00	100.00	0.00	0.00	0.00	0.00
2015	6032.38	6514	1000	74.11	74.11	68.86	74.36	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

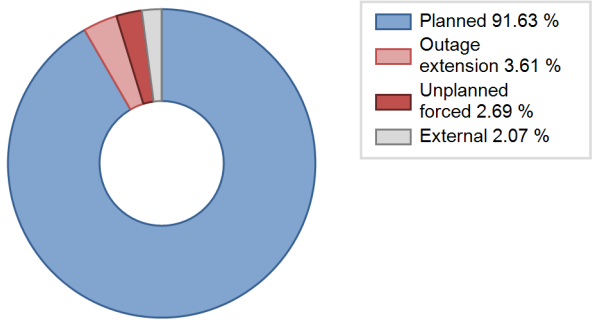
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2014 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					54	
C. Inspection, maintenance or repair combined with refuelling				783		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			78			357
Subtotal			78	783	54	357
Total		**78**			**1194**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2014 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		11
16. Steam generation systems		10
34. Miscellaneous Systems	78	13
42. Electrical Power Supply Systems		33
Total	**78**	**67**

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2020 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

Reactor type and model	:	PWR / CNP-1000
Thermal power	:	2905 MWth
Gross electrical power	:	1089 MWe
Reference unit power (net)	:	1000 MWe

Key Dates

Construction Date	:	2009-06-17
Grid Date	:	2015-08-06
Commercial Date	:	2015-10-16
Age at end of year	:	5 years

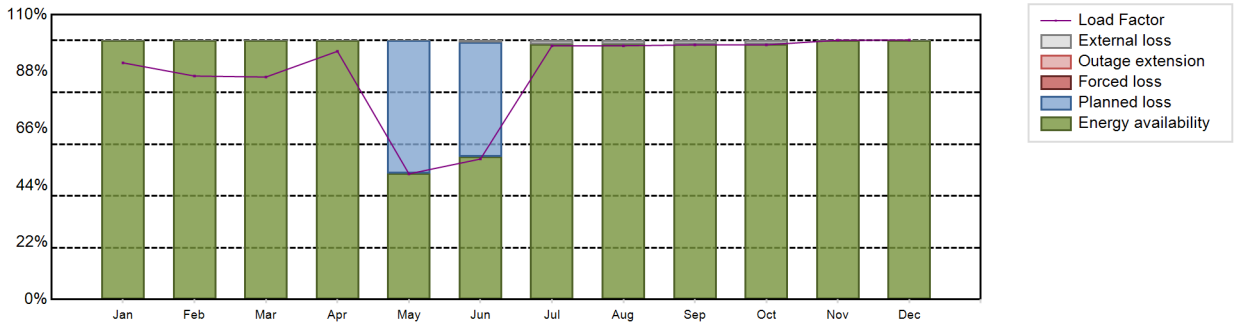
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.4
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	33
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]	:	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	:	4
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	7726.34 GW(e).h
Energy Availability Factor (EAF)	:	91.54 %
Unit Capability Factor (UCF)	:	92.02 %
Load Factor (LF)	:	87.96 %
Operating Factor (OF)	:	92.63 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	7.98 %
Externally cause unavailability (XUF)	:	0.49 %
Total off-line time	:	647 hours

Annual Summary



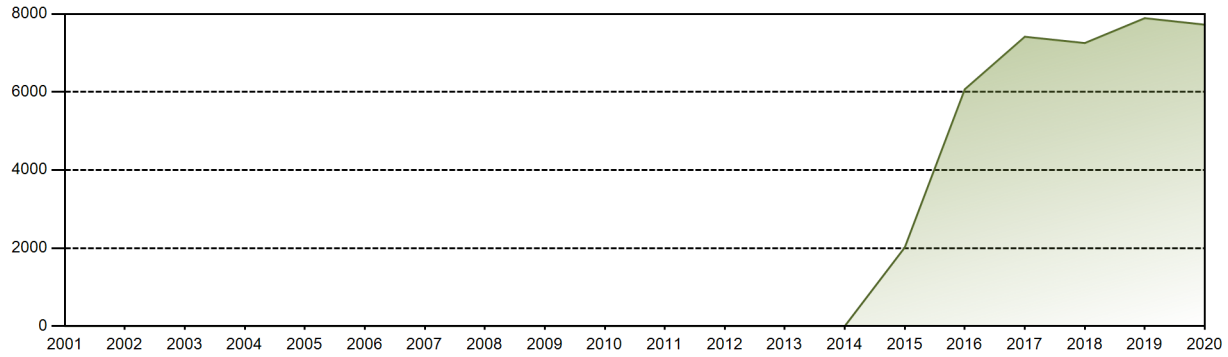
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	680.11	600.70	639.29	690.20	361.10	390.70	728.66	729.05	708.13	731.73	720.92	745.73	7726.34
EAF [%]	100.00	100.00	100.00	100.00	48.63	55.10	98.71	98.71	98.71	98.71	100.00	100.00	91.54
UCF [%]	100.00	100.00	100.00	100.00	48.63	55.79	100.00	100.00	100.00	100.00	100.00	100.00	92.02
LF [%]	91.41	86.31	85.93	95.86	48.53	54.26	97.94	97.99	98.35	98.35	100.13	100.23	87.96
OF [%]	100.00	100.00	100.00	100.00	49.46	62.36	100.00	100.00	100.00	100.00	100.00	100.00	92.63
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	0.00	51.37	44.21	0.00	0.00	0.00	0.00	0.00	0.00	7.98
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.69	1.29	1.29	1.29	1.29	0.00	0.00	0.49

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Historical Summary

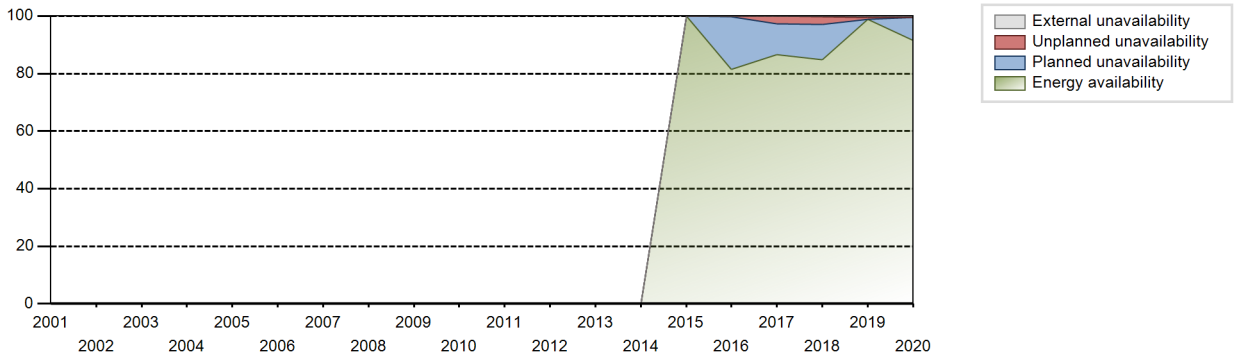
Lifetime energy generation	:	38372.34 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.35 %
Cumulative Energy Availability Factor (EAF)	:	89.02 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.22 %
Cumulative Unit Capability Factor (UCF)	:	89.24 %	Cumulative Planned Unavailability Factor (PUF)	:	9.54 %
Cumulative Load Factor (LF)	:	83.09 %	Cumulative Externally cause unavailability (XUF)	:	0.21 %
Cumulative Operating Factor (OF)	:	89.02 %			

Electricity Production (net) [GWh]

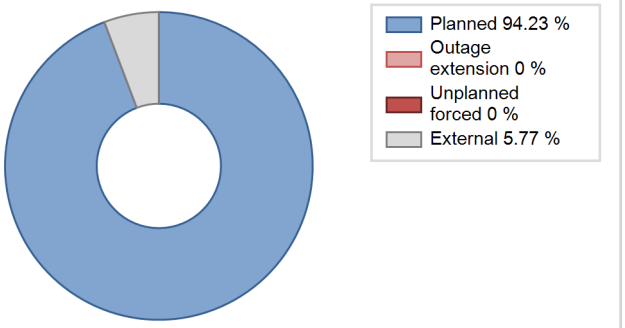


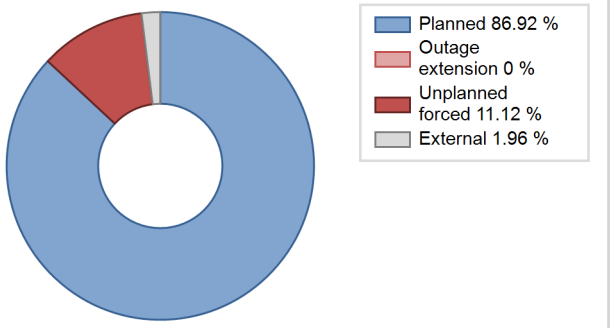
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2015	2017.22	3487	1000	100.00	100.00	87.75	100.00	0.00	0.00	0.00	0.00
2016	6070.84	6807	1000	81.46	81.46	69.11	77.49	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2015 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					93	
C. Inspection, maintenance or repair combined with refuelling	647			775		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						99
Subtotal	647			775	93	99
Total	**647**			**967**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2015 to 2020
	Hours Lost	Average hours lost per reactor-year
32. Feedwater and Main Steam System		2
33. Circulating Water System		72
41. Main Generator Systems		4
42. Electrical Power Supply Systems		11
Total		**89**

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2020 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

Reactor type and model	:	PWR / CNP-1000
Thermal power	:	2905 MWth
Gross electrical power	:	1089 MWe
Reference unit power (net)	:	1000 MWe

Key Dates

Construction Date	:	2010-12-31
Grid Date	:	2016-09-07
Commercial Date	:	2016-10-24
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]	:	2.4
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	33
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

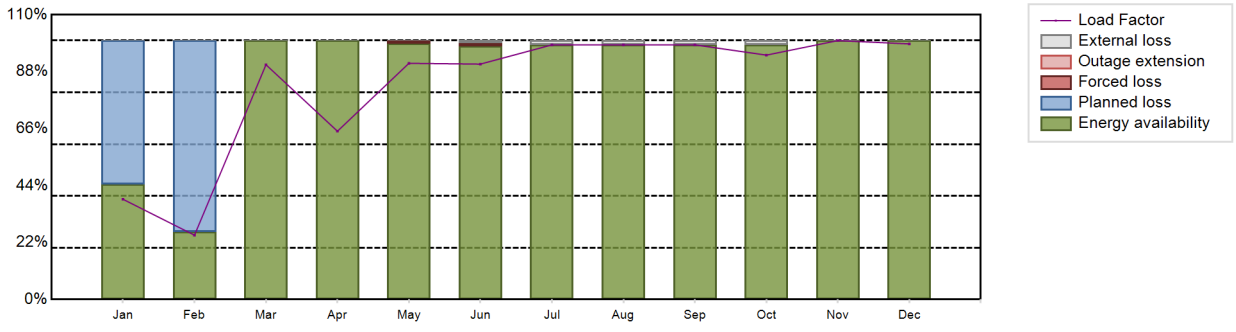
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.6
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	0.52
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP 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	:	4
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	7265.42 GW(e).h
Energy Availability Factor (EAF)	:	88.61 %
Unit Capability Factor (UCF)	:	89.24 %
Load Factor (LF)	:	82.71 %
Operating Factor (OF)	:	87.93 %

Forced Loss Rate (FLR)	:	0.22 %
Unplanned Capability Loss Factor (UCL)	:	0.2 %
Planned Unavailability Factor (PUF)	:	10.56 %
Externally cause unavailability (XUF)	:	0.63 %
Total off-line time	:	1060 hours

Annual Summary



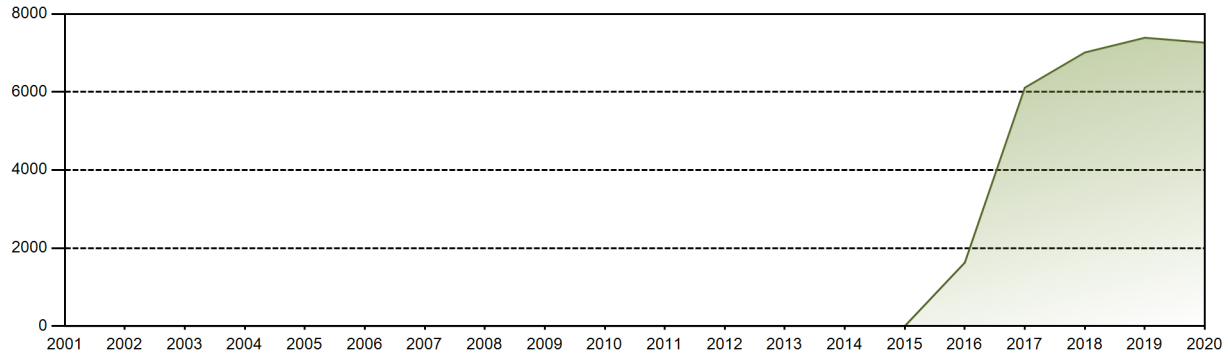
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	288.11	172.93	674.64	468.04	678.80	654.63	731.70	731.70	708.10	702.27	720.00	734.49	7265.42
EAF [%]	44.45	26.06	100.00	100.00	98.88	97.88	98.35	98.35	98.35	98.35	100.00	100.00	88.61
UCF [%]	44.45	26.06	100.00	100.00	98.88	98.76	100.00	100.00	100.00	100.00	100.00	100.00	89.24
LF [%]	38.73	24.85	90.68	65.01	91.24	90.92	98.35	98.35	98.35	94.39	100.00	98.72	82.71
OF [%]	45.30	36.06	100.00	71.11	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	87.93
FLR [%]	0.00	0.00	0.00	0.00	1.12	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.22
UCL [%]	0.00	0.00	0.00	0.00	1.12	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.20
PUF [%]	55.55	73.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.56
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.88	1.65	1.65	1.65	1.65	0.00	0.00	0.63

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Historical Summary

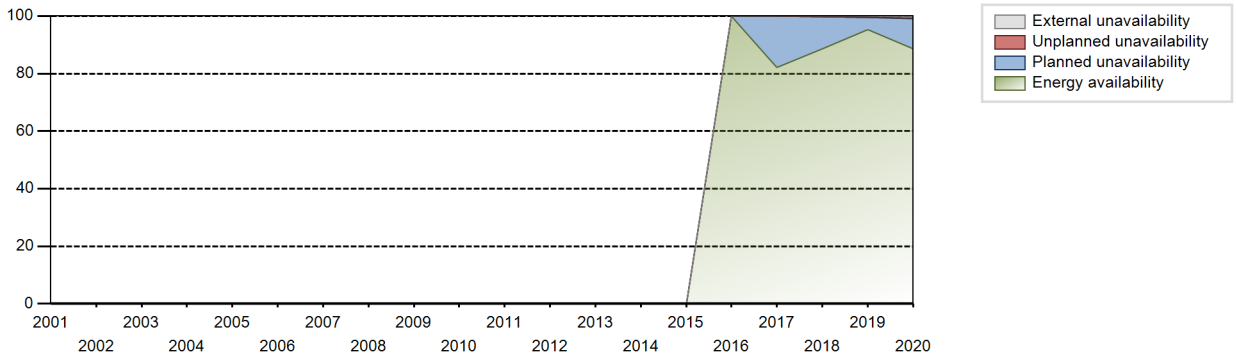
Lifetime energy generation	:	27943.42 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.05 %
Cumulative Energy Availability Factor (EAF)	:	89.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.05 %
Cumulative Unit Capability Factor (UCF)	:	89.45 %	Cumulative Planned Unavailability Factor (PUF)	:	10.51 %
Cumulative Load Factor (LF)	:	80.01 %	Cumulative Externally cause unavailability (XUF)	:	0.33 %
Cumulative Operating Factor (OF)	:	85.53 %			

Electricity Production (net) [GWh]

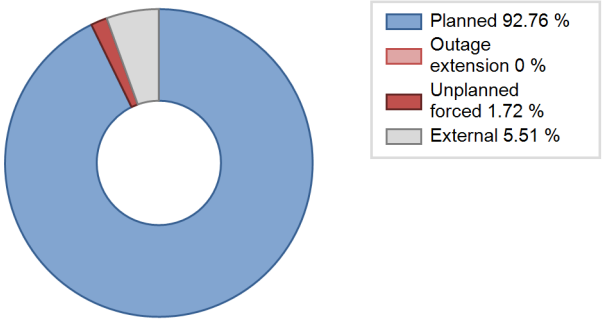


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	1628.31	1648	1000	100.00	100.00	98.60	100.00	0.00	0.00	0.00	0.00
2017	6110.93	6592	1000	82.12	82.12	69.76	75.25	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

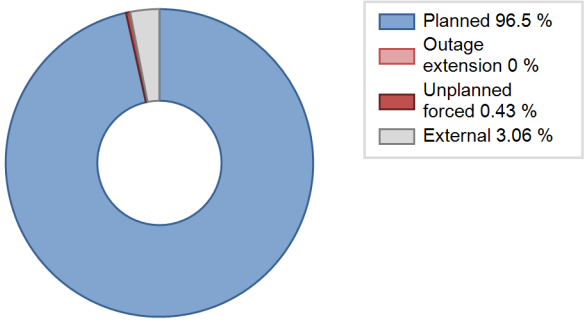
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling	852			862		
H. Nuclear regulatory requirements						2
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			208			404
Subtotal	852		208	862		406
Total	**1060**			**1268**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
34. Miscellaneous Systems	208	48
Total	**208**	**48**

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2020 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

Reactor type and model	:	PWR / CNP-1000
Thermal power	:	2905 MWth
Gross electrical power	:	1089 MWe
Reference unit power (net)	:	1000 MWe

Key Dates

Construction Date	:	2012-11-17
Grid Date	:	2017-07-29
Commercial Date	:	2017-09-17
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]	:	2.4
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	33
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

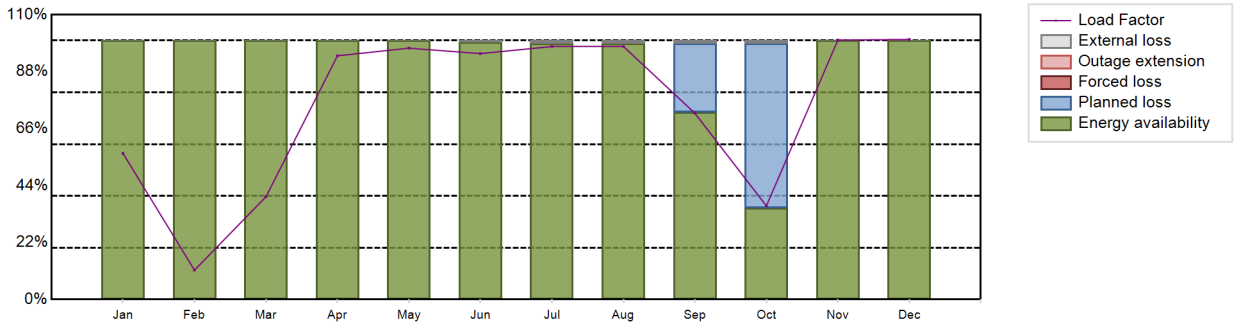
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.6
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	0.52
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP 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	:	4
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	6587.82 GW(e).h
Energy Availability Factor (EAF)	:	92.01 %
Unit Capability Factor (UCF)	:	92.47 %
Load Factor (LF)	:	75 %
Operating Factor (OF)	:	79.16 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	7.53 %
Externally cause unavailability (XUF)	:	0.45 %
Total off-line time	:	1831 hours

Annual Summary



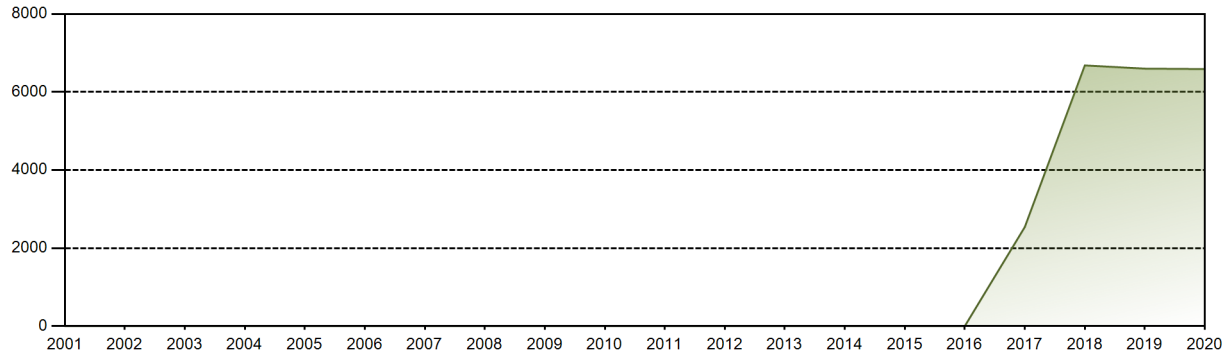
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	419.92	78.99	295.24	677.72	722.20	683.91	726.86	727.24	518.07	268.97	721.41	747.28	6587.82
EAF [%]	100.00	100.00	100.00	100.00	100.00	99.36	98.81	98.81	72.35	35.45	100.00	100.00	92.01
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	73.55	36.65	100.00	100.00	92.47
LF [%]	56.44	11.35	39.68	94.13	97.07	94.99	97.70	97.75	71.95	36.15	100.20	100.44	75.00
OF [%]	61.29	16.38	49.06	100.00	100.00	100.00	100.00	100.00	74.31	46.64	100.00	100.00	79.16
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	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	26.45	63.35	0.00	0.00	7.53
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.64	1.19	1.19	1.19	1.19	0.00	0.00	0.45

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Historical Summary

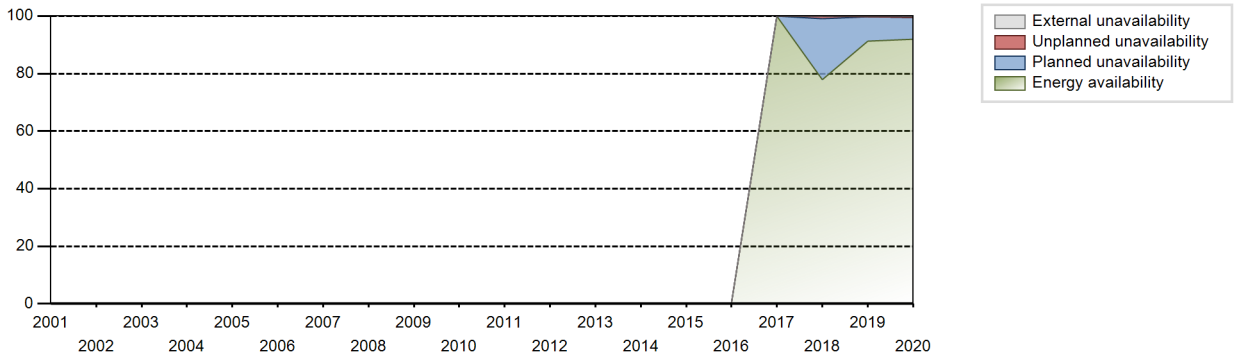
Lifetime energy generation	:	22409.6 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.27 %
Cumulative Energy Availability Factor (EAF)	:	88.05 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.24 %
Cumulative Unit Capability Factor (UCF)	:	88.34 %	Cumulative Planned Unavailability Factor (PUF)	:	11.43 %
Cumulative Load Factor (LF)	:	77.43 %	Cumulative Externally cause unavailability (XUF)	:	0.29 %
Cumulative Operating Factor (OF)	:	81.6 %			

Electricity Production (net) [GWh]

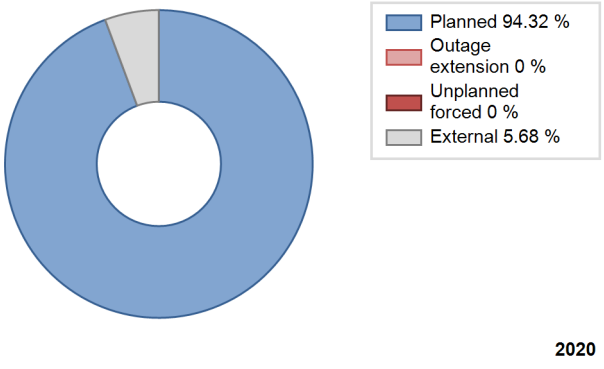


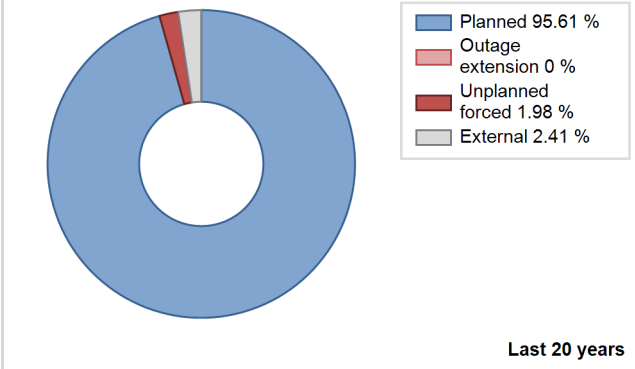
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2017	2540.07	2544	1000	100.00	100.00	100.00	100.00	0.00	0.00	0.00	0.00
2018	6682.09	6890	1000	77.79	77.91	76.28	78.65	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2017 to 2020		
	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	606			1029		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			1249			708
Subtotal	606		1249	1029	17	708
Total	**1855**			**1754**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2017 to 2020
	Hours Lost	Average hours lost per reactor-year
32. Feedwater and Main Steam System		17
34. Miscellaneous Systems	1249	416
Total	**1249**	**433**

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2020 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	:	3060 MWth
Gross electrical power	:	1150 MWe
Reference unit power (net)	:	1000 MWe

Key Dates

Construction Date	:	2015-05-07
Grid Date	:	2020-11-27
Commercial Date	:	2021-01-29
Age at end of year	:	0 years

Design Characteristics

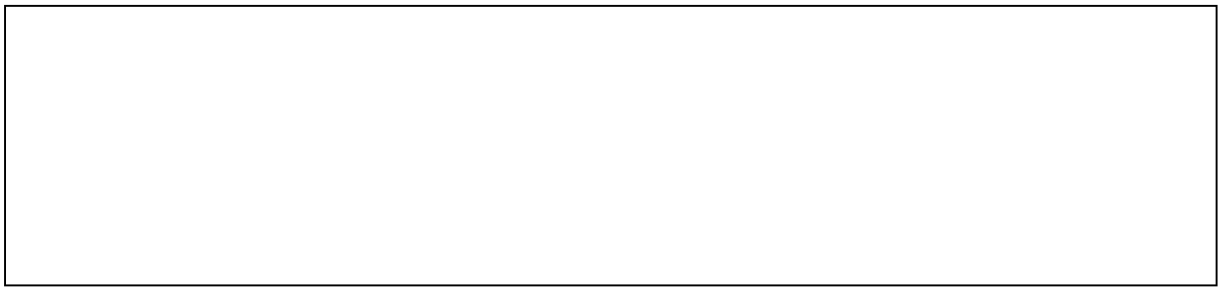
Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.4
Refuelling frequency [month]	:	18
Part of the core refuelled [%]	:	33.3
Average discharge burnup [MWd/t]	:	46410
Active core diameter [m]	:	3.228
Active core height/length [m]	:	3.66
Number of fissile fuel assemblies/bundles	:	177
Fuel linear heat generation rate [kW/m]	:	17.38
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]	:	328.5
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]	:	6.5
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	:	none

Annual Production Results (2020)

Net Energy Production	:	91.72 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	:	528 hours

Annual Summary

No data found



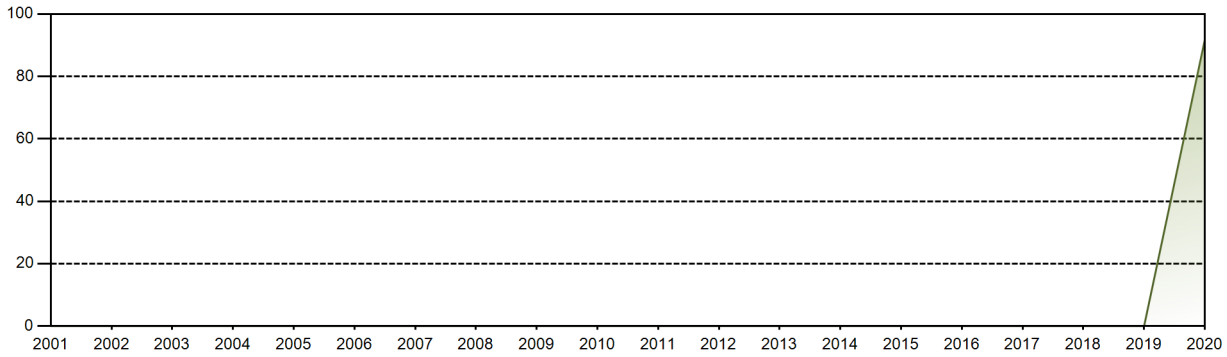
	Jan	Oct	Nov	Dec	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
GW(e)-h												
EAF [%]												
UCF [%]												
LF [%]												
OF [%]												
FLR [%]												
UCL [%]												
PUF [%]												
XUF [%]												

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Historical Summary

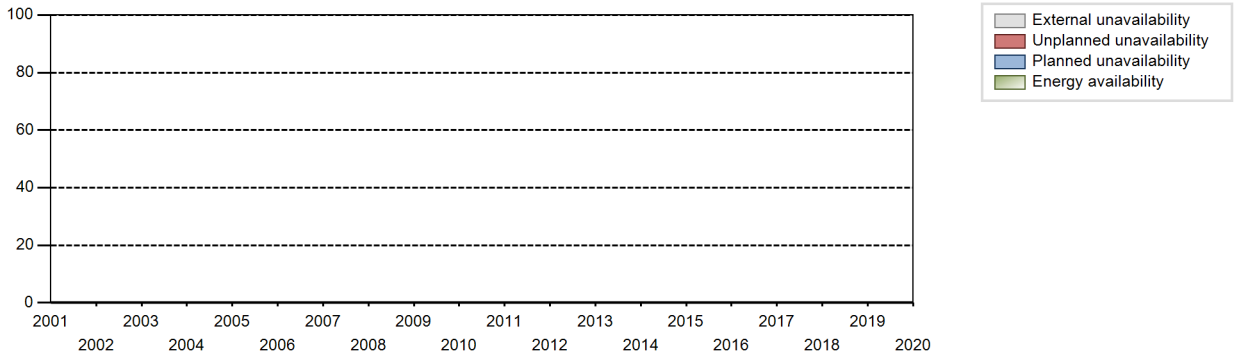
Lifetime energy generation	:	91.72 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	0 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	0 %	Cumulative Planned Unavailability Factor (PUF)	:	0 %
Cumulative Load Factor (LF)	:	0 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	0 %			

Electricity Production (net) [GWh]

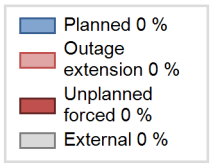


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]

Key Factors in Last 20 Years [%]



Energy Losses by Type



2020

No Data Available

Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2021 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
E. Testing of plant systems or components	527					
Subtotal	527					
Total	**527**			**0**		

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Equipment Related Unplanned Full Outages, Analysis by System		
System	2020	2021 to 2020
	Hours Lost	Average hours lost per reactor-year
Total		

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2020 Operating Experience

CN-30 HAIYANG-1 CHINA

Status at end of year	:	**Operational**
Operator	:	SDNPC (Shandong Nuclear Power Company, Ltd.)
Owner	:	CPIC (China Power Investment Corporation)
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	:	2 years

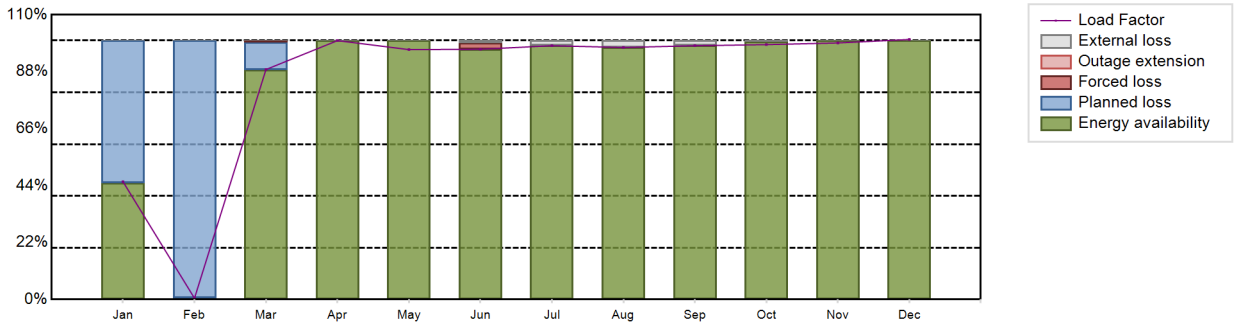
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.7239
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	:	none

Annual Production Results (2020)

Net Energy Production	:	8762.3 GW(e).h
Energy Availability Factor (EAF)	:	85.68 %
Unit Capability Factor (UCF)	:	86.31 %
Load Factor (LF)	:	85.26 %
Operating Factor (OF)	:	87.67 %
Forced Loss Rate (FLR)	:	0.31 %
Unplanned Capability Loss Factor (UCL)	:	0.27 %
Planned Unavailability Factor (PUF)	:	13.42 %
Externally cause unavailability (XUF)	:	0.63 %
Total off-line time	:	1083 hours

Annual Summary



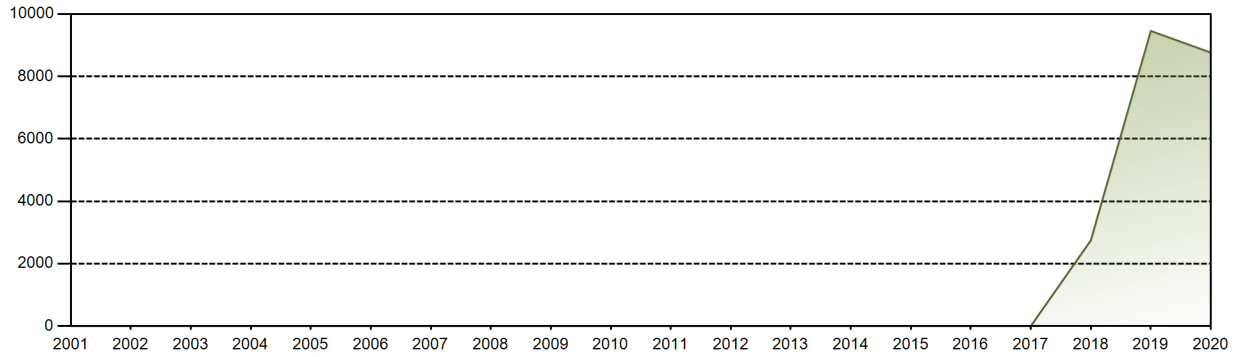
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	396.16	4.13	773.28	842.35	840.14	814.24	853.22	847.19	825.71	856.86	834.81	874.21	8762.30
EAF [%]	45.07	0.51	88.80	100.00	100.00	96.71	98.18	97.32	98.02	99.71	100.00	100.00	85.68
UCF [%]	45.07	0.51	88.80	100.00	100.00	97.52	100.00	100.00	99.99	100.00	100.00	100.00	86.31
LF [%]	45.51	0.51	88.83	99.99	96.51	96.66	98.02	97.32	98.02	98.44	99.10	100.43	85.26
OF [%]	45.43	4.02	100.00	100.00	100.00	98.75	100.00	100.00	100.00	100.00	100.00	100.00	87.67
FLR [%]	0.00	0.00	0.84	0.00	0.00	2.48	0.00	0.00	0.01	0.00	0.00	0.00	0.31
UCL [%]	0.00	0.00	0.75	0.00	0.00	2.48	0.00	0.00	0.01	0.00	0.00	0.00	0.27
PUF [%]	54.93	99.49	10.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.42
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.81	1.82	2.68	1.97	0.29	0.00	0.00	0.63

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Historical Summary

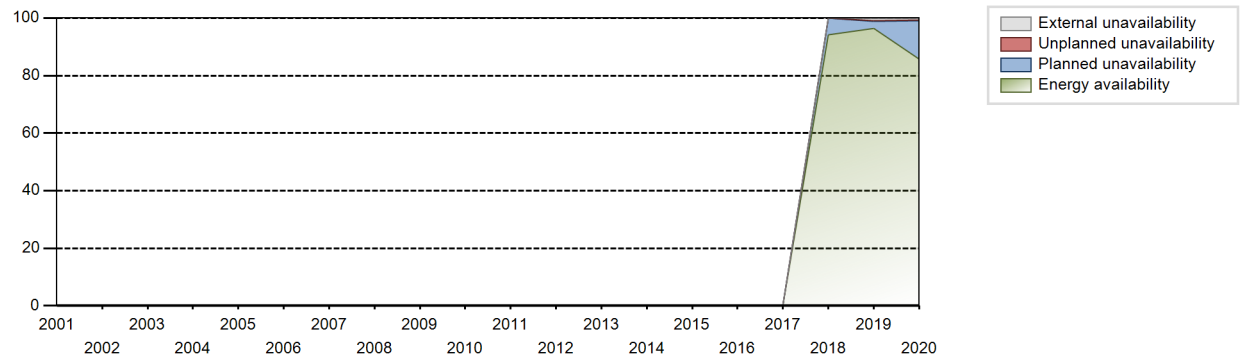
Lifetime energy generation	:	20965.05 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.21 %
Cumulative Energy Availability Factor (EAF)	:	91.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.2 %
Cumulative Unit Capability Factor (UCF)	:	92.02 %	Cumulative Planned Unavailability Factor (PUF)	:	7.78 %
Cumulative Load Factor (LF)	:	89.16 %	Cumulative Externally cause unavailability (XUF)	:	0.72 %
Cumulative Operating Factor (OF)	:	91.1 %			

Electricity Production (net) [GWh]

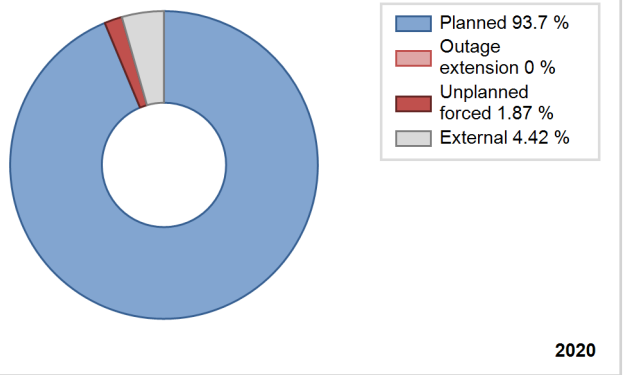


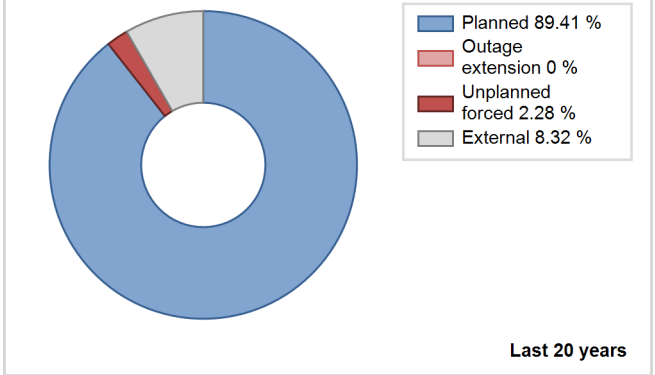
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	2746.03	2870	1170	94.20	94.20	93.91	95.29	0.00	0.00	5.80	0.00
2019	9456.75	8221	1170	96.46	97.39	92.27	93.85	0.16	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2018 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling	1074			495		
D. Inspection, maintenance or repair without refuelling				280		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						153
L. Human factor related					3	
Subtotal	1074			775	3	153
Total	**1074**			**931**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2018 to 2020
	Hours Lost	Average hours lost per reactor-year
41. Main Generator Systems		3
Total		**3**

Highlights (2020)

From Jan.14 to Mar.8,HY1 started the First Refueling Outage. During this year, HY1 has external load 11 times and internal load 10 times.There has an unplanned turbine trip at Jun.24 without shutdown. On Mar.3,the unit unplanned reduced power due to deal with the defects of main feedwater pump. On Sept.10,the unit unplanned reduced power to clean the temporary filter which is on the inlet of drain pump from MSR B shell-side. During May to October, the unit reduced power due to the seawater temperature.

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2020 Operating Experience

CN-31 HAIYANG-2 CHINA

Status at end of year	:	**Operational**
Operator	:	SDNPC (Shandong Nuclear Power Company, Ltd.)
Owner	:	CPIC (China Power Investment Corporation)
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	:	2 years

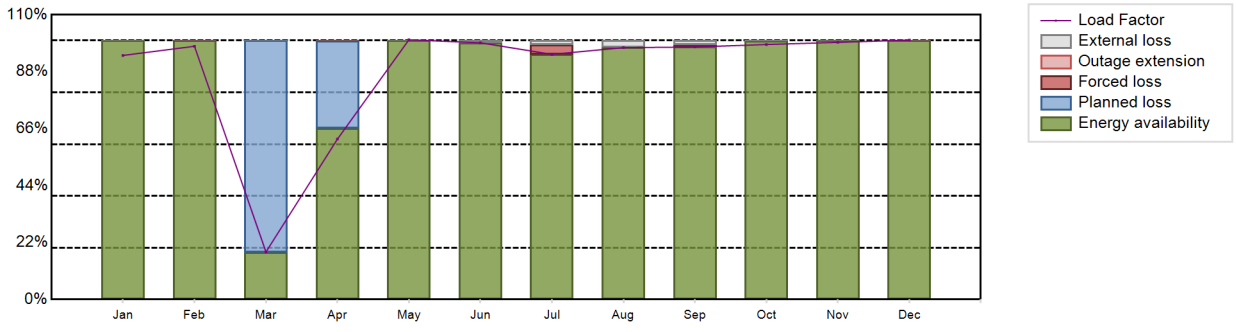
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.7239
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	:	none

Annual Production Results (2020)

Net Energy Production	:	9066.38 GW(e).h
Energy Availability Factor (EAF)	:	89.33 %
Unit Capability Factor (UCF)	:	89.91 %
Load Factor (LF)	:	88.22 %
Operating Factor (OF)	:	90.88 %
Forced Loss Rate (FLR)	:	0.44 %
Unplanned Capability Loss Factor (UCL)	:	0.4 %
Planned Unavailability Factor (PUF)	:	9.69 %
Externally cause unavailability (XUF)	:	0.58 %
Total off-line time	:	801 hours

Annual Summary



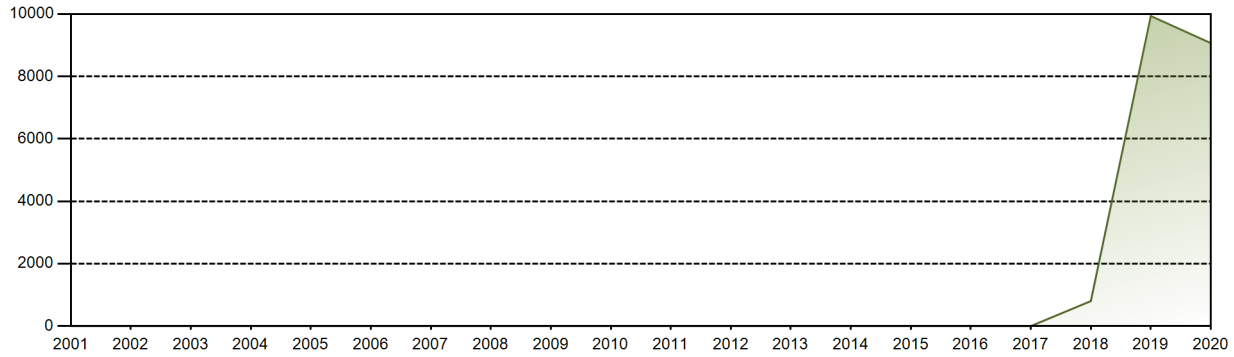
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	820.60	796.49	159.94	522.08	873.28	835.19	824.28	846.76	821.61	857.28	836.60	872.27	9066.38
EAF [%]	100.00	100.00	18.29	66.14	100.00	99.16	94.69	97.28	97.53	99.79	100.00	100.00	89.33
UCF [%]	100.00	100.00	18.29	66.14	100.00	100.00	96.38	99.91	99.04	100.00	100.00	100.00	89.91
LF [%]	94.27	97.81	18.37	61.98	100.32	99.14	94.69	97.28	97.53	98.48	99.31	100.21	88.22
OF [%]	100.00	100.00	18.28	75.00	100.00	100.00	98.25	100.00	100.00	100.00	100.00	100.00	90.88
FLR [%]	0.00	0.00	0.00	0.13	0.00	0.00	3.62	0.09	0.96	0.00	0.00	0.00	0.44
UCL [%]	0.00	0.00	0.00	0.09	0.00	0.00	3.62	0.09	0.96	0.00	0.00	0.00	0.40
PUF [%]	0.00	0.00	81.71	33.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.69
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.84	1.69	2.63	1.51	0.21	0.00	0.00	0.58

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Historical Summary

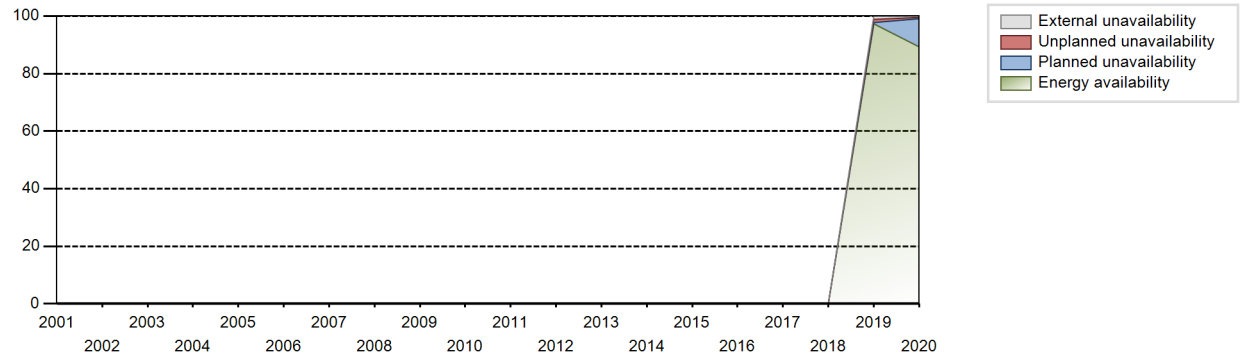
Lifetime energy generation	:	19802.32 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.87 %
Cumulative Energy Availability Factor (EAF)	:	93.35 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.82 %
Cumulative Unit Capability Factor (UCF)	:	94.16 %	Cumulative Planned Unavailability Factor (PUF)	:	5.01 %
Cumulative Load Factor (LF)	:	92.57 %	Cumulative Externally cause unavailability (XUF)	:	0.81 %
Cumulative Operating Factor (OF)	:	95.16 %			

Electricity Production (net) [GWh]

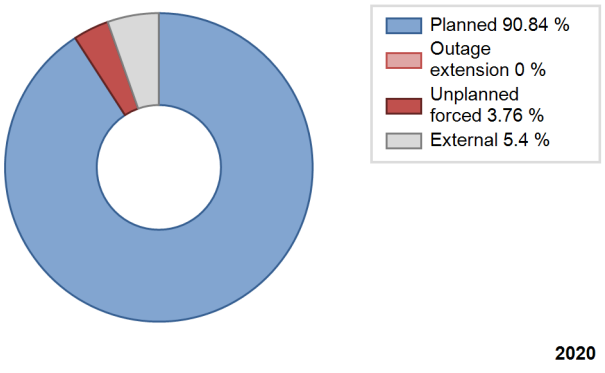


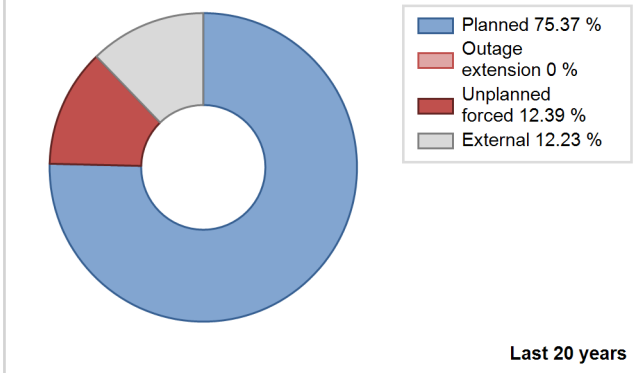
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2019	9935.22	8711	1170	97.38	98.43	96.94	99.44	1.25	1.25	0.32	1.05
2020	9066.38	7983	1170	89.33	89.91	88.22	90.88	0.44	0.40	9.69	0.58

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2019 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		13			31	
C. Inspection, maintenance or repair combined with refuelling	788			394		
D. Inspection, maintenance or repair without refuelling				195		
E. Testing of plant systems or components				47		
L. Human factor related					164	
Subtotal	788	13		636	195	
Total	**801**			**831**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2019 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		16
31. Turbine and auxiliaries		5
32. Feedwater and Main Steam System	13	151
Total	**13**	**172**

Highlights (2020)

From May.6 to Apr.15,HY2 started the First Refueling Outage. During this year, HY2 has external load 11 times and internal load 10 times.There has an unplanned shutdown event at May.6. To deal with the defects, the unit unplanned reduced power for 3 times and shutdown 1 time. On Apr.11,the unit reduced power because there is an abnormality by the chlorine ion in sewage discharge of SG. During May to October, the unit reduced power due to the seawater temperature.

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2020 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

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	:	2007-08-18
Grid Date	:	2013-02-17
Commercial Date	:	2013-06-06
Age at end of year	:	7 years

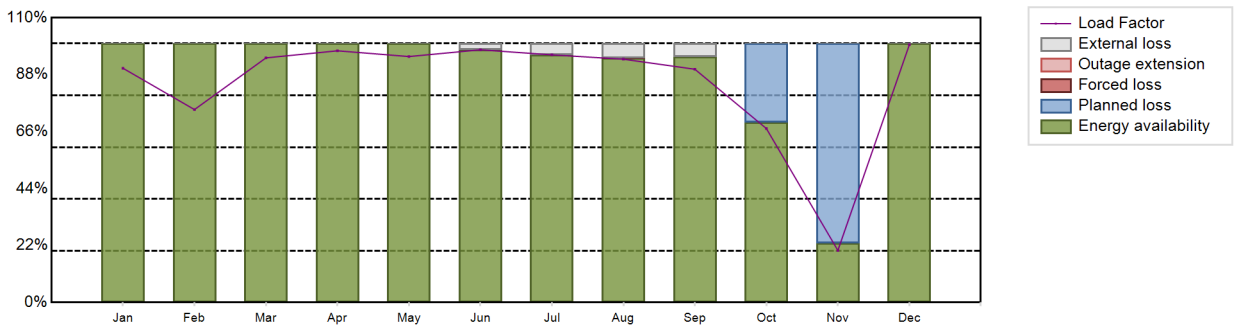
Design Characteristics

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]	:	2.43	**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]	:	NA	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	6.11
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 (2020)

Net Energy Production	:	7903.95 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	89.65 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	91.1 %	Planned Unavailability Factor (PUF)	:	8.9 %
Load Factor (LF)	:	84.81 %	Externally cause unavailability (XUF)	:	1.44 %
Operating Factor (OF)	:	91.45 %	Total off-line time	:	751 hours

Annual Summary



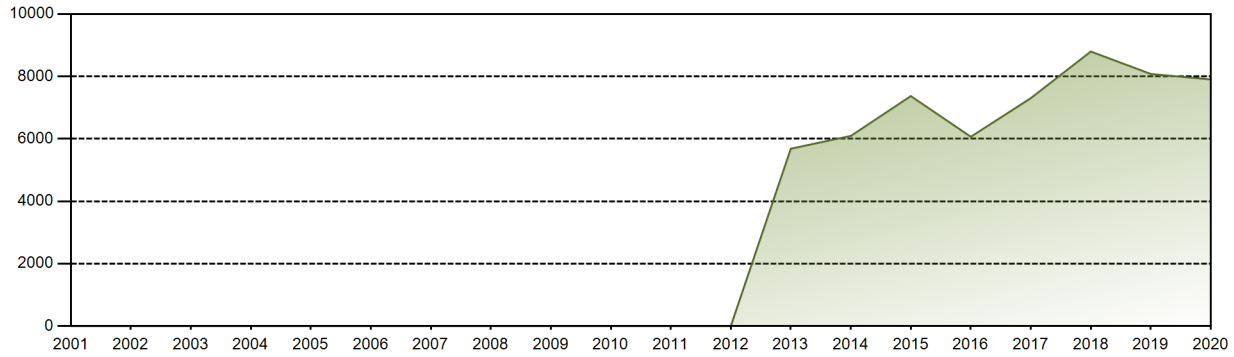
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	714.30	550.37	745.86	742.64	749.95	745.63	755.01	741.80	688.24	530.52	153.65	785.97	7903.95
EAF [%]	100.00	100.00	100.00	100.00	100.00	97.60	95.64	94.49	94.95	69.50	22.93	100.00	89.65
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	100.00	69.50	22.93	100.00	91.10
LF [%]	90.49	74.53	94.49	97.21	95.00	97.61	95.65	93.97	90.09	67.21	20.11	99.57	84.81
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	69.89	26.81	100.00	91.45
FLR [%]	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
UCL [%]	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
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.50	77.07	0.00	8.90
XUF [%]	0.00	0.00	0.00	0.00	0.00	2.40	4.36	5.49	5.05	0.00	0.00	0.00	1.44

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Historical Summary

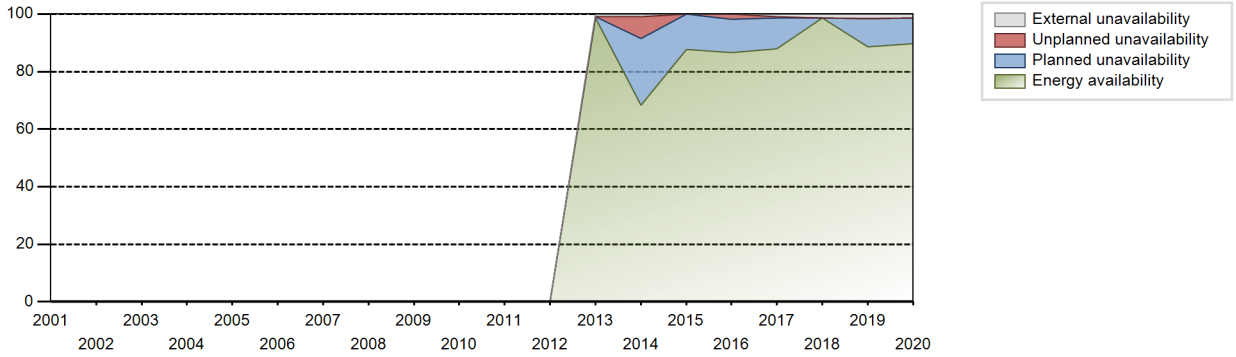
Lifetime energy generation	:	57389.57 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.43 %
Cumulative Energy Availability Factor (EAF)	:	87.69 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.32 %
Cumulative Unit Capability Factor (UCF)	:	88.62 %	Cumulative Planned Unavailability Factor (PUF)	:	10.06 %
Cumulative Load Factor (LF)	:	81.06 %	Cumulative Externally cause unavailability (XUF)	:	0.93 %
Cumulative Operating Factor (OF)	:	87.62 %			

Electricity Production (net) [GWh]

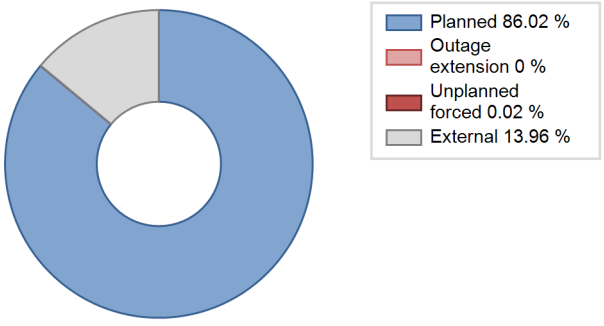


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2013	5683.38	7632	1061	98.62	99.55	102.41	100.00	0.01	0.01	0.44	0.94
2014	6093.20	6218	1061	68.38	69.32	65.56	70.98	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

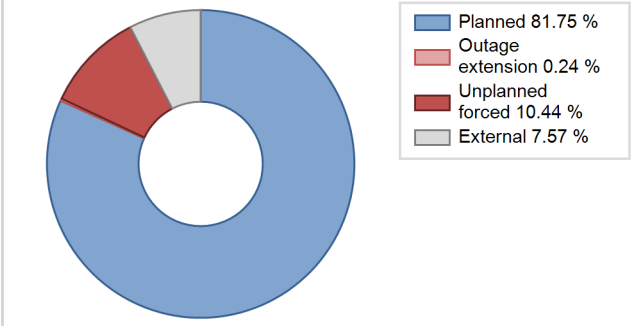
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2013 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					85	
C. Inspection, maintenance or repair combined with refuelling	751			829		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						173
Subtotal	751			829	85	173
Total	**751**			**1087**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2013 to 2020
	Hours Lost	Average hours lost per reactor-year
31. Turbine and auxiliaries		0
33. Circulating Water System		16
41. Main Generator Systems		63
42. Electrical Power Supply Systems		2
Total		**81**

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2020 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	:	7 years

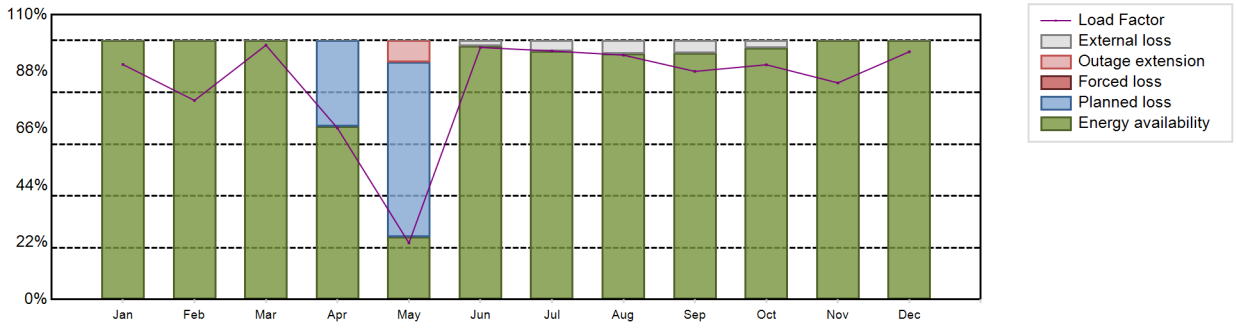
Design Characteristics

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]	:	2.43	**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]	:	NA	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	NA
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 (2020)

Net Energy Production	:	7767.35 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	89.29 %	Unplanned Capability Loss Factor (UCL)	:	0.7 %
Unit Capability Factor (UCF)	:	90.88 %	Planned Unavailability Factor (PUF)	:	8.42 %
Load Factor (LF)	:	83.34 %	Externally cause unavailability (XUF)	:	1.59 %
Operating Factor (OF)	:	91.28 %	Total off-line time	:	766 hours

Annual Summary



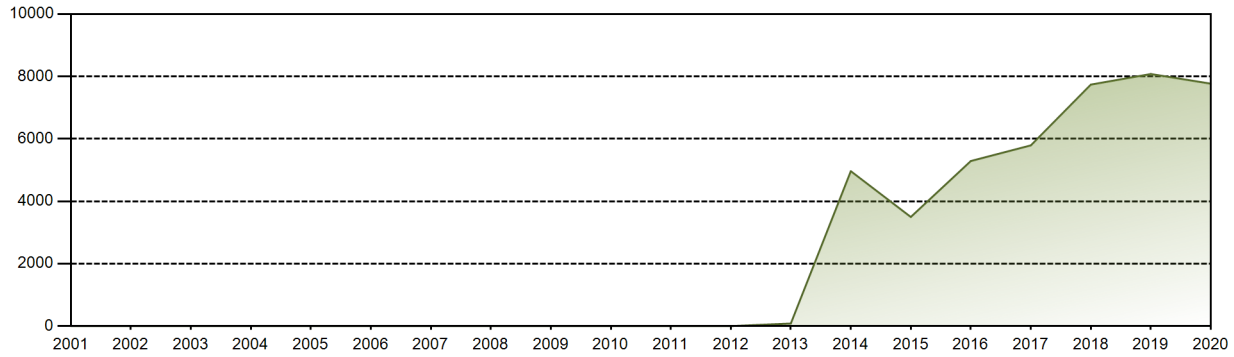
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	716.38	567.75	775.36	505.75	172.35	743.61	757.74	745.00	673.05	715.76	639.15	755.46	7767.35
EAF [%]	100.00	100.00	100.00	66.96	24.29	97.77	95.98	94.88	95.26	97.13	100.00	100.00	89.29
UCF [%]	100.00	100.00	100.00	66.96	24.29	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.88
LF [%]	90.75	76.88	98.22	66.20	21.83	97.34	95.99	94.38	88.11	90.67	83.67	95.70	83.34
OF [%]	100.00	100.00	100.00	67.36	28.63	100.00	100.00	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCL [%]	0.00	0.00	0.00	0.00	8.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70
PUF [%]	0.00	0.00	0.00	33.04	67.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.42
XUF [%]	0.00	0.00	0.00	0.00	0.00	2.23	4.02	5.12	4.74	2.87	0.00	0.00	1.59

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Historical Summary

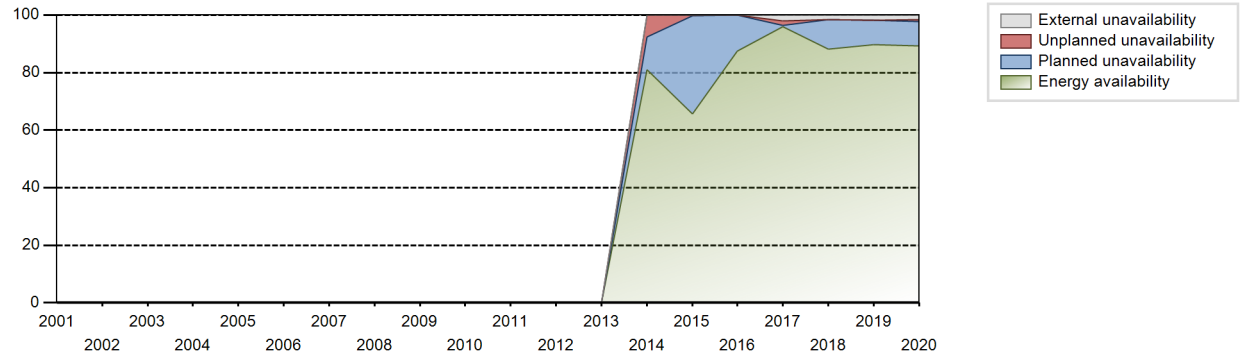
Lifetime energy generation	:	43200.72 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.9 %
Cumulative Energy Availability Factor (EAF)	:	85.55 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.15 %
Cumulative Unit Capability Factor (UCF)	:	86.64 %	Cumulative Planned Unavailability Factor (PUF)	:	12.21 %
Cumulative Load Factor (LF)	:	68.77 %	Cumulative Externally cause unavailability (XUF)	:	1.08 %
Cumulative Operating Factor (OF)	:	75.58 %			

Electricity Production (net) [GWh]

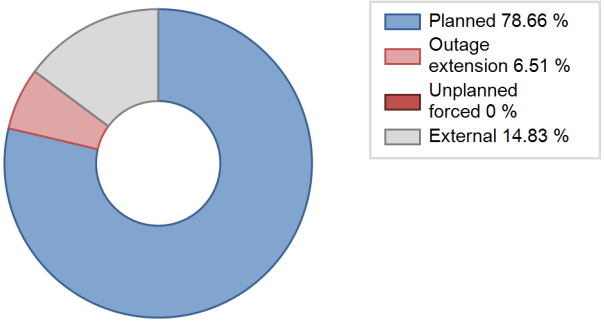


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2014	4963.31	5053	1061	81.06	81.06	72.46	79.81	8.62	7.64	11.29	0.00
2015	3496.01	3925	1061	65.63	65.63	37.61	44.81	0.16	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

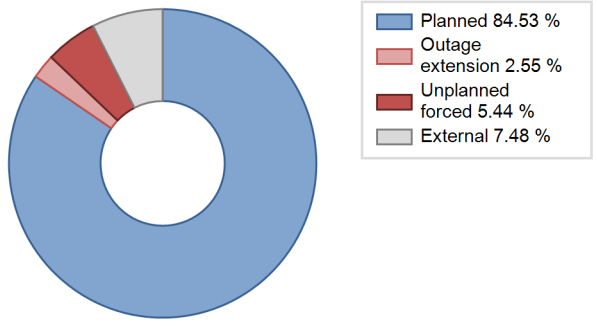
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2014 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		61			96	
C. Inspection, maintenance or repair combined with refuelling	705			1030		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						1001
Subtotal	705	61		1030	96	1001
Total	**766**			**2127**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2014 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	61	9
15. Reactor Cooling Systems		19
31. Turbine and auxiliaries		26
33. Circulating Water System		37
Total	**61**	**91**

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2020 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	:	5 years

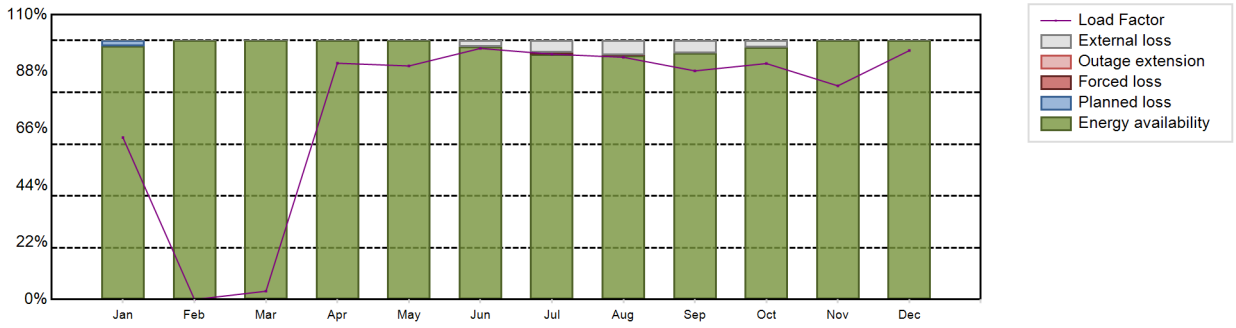
Design Characteristics

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]	:	12	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	33	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	-	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	6.11
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 (2020)

Net Energy Production	:	6938.56 GW(e).h	Forced Loss Rate (FLR)	:	0.09 %
Energy Availability Factor (EAF)	:	98.05 %	Unplanned Capability Loss Factor (UCL)	:	0.09 %
Unit Capability Factor (UCF)	:	99.73 %	Planned Unavailability Factor (PUF)	:	0.18 %
Load Factor (LF)	:	74.45 %	Externally cause unavailability (XUF)	:	1.69 %
Operating Factor (OF)	:	81.01 %	Total off-line time	:	1668 hours

Annual Summary



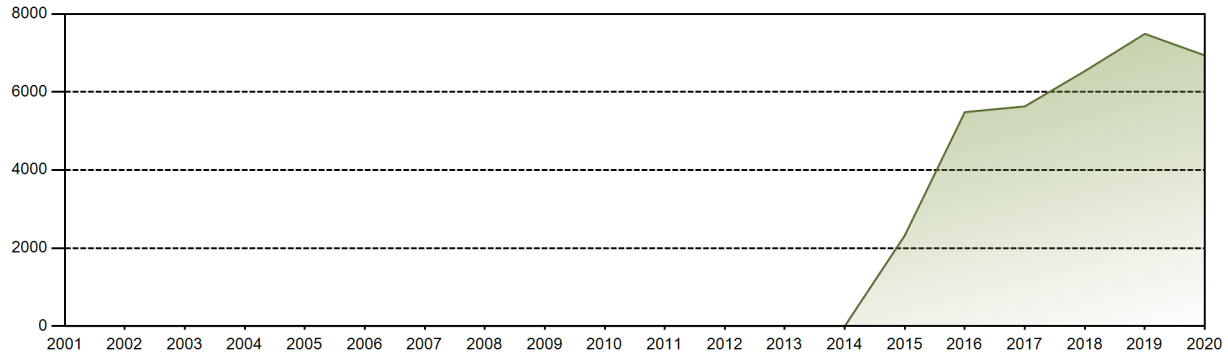
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	493.49	0.00	25.31	697.19	712.08	740.79	747.90	738.46	674.53	719.46	630.39	758.96	6938.56
EAF [%]	97.87	100.00	100.00	100.00	100.00	97.54	94.75	94.12	95.13	97.30	100.00	100.00	98.05
UCF [%]	97.87	100.00	100.00	100.00	100.00	100.00	99.34	99.65	100.00	100.00	100.00	100.00	99.73
LF [%]	62.52	0.00	3.21	91.27	90.21	96.97	94.75	93.55	88.30	91.14	82.52	96.15	74.45
OF [%]	64.65	0.00	4.70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	81.01
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.35	0.00	0.00	0.00	0.00	0.09
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.35	0.00	0.00	0.00	0.00	0.09
PUF [%]	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18
XUF [%]	0.00	0.00	0.00	0.00	0.00	2.46	4.59	5.53	4.87	2.70	0.00	0.00	1.69

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Historical Summary

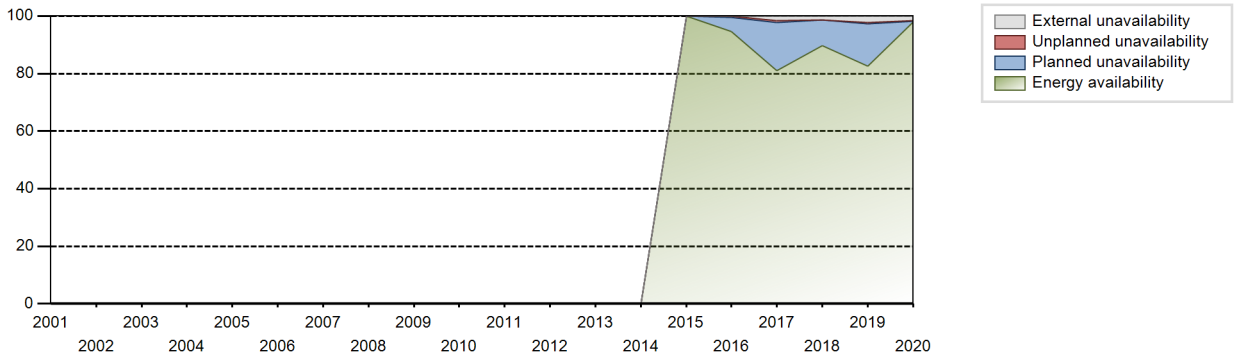
Lifetime energy generation	:	34386.39 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.35 %
Cumulative Energy Availability Factor (EAF)	:	89.9 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.32 %
Cumulative Unit Capability Factor (UCF)	:	91.22 %	Cumulative Planned Unavailability Factor (PUF)	:	8.46 %
Cumulative Load Factor (LF)	:	67.35 %	Cumulative Externally cause unavailability (XUF)	:	1.32 %
Cumulative Operating Factor (OF)	:	73.62 %			

Electricity Production (net) [GWh]

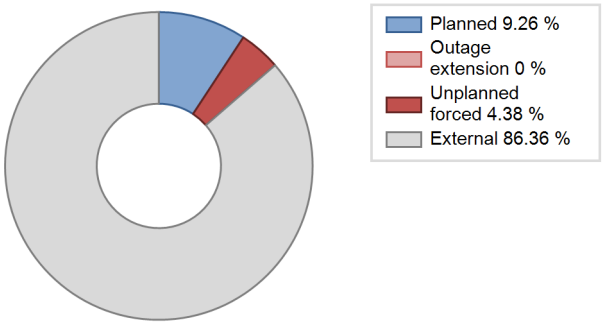


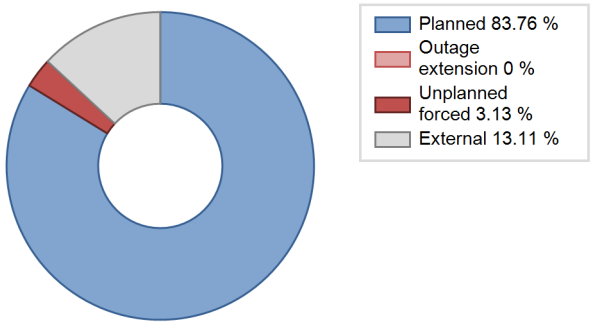
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2015	2322.53	2835	1061	99.98	99.98	43.20	47.98	0.01	0.01	0.01	0.00
2016	5483.99	5764	1061	94.69	94.69	58.84	65.62	0.55	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2015 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					16	
C. Inspection, maintenance or repair combined with refuelling				718		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			1668			1581
Subtotal			1668	718	16	1581
Total		**1668**			**2315**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2015 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	1668	286
12. Reactor I&C Systems		8
33. Circulating Water System		7
Total	**1668**	**301**

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2020 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	:	4 years

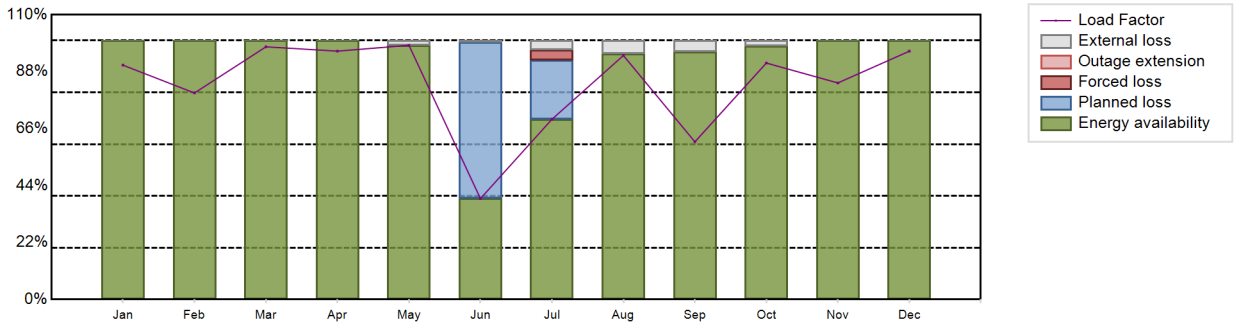
Design Characteristics

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]	:	12	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	33	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	NA	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]	:	NA	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 (2020)

Net Energy Production	:	7755.39 GW(e).h	Forced Loss Rate (FLR)	:	0.37 %
Energy Availability Factor (EAF)	:	91.28 %	Unplanned Capability Loss Factor (UCL)	:	0.35 %
Unit Capability Factor (UCF)	:	92.78 %	Planned Unavailability Factor (PUF)	:	6.87 %
Load Factor (LF)	:	83.21 %	Externally cause unavailability (XUF)	:	1.5 %
Operating Factor (OF)	:	93.16 %	Total off-line time	:	601 hours

Annual Summary



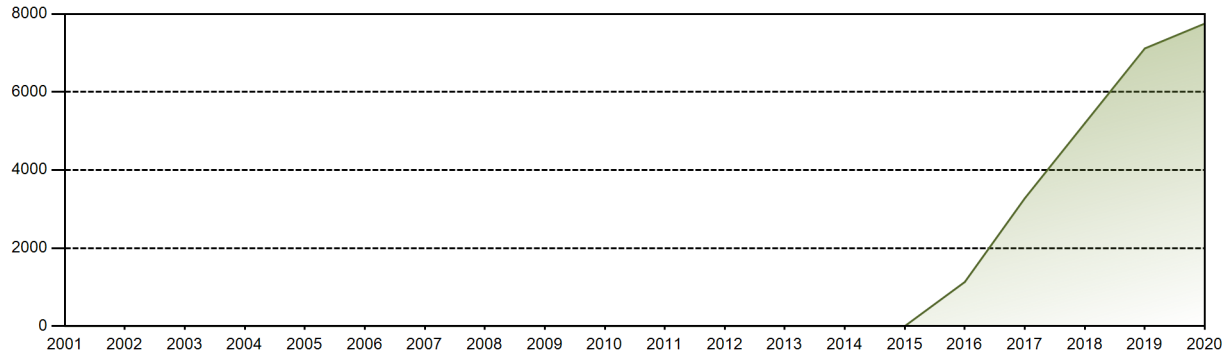
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	714.47	589.09	770.42	732.87	775.05	297.71	549.43	743.97	465.31	721.00	639.03	757.03	7755.39
EAF [%]	100.00	100.00	100.00	100.00	98.18	38.97	69.61	94.79	95.54	97.83	100.00	100.00	91.28
UCF [%]	100.00	100.00	100.00	100.00	100.00	39.66	73.13	100.00	100.00	100.00	100.00	100.00	92.78
LF [%]	90.51	79.77	97.60	95.94	98.18	38.97	69.60	94.25	60.91	91.34	83.65	95.90	83.21
OF [%]	100.00	100.00	100.00	100.00	100.00	40.00	77.28	100.00	100.00	100.00	100.00	100.00	93.16
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	5.33	0.00	0.00	0.00	0.00	0.00	0.37
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	4.12	0.00	0.00	0.00	0.00	0.00	0.35
PUF [%]	0.00	0.00	0.00	0.00	0.00	60.34	22.75	0.00	0.00	0.00	0.00	0.00	6.87
XUF [%]	0.00	0.00	0.00	0.00	1.82	0.69	3.52	5.21	4.46	2.17	0.00	0.00	1.50

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Historical Summary

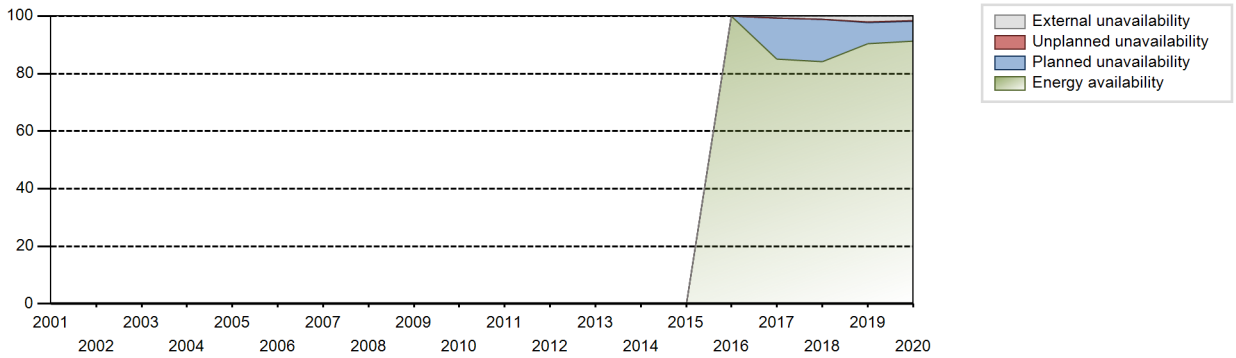
Lifetime energy generation	:	24985.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.17 %
Cumulative Energy Availability Factor (EAF)	:	89.21 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.16 %
Cumulative Unit Capability Factor (UCF)	:	90.37 %	Cumulative Planned Unavailability Factor (PUF)	:	9.47 %
Cumulative Load Factor (LF)	:	57.81 %	Cumulative Externally cause unavailability (XUF)	:	1.16 %
Cumulative Operating Factor (OF)	:	63.23 %			

Electricity Production (net) [GWh]

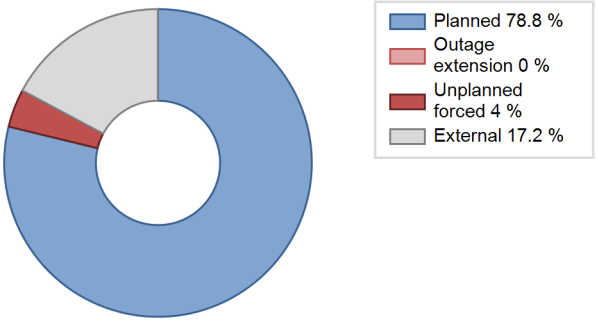


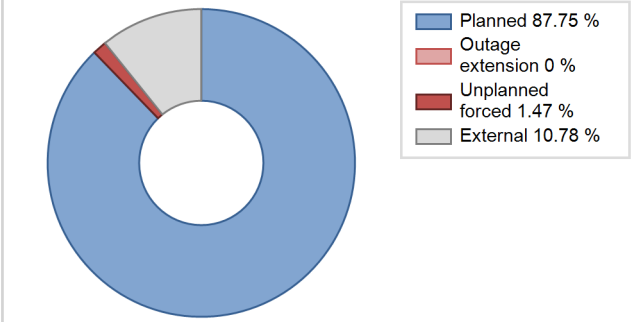
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	1130.44	1200	1000	99.99	99.99	22.01	23.36	0.00	0.00	0.01	0.00
2017	3276.06	3638	1061	85.13	85.76	35.25	41.53	0.17	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		31			10	
C. Inspection, maintenance or repair combined with refuelling	570			804		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						1833
Subtotal	570	31		804	10	1833
Total	**601**			**2647**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
32. Feedwater and Main Steam System		4
33. Circulating Water System	31	6
Total	**31**	**10**

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2020 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	:	18 years

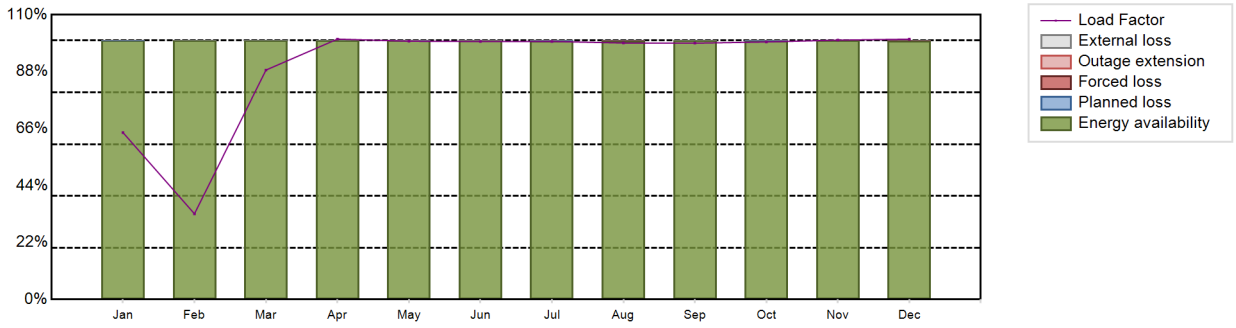
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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 (2020)

Net Energy Production	:	7556.54 GW(e).h
Energy Availability Factor (EAF)	:	99.99 %
Unit Capability Factor (UCF)	:	99.99 %
Load Factor (LF)	:	90.55 %
Operating Factor (OF)	:	100 %
Forced Loss Rate (FLR)	:	0.01 %
Unplanned Capability Loss Factor (UCL)	:	0.01 %
Planned Unavailability Factor (PUF)	:	0.01 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	0 hours

Annual Summary



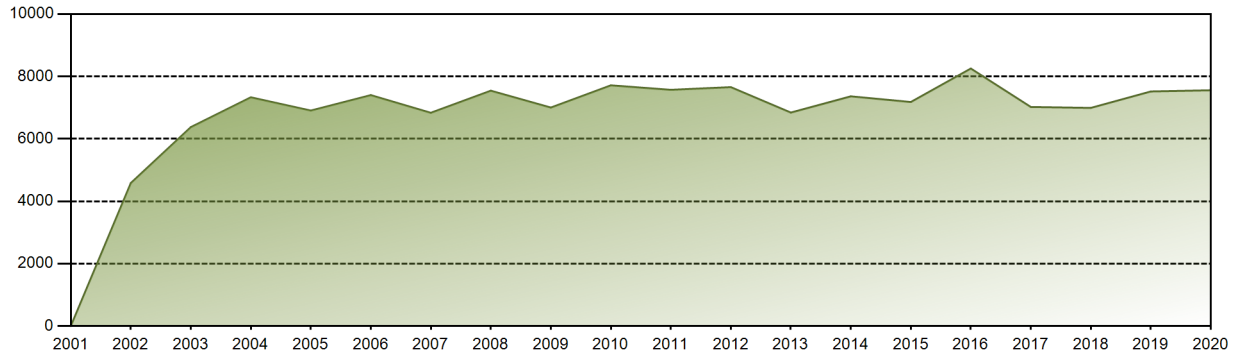
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	455.80	218.86	626.41	687.94	705.09	681.58	704.44	700.21	677.17	703.11	685.27	710.65	7556.54
EAF [%]	100.00	100.00	100.00	100.00	99.99	100.00	99.96	99.98	100.00	99.98	100.00	99.96	99.99
UCF [%]	100.00	100.00	100.00	100.00	99.99	100.00	99.96	99.98	100.00	99.98	100.00	99.96	99.99
LF [%]	64.49	33.10	88.63	100.58	99.76	99.65	99.67	99.07	99.00	99.48	100.19	100.54	90.55
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	0.02	0.00	0.00	0.00	0.04	0.01
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.04	0.01
PUF [%]	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.02	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

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Historical Summary

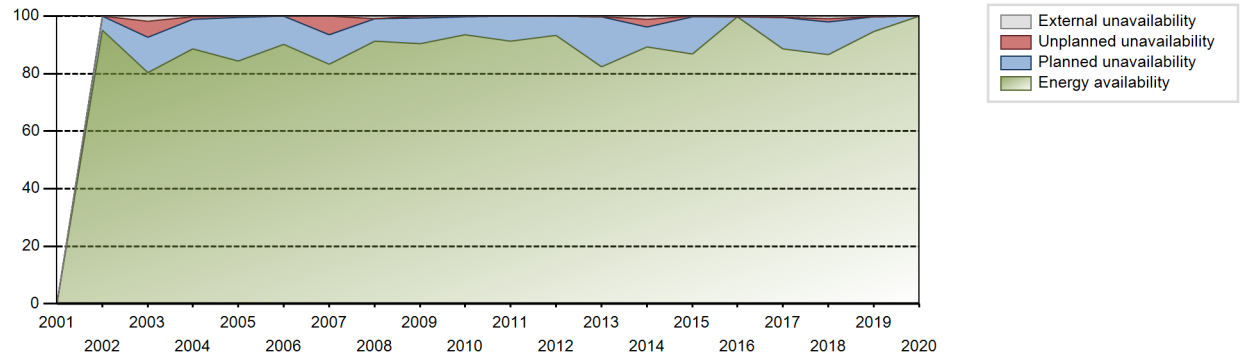
Lifetime energy generation	:	136045.33 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.44 %
Cumulative Energy Availability Factor (EAF)	:	89.87 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.99 %
Cumulative Unit Capability Factor (UCF)	:	90.24 %	Cumulative Planned Unavailability Factor (PUF)	:	8.77 %
Cumulative Load Factor (LF)	:	88.22 %	Cumulative Externally cause unavailability (XUF)	:	0.37 %
Cumulative Operating Factor (OF)	:	90.7 %			

Electricity Production (net) [GWh]



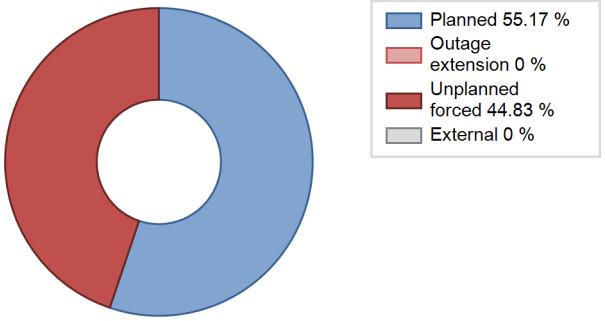
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	4583.85	5184	938	95.06	95.06	93.54	99.51	0.00	0.00	4.94	0.00
2003	6375.05	7215	938	80.36	82.30	77.58	82.36	6.17	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	0.01	0.01	0.01	0.00

Key Factors in Last 20 Years [%]

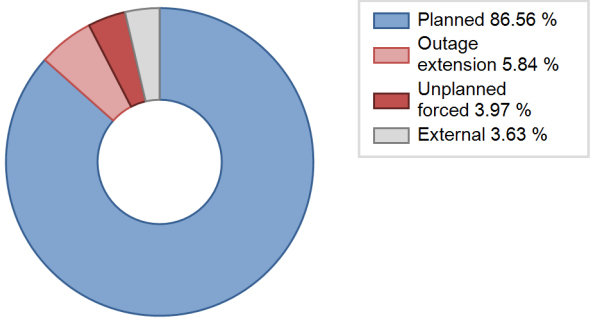


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2002 to 2020 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				732	13	
J. Grid limitation, failure or grid unavailability						1
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						21
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						3
Subtotal				732	84	25
Total		**0**			**841**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2002 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		1
15. Reactor Cooling Systems		32
16. Steam generation systems		3
31. Turbine and auxiliaries		3
42. Electrical Power Supply Systems		33
Total		**72**

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2020 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	:	18 years

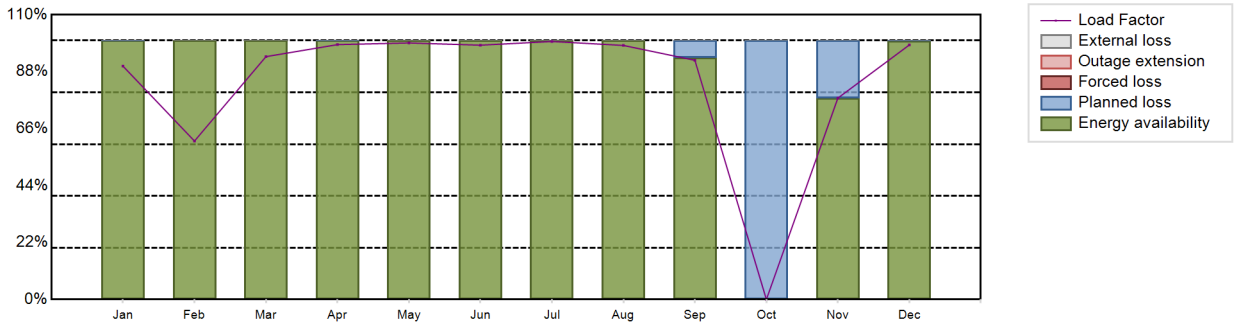
Design Characteristics

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]	:	16	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	40	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	46000	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 (2020)

Net Energy Production	:	7007.26 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	89.17 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	89.17 %	Planned Unavailability Factor (PUF)	:	10.83 %
Load Factor (LF)	:	83.97 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	90.02 %	Total off-line time	:	877 hours

Annual Summary



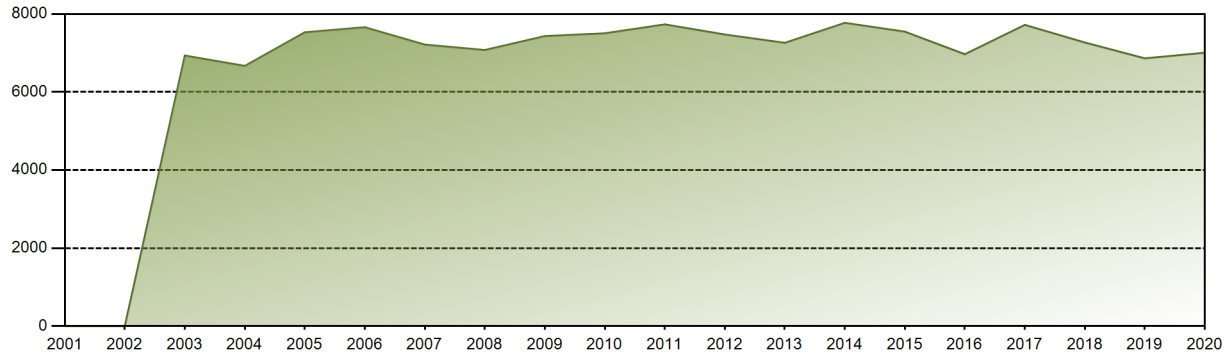
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	637.02	404.68	663.03	673.36	700.41	671.88	704.33	693.60	631.92	0.00	532.16	694.88	7007.26
EAF [%]	99.99	100.00	100.00	99.99	100.00	100.00	100.00	100.00	93.42	0.00	77.81	99.99	89.17
UCF [%]	99.99	100.00	100.00	99.99	100.00	100.00	100.00	100.00	93.42	0.00	77.81	99.99	89.17
LF [%]	90.13	61.20	93.81	98.44	99.10	98.23	99.65	98.13	92.39	0.00	77.80	98.31	83.97
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.75	0.00	87.78	100.00	90.02
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 [%]	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	6.58	100.00	22.19	0.01	10.83
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

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Historical Summary

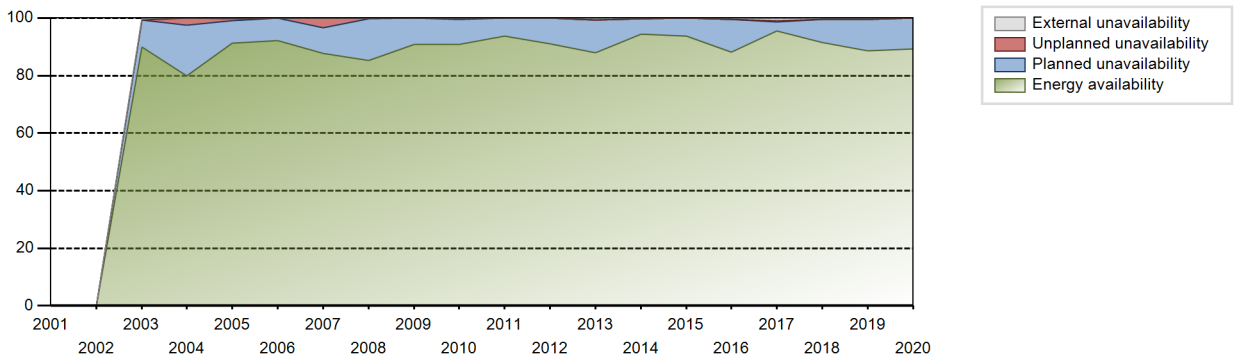
Lifetime energy generation	:	131709.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.45 %
Cumulative Energy Availability Factor (EAF)	:	90.08 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.45 %
Cumulative Unit Capability Factor (UCF)	:	90.33 %	Cumulative Planned Unavailability Factor (PUF)	:	9.22 %
Cumulative Load Factor (LF)	:	88.44 %	Cumulative Externally cause unavailability (XUF)	:	0.25 %
Cumulative Operating Factor (OF)	:	90.32 %			

Electricity Production (net) [GWh]



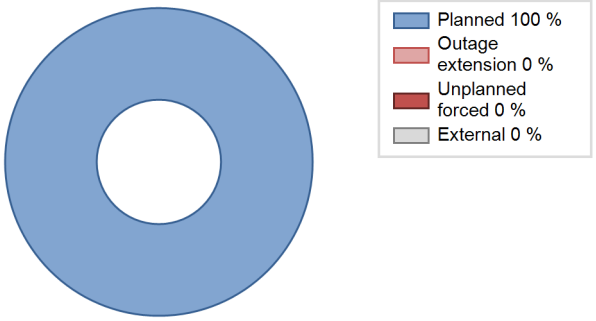
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2003	6934.88	7494	938	89.94	90.58	84.40	85.55	0.08	0.08	9.35	0.64
2004	6669.41	7109	938	79.80	79.85	80.95	80.93	2.01	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

Key Factors in Last 20 Years [%]

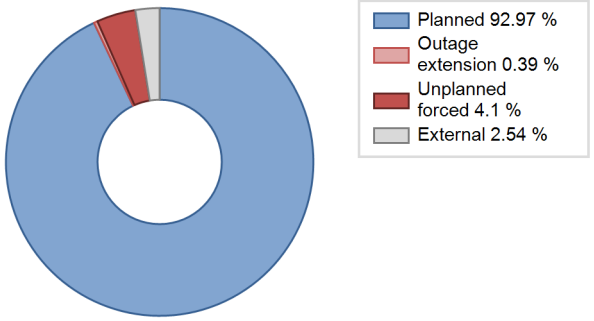


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2003 to 2020 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	877			734		
D. Inspection, maintenance or repair without refuelling				15		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						49
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	877			749	23	51
Total	**877**			**823**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2003 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		1
13. Reactor Auxiliary Systems		2
31. Turbine and auxiliaries		0
32. Feedwater and Main Steam System		3
33. Circulating Water System		2
41. Main Generator Systems		18
Total		**26**

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2020 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	:	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]	:	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

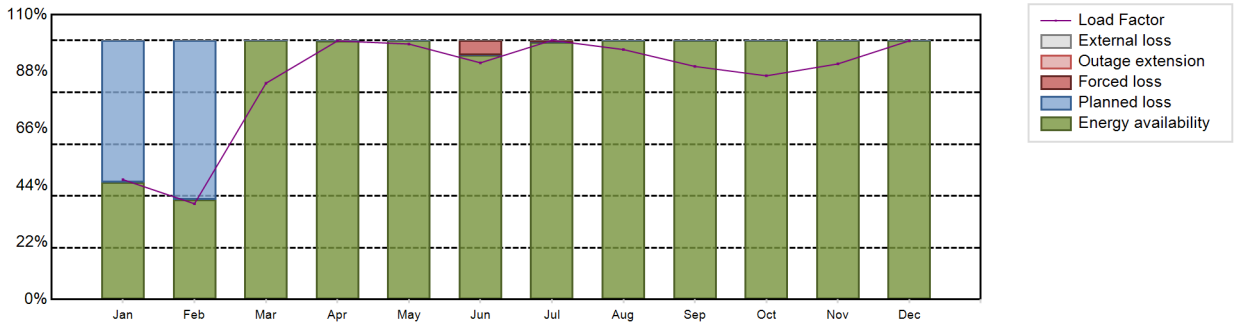
Operating coolant pressure [MPa]	:	15.81
Reactor outlet temperature [°C]	:	327.6
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	0.52
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
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	:	none

Annual Production Results (2020)

Net Energy Production	:	7539.38 GW(e).h
Energy Availability Factor (EAF)	:	89.98 %
Unit Capability Factor (UCF)	:	89.98 %
Load Factor (LF)	:	85.23 %
Operating Factor (OF)	:	90.93 %

Forced Loss Rate (FLR)	:	0.56 %
Unplanned Capability Loss Factor (UCL)	:	0.51 %
Planned Unavailability Factor (PUF)	:	9.51 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	797 hours

Annual Summary



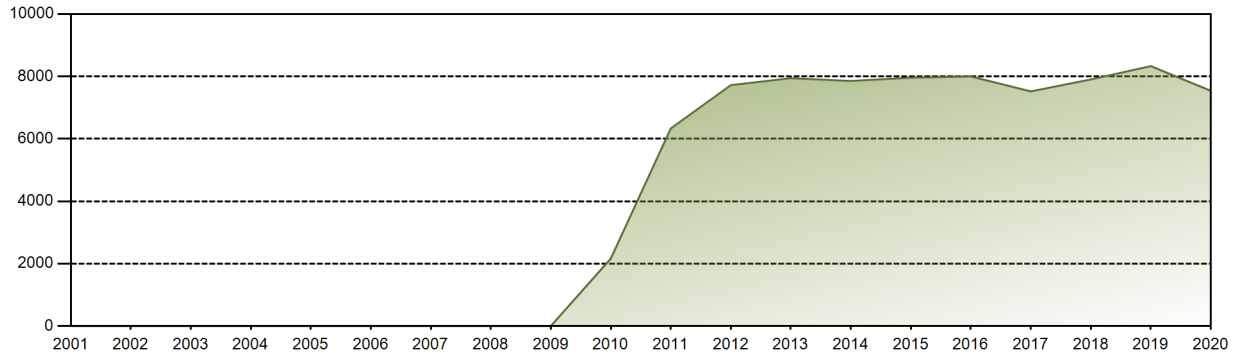
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	346.94	259.21	625.76	724.10	739.27	662.72	749.86	723.26	652.61	647.32	659.74	748.59	7539.38
EAF [%]	45.33	38.48	99.99	99.97	100.00	94.32	99.46	99.99	100.00	100.00	99.99	99.99	89.98
UCF [%]	45.33	38.48	99.99	99.97	100.00	94.32	99.46	99.99	100.00	100.00	99.99	99.99	89.98
LF [%]	46.31	36.98	83.52	99.87	98.67	91.40	100.09	96.54	90.01	86.40	90.99	99.92	85.23
OF [%]	45.70	43.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.93
FLR [%]	0.00	0.00	0.00	0.00	0.00	5.67	0.54	0.00	0.00	0.00	0.00	0.00	0.56
UCL [%]	0.00	0.00	0.00	0.00	0.00	5.67	0.54	0.00	0.00	0.00	0.00	0.00	0.51
PUF [%]	54.67	61.52	0.01	0.03	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	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

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Historical Summary

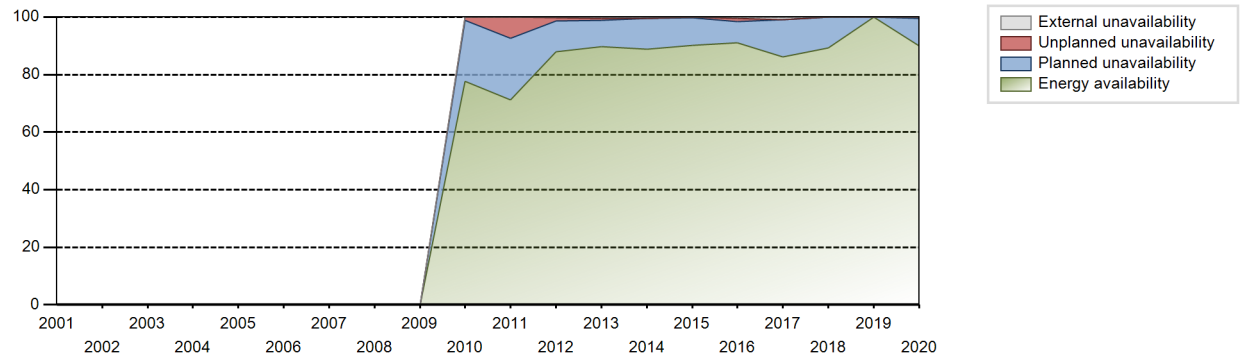
Lifetime energy generation	:	78713.39 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.93 %
Cumulative Energy Availability Factor (EAF)	:	88.1 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.11 %
Cumulative Unit Capability Factor (UCF)	:	88.35 %	Cumulative Planned Unavailability Factor (PUF)	:	10.55 %
Cumulative Load Factor (LF)	:	86.47 %	Cumulative Externally cause unavailability (XUF)	:	0.25 %
Cumulative Operating Factor (OF)	:	89.18 %			

Electricity Production (net) [GWh]



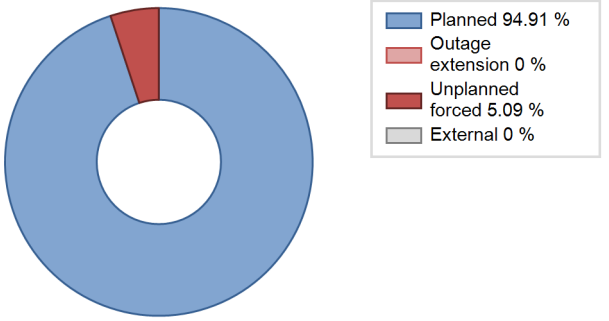
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2010	2164.44	2642	1007	77.65	77.65	62.01	64.34	1.39	1.09	21.26	0.00
2011	6333.19	6866	1007	71.31	71.31	71.79	78.38	7.44	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	89.98	89.98	85.23	90.93	0.56	0.51	9.51	0.00

Key Factors in Last 20 Years [%]

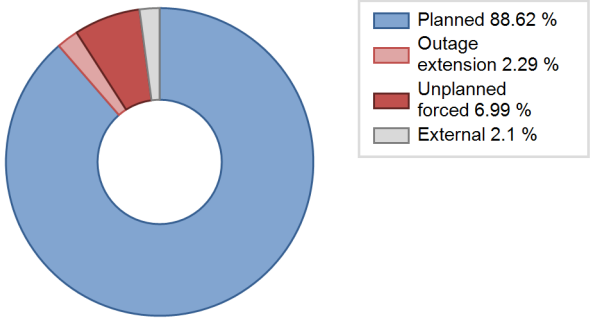


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2010 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					31	
C. Inspection, maintenance or repair combined with refuelling	797			803		
D. Inspection, maintenance or repair without refuelling				95		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						9
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						2
Subtotal	797			898	31	11
Total	**797**			**940**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2010 to 2020 Average hours lost per reactor-year
15. Reactor Cooling Systems		14
31. Turbine and auxiliaries		3
32. Feedwater and Main Steam System		13
41. Main Generator Systems		1
Total		**31**

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2020 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	:	9 years

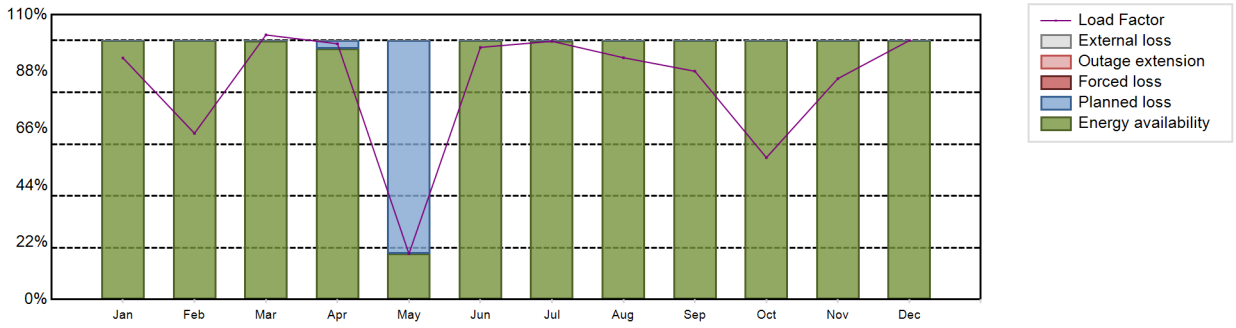
Design Characteristics

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]	:	3.2	**Secondary systems**		
Refuelling frequency [month]	:	16	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	40	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	46000	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	:	3
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 (2020)

Net Energy Production	:	7333.58 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	92.77 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	92.77 %	Planned Unavailability Factor (PUF)	:	7.23 %
Load Factor (LF)	:	82.91 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	93.18 %	Total off-line time	:	599 hours

Annual Summary



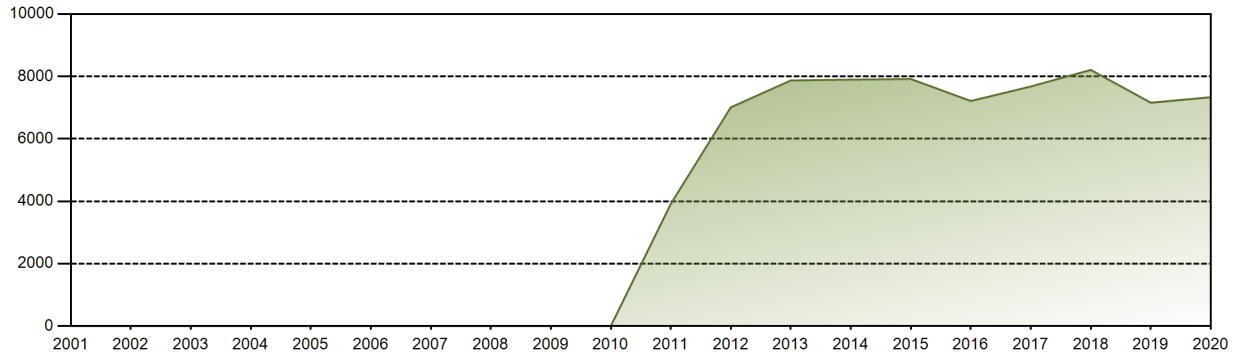
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	698.89	449.79	765.55	716.21	132.49	705.95	747.23	699.74	639.20	410.52	618.64	749.38	7333.58
EAF [%]	99.99	100.00	99.98	96.82	17.77	99.99	99.98	100.00	99.99	100.00	99.99	99.99	92.77
UCF [%]	99.99	100.00	99.98	96.82	17.77	99.99	99.98	100.00	99.99	100.00	99.99	99.99	92.77
LF [%]	93.28	64.18	102.18	98.78	17.68	97.37	99.74	93.40	88.16	54.79	85.33	100.02	82.91
OF [%]	100.00	100.00	100.00	97.08	22.85	100.00	100.00	100.00	99.44	100.00	100.00	100.00	93.18
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	0.02	3.18	82.23	0.01	0.02	0.00	0.01	0.00	0.01	0.01	7.23
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

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Historical Summary

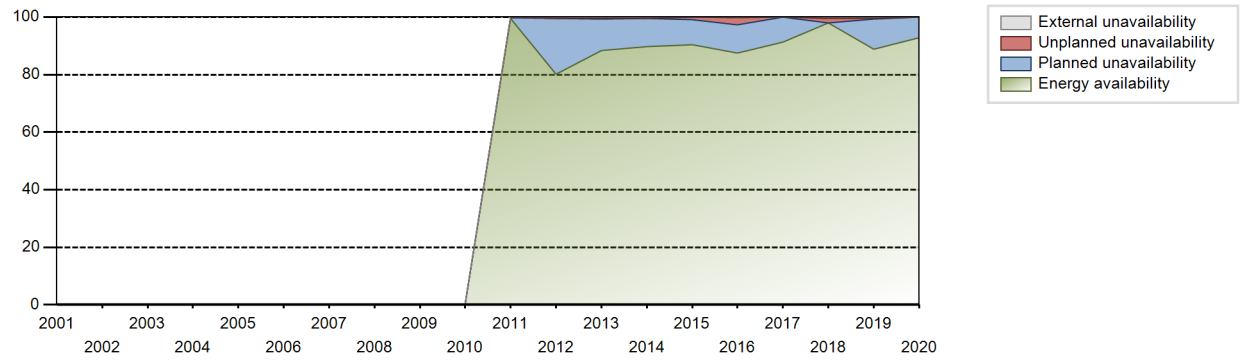
Lifetime energy generation	:	71823.95 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.26 %
Cumulative Energy Availability Factor (EAF)	:	90.07 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.56 %
Cumulative Unit Capability Factor (UCF)	:	90.38 %	Cumulative Planned Unavailability Factor (PUF)	:	9.06 %
Cumulative Load Factor (LF)	:	86.25 %	Cumulative Externally cause unavailability (XUF)	:	0.3 %
Cumulative Operating Factor (OF)	:	89.44 %			

Electricity Production (net) [GWh]



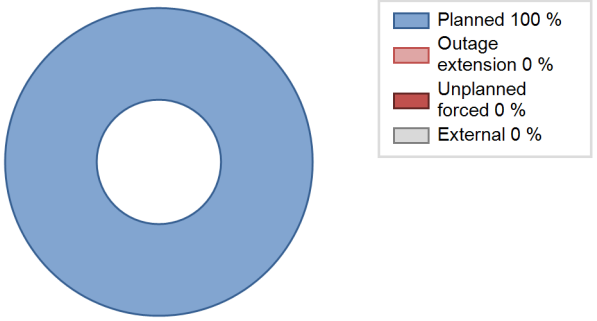
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2011	3914.72	5268	1007	99.60	99.60	96.00	100.00	0.35	0.35	0.05	0.00
2012	7009.72	7156	1020	80.10	80.55	78.24	81.47	0.01	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

Key Factors in Last 20 Years [%]

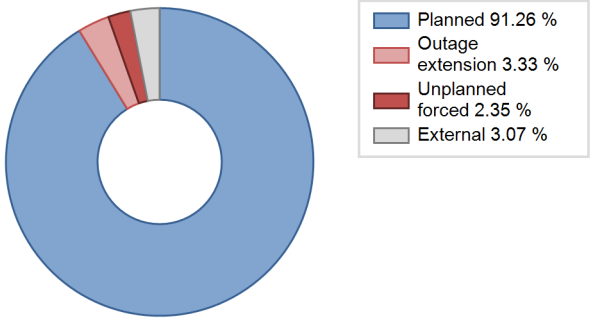


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2011 to 2020 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	595			747		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						138
L. Human factor related					21	
Subtotal	595			747	42	138
Total	**595**			**927**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2011 to 2020 Average hours lost per reactor-year
15. Reactor Cooling Systems		8
31. Turbine and auxiliaries		9
33. Circulating Water System		3
34. Miscellaneous Systems		30
Total		**50**

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2020 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

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	:	2008-02-18
Grid Date	:	2012-12-28
Commercial Date	:	2013-04-15
Age at end of year	:	8 years

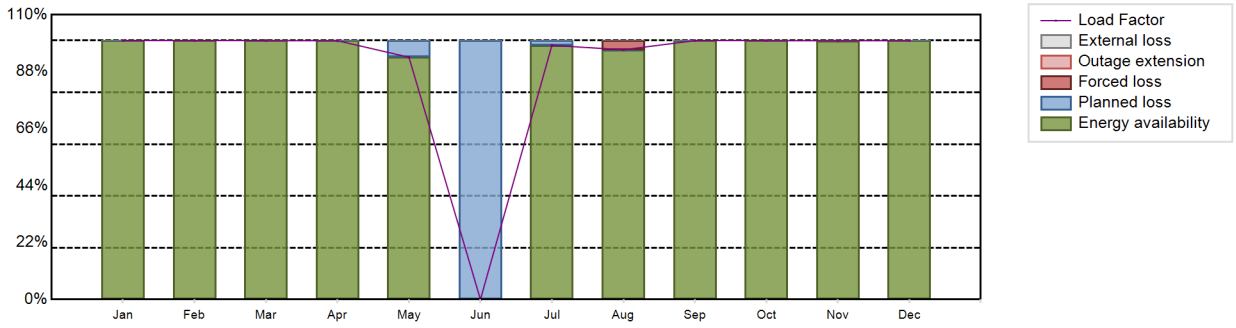
Design Characteristics

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 (2020)

Net Energy Production	:	8119.41 GW(e).h	Forced Loss Rate (FLR)	:	0.33 %
Energy Availability Factor (EAF)	:	90.8 %	Unplanned Capability Loss Factor (UCL)	:	0.3 %
Unit Capability Factor (UCF)	:	90.8 %	Planned Unavailability Factor (PUF)	:	8.9 %
Load Factor (LF)	:	90.8 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	91.15 %	Total off-line time	:	777 hours

Annual Summary



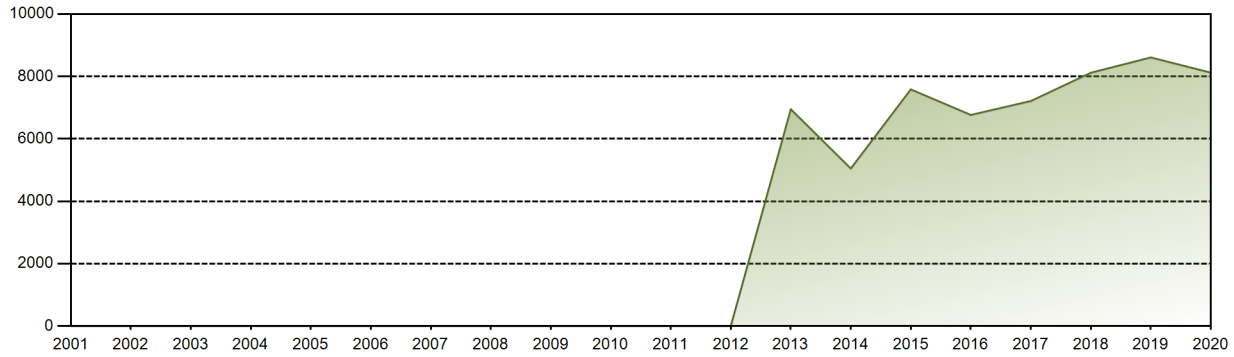
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	757.35	708.52	757.34	732.78	708.80	0.17	743.48	730.51	732.96	757.31	732.83	757.36	8119.41
EAF [%]	99.99	100.00	99.99	99.99	93.58	0.02	98.16	96.45	100.00	99.99	99.98	100.00	90.80
UCF [%]	99.99	100.00	99.99	99.99	93.58	0.02	98.16	96.45	100.00	99.99	99.98	100.00	90.80
LF [%]	99.99	100.00	99.99	99.98	93.58	0.02	98.16	96.45	100.00	99.99	99.98	100.00	90.80
OF [%]	100.00	100.00	100.00	100.00	94.09	0.00	98.25	100.00	100.00	100.00	100.00	100.00	91.15
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.54	0.00	0.00	0.00	0.00	0.33
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.54	0.00	0.00	0.00	0.00	0.30
PUF [%]	0.01	0.00	0.01	0.01	6.42	99.98	1.84	0.01	0.00	0.01	0.02	0.00	8.90
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

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Historical Summary

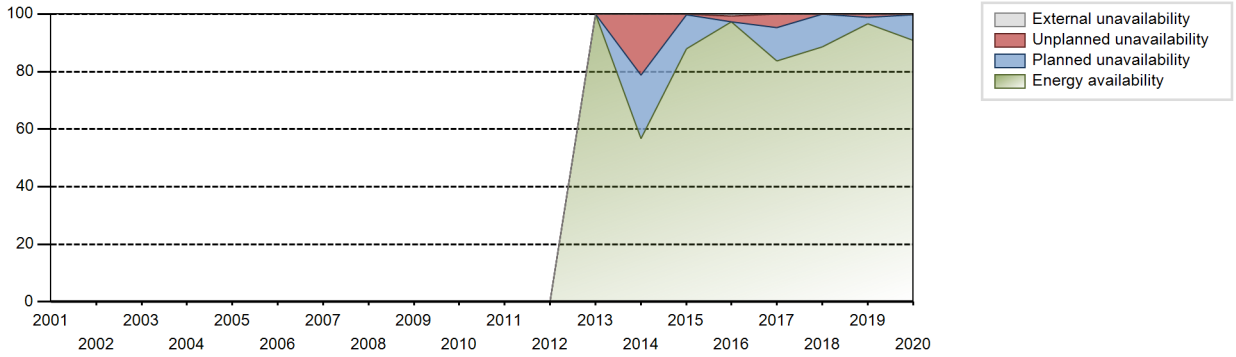
Lifetime energy generation	:	58398.41 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.52 %
Cumulative Energy Availability Factor (EAF)	:	87.32 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.82 %
Cumulative Unit Capability Factor (UCF)	:	87.42 %	Cumulative Planned Unavailability Factor (PUF)	:	8.77 %
Cumulative Load Factor (LF)	:	83.74 %	Cumulative Externally cause unavailability (XUF)	:	0.1 %
Cumulative Operating Factor (OF)	:	85.61 %			

Electricity Production (net) [GWh]

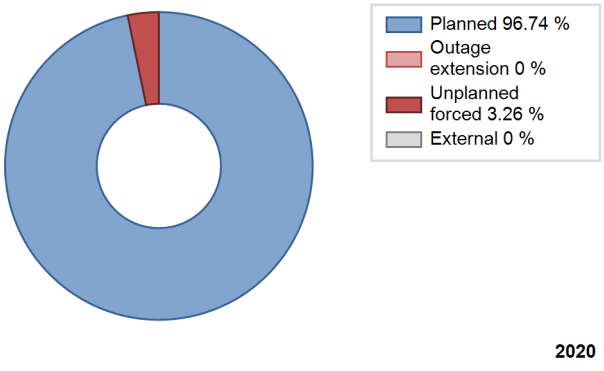


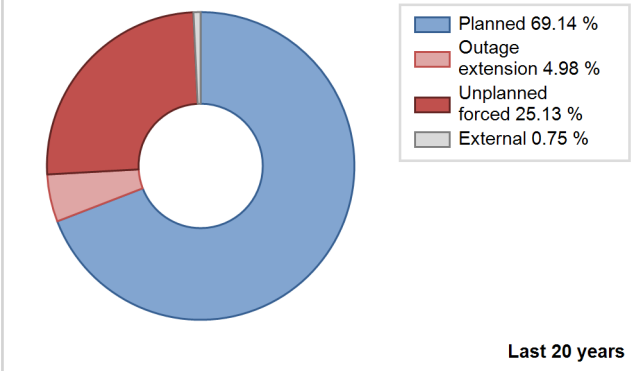
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2013	6947.98	7369	1018	99.94	99.94	96.64	99.33	0.03	0.03	0.04	0.00
2014	5047.23	5119	1018	56.73	56.73	56.60	58.44	23.57	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2013 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					268	
C. Inspection, maintenance or repair combined with refuelling	777			730		
H. Nuclear regulatory requirements					40	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						211
M. Governmental requirements or court decisions						1
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					12	
Subtotal	777			730	320	212
Total	**777**			**1262**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2013 to 2020
	Hours Lost	Average hours lost per reactor-year
16. Steam generation systems		8
31. Turbine and auxiliaries		187
32. Feedwater and Main Steam System		20
41. Main Generator Systems		13
42. Electrical Power Supply Systems		32
Total		**260**

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2020 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

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	:	2008-11-12
Grid Date	:	2014-01-04
Commercial Date	:	2014-05-04
Age at end of year	:	6 years

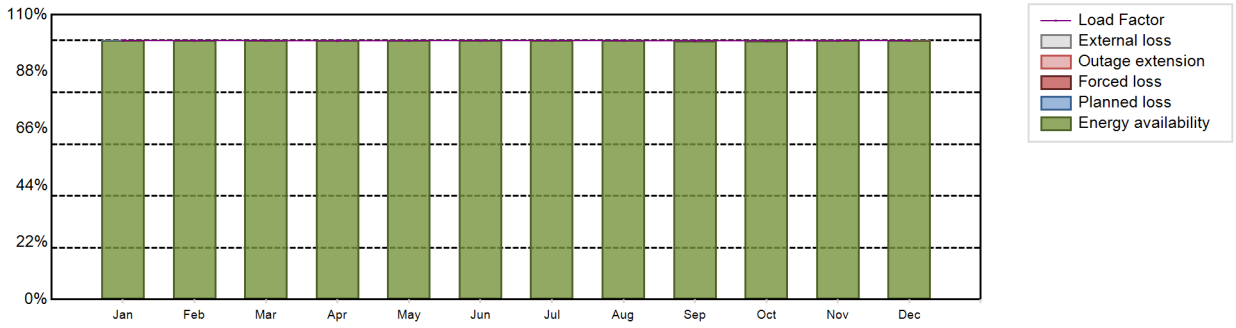
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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 (2020)

Net Energy Production	:	8940.5 GW(e).h
Energy Availability Factor (EAF)	:	99.98 %
Unit Capability Factor (UCF)	:	99.98 %
Load Factor (LF)	:	99.98 %
Operating Factor (OF)	:	100 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	0.01 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	0 hours

Annual Summary



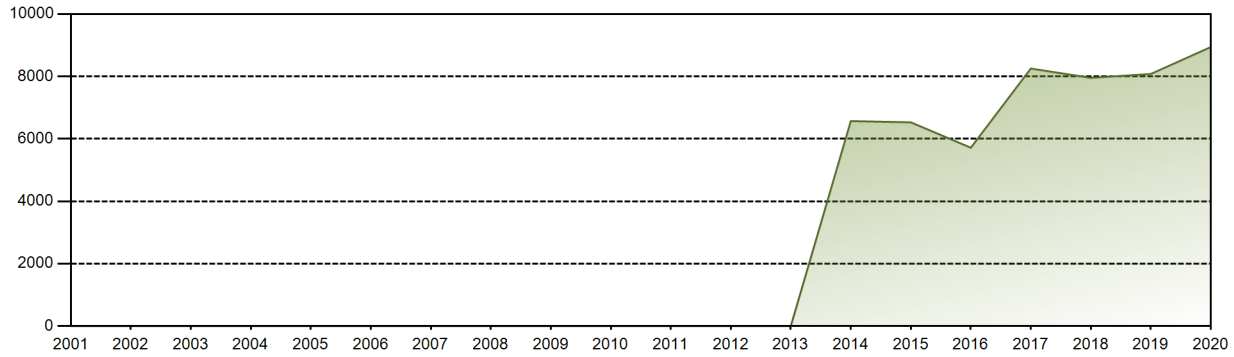
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	757.34	708.53	757.34	732.69	757.34	732.87	757.32	757.33	732.46	757.05	732.92	757.33	8940.50
EAF [%]	99.99	100.00	99.99	99.99	99.99	99.99	99.99	99.99	99.93	99.95	99.99	99.99	99.98
UCF [%]	99.99	100.00	99.99	99.99	99.99	99.99	99.99	99.99	99.93	99.95	99.99	99.99	99.98
LF [%]	99.99	100.00	99.99	99.96	99.99	99.99	99.99	99.99	99.93	99.95	99.99	99.99	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	0.01	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	0.01	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	0.00	0.01	0.01	0.01	0.01	0.07	0.05	0.01	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

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Historical Summary

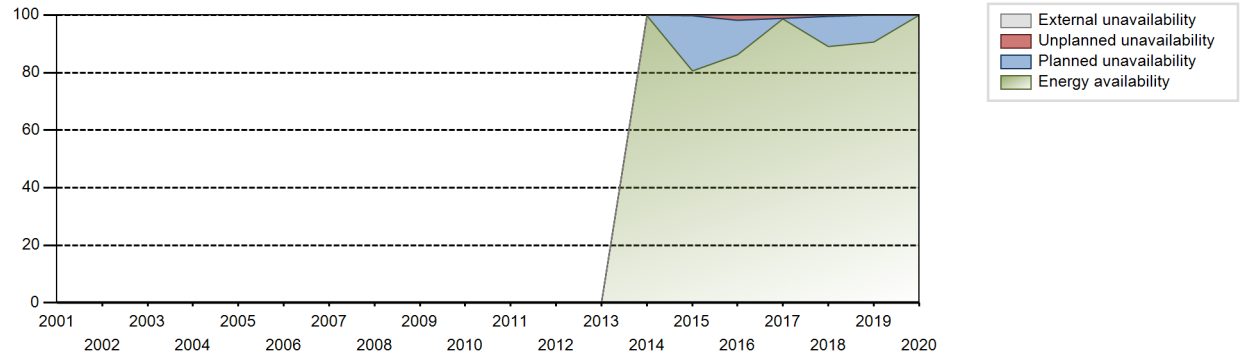
Lifetime energy generation	:	52037.5 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.35 %
Cumulative Energy Availability Factor (EAF)	:	91.76 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.52 %
Cumulative Unit Capability Factor (UCF)	:	91.79 %	Cumulative Planned Unavailability Factor (PUF)	:	7.69 %
Cumulative Load Factor (LF)	:	86.17 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	89.65 %			

Electricity Production (net) [GWh]

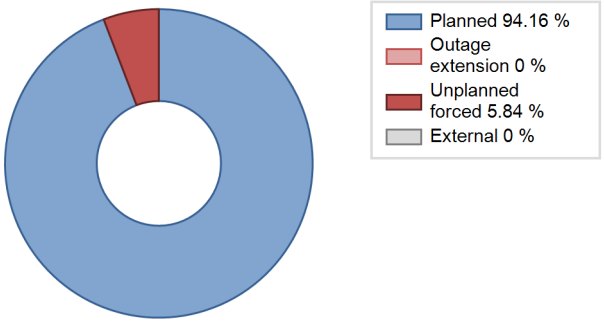


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2014	6568.05	7044	1018	99.85	99.85	97.55	100.00	0.02	0.01	0.14	0.00
2015	6528.23	7145	1018	80.58	80.58	73.21	81.56	0.22	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

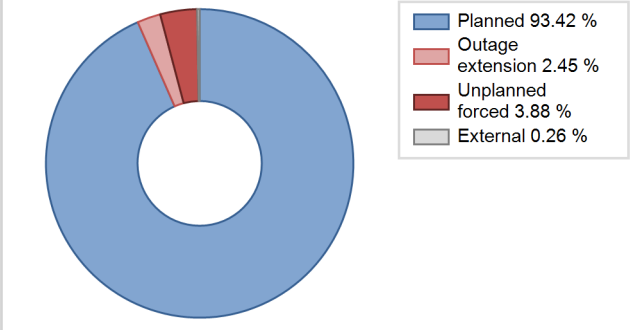
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2014 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling				627		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						263
Z. Other					18	
Subtotal				627	18	263
Total		**0**			**908**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2014 to 2020 Average hours lost per reactor-year
Total		

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2020 Operating Experience

CN-34 NINGDE-3 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	:	2010-01-08
Grid Date	:	2015-03-21
Commercial Date	:	2015-06-10
Age at end of year	:	5 years

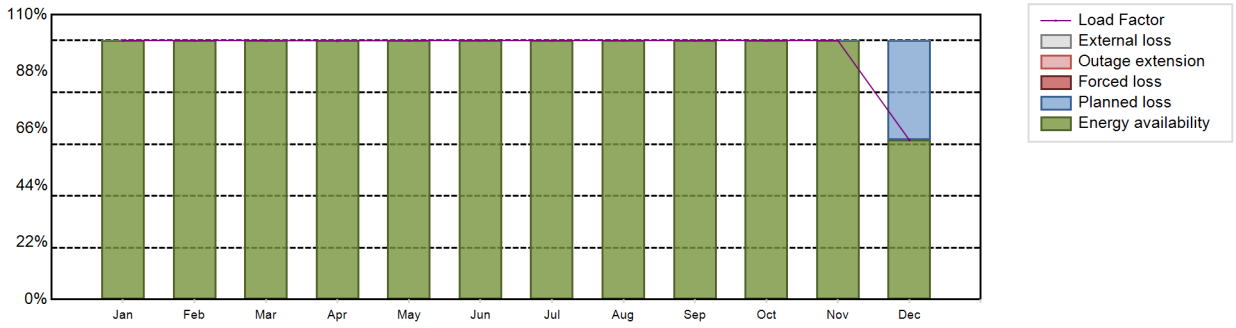
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.43
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 (2020)

Net Energy Production	:	8650.7 GW(e).h
Energy Availability Factor (EAF)	:	96.74 %
Unit Capability Factor (UCF)	:	96.74 %
Load Factor (LF)	:	96.74 %
Operating Factor (OF)	:	96.78 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	3.26 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	283 hours

Annual Summary



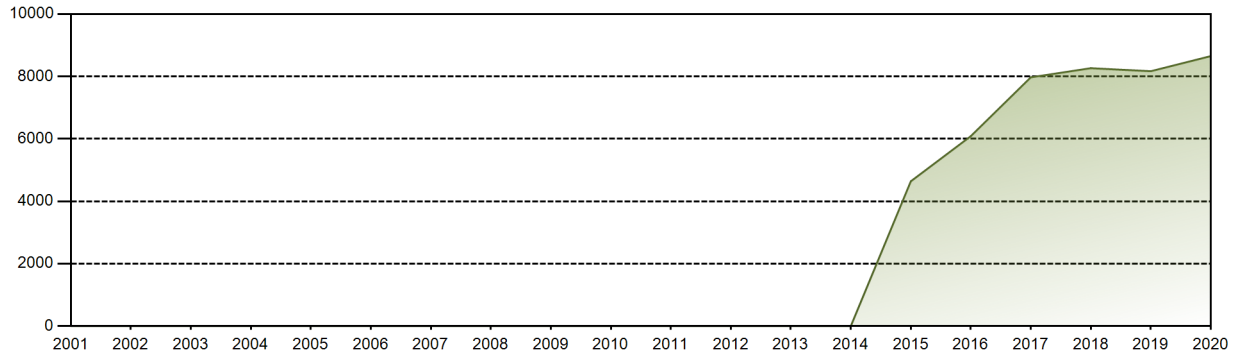
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	757.39	708.53	757.38	732.72	757.33	732.94	757.34	757.34	732.89	757.37	732.90	466.58	8650.70
EAF [%]	100.00	100.00	100.00	99.99	99.99	100.00	99.99	99.99	99.99	100.00	99.99	61.60	96.74
UCF [%]	100.00	100.00	100.00	99.99	99.99	100.00	99.99	99.99	99.99	100.00	99.99	61.60	96.74
LF [%]	100.00	100.00	100.00	99.97	99.99	100.00	99.99	99.99	99.99	100.00	99.99	61.60	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	61.96	96.78
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	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.01	38.40	3.26
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

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Historical Summary

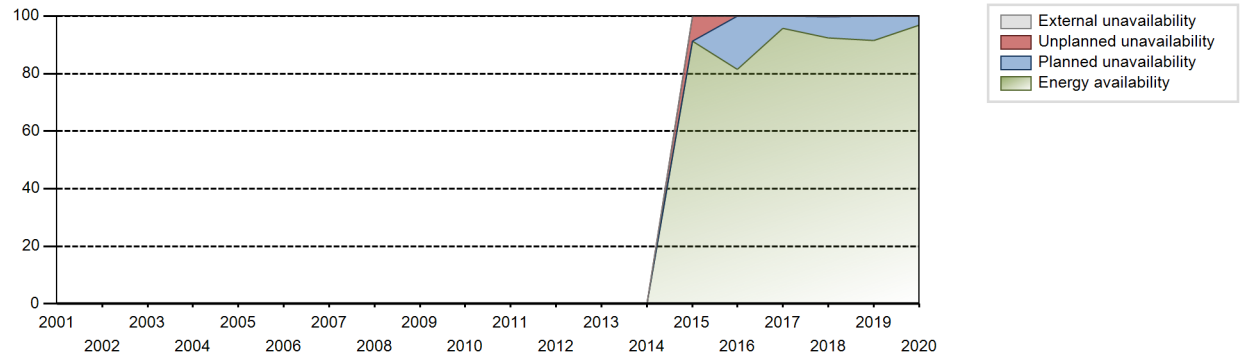
Lifetime energy generation	:	43171.7 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.05 %
Cumulative Energy Availability Factor (EAF)	:	91.51 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.97 %
Cumulative Unit Capability Factor (UCF)	:	91.52 %	Cumulative Planned Unavailability Factor (PUF)	:	7.51 %
Cumulative Load Factor (LF)	:	86.97 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	90.04 %			

Electricity Production (net) [GWh]

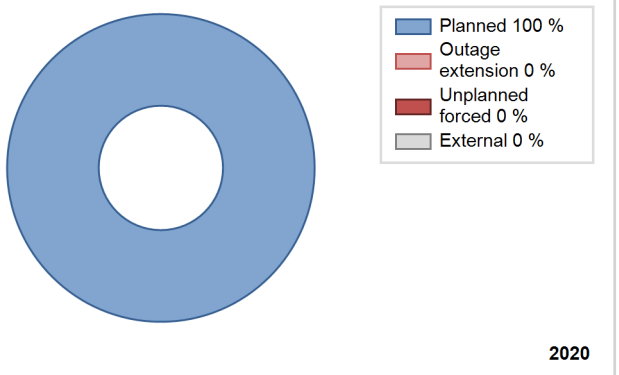


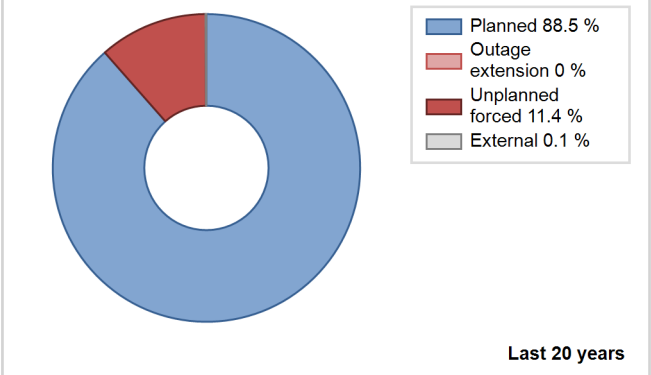
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2015	4638.75	5586	1018	91.25	91.25	80.88	92.85	8.74	8.74	0.01	0.00
2016	6086.41	6514	1018	81.37	81.37	68.06	74.16	0.02	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2015 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					26	
C. Inspection, maintenance or repair combined with refuelling	282			635		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						168
L. Human factor related					50	
Subtotal	282			635	76	168
Total	**282**			**879**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2015 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		48
31. Turbine and auxiliaries		8
33. Circulating Water System		16
Total		**72**

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2020 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	:	4 years

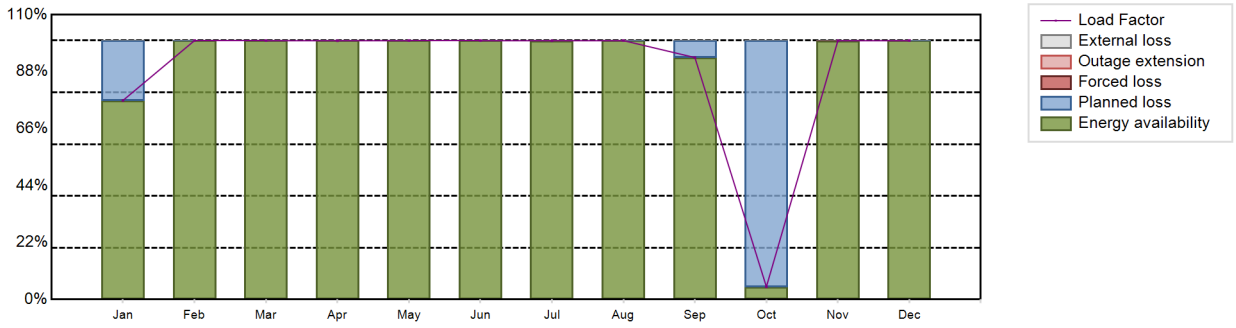
Design Characteristics

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 (2020)

Net Energy Production	:	7998.17 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	89.45 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	89.45 %	Planned Unavailability Factor (PUF)	:	10.55 %
Load Factor (LF)	:	89.44 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	91.45 %	Total off-line time	:	751 hours

Annual Summary



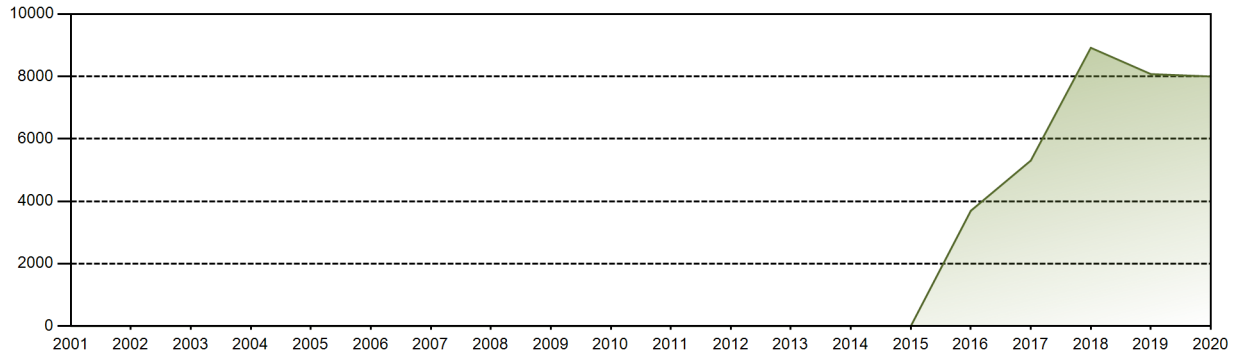
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	582.40	708.52	757.39	732.74	757.38	732.88	757.27	757.37	684.98	37.28	732.58	757.38	7998.17
EAF [%]	76.89	100.00	100.00	100.00	100.00	99.99	99.98	100.00	93.45	4.92	99.95	100.00	89.45
UCF [%]	76.89	100.00	100.00	100.00	100.00	99.99	99.98	100.00	93.45	4.92	99.95	100.00	89.45
LF [%]	76.89	100.00	100.00	99.97	100.00	99.99	99.98	100.00	93.45	4.92	99.95	100.00	89.44
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.89	4.97	100.00	100.00	91.45
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 [%]	23.11	0.00	0.00	0.00	0.00	0.01	0.02	0.00	6.55	95.08	0.05	0.00	10.55
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

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Historical Summary

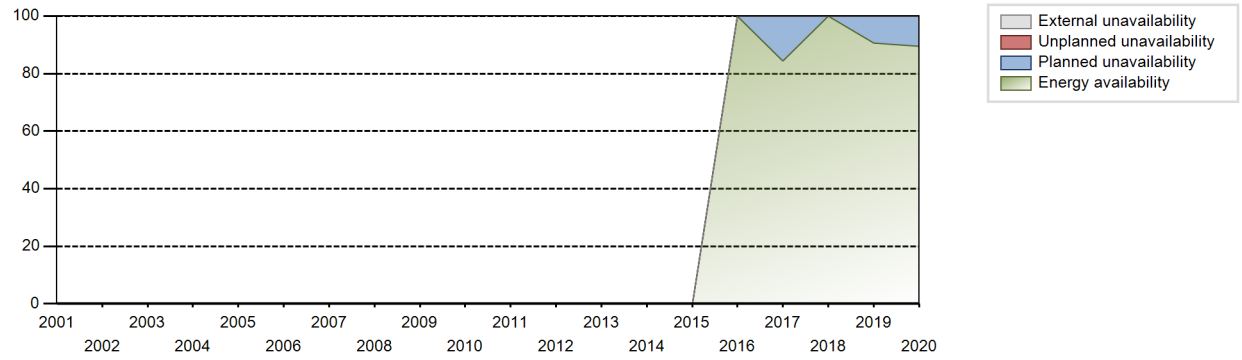
Lifetime energy generation	:	33988.17 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.04 %
Cumulative Energy Availability Factor (EAF)	:	91.91 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.03 %
Cumulative Unit Capability Factor (UCF)	:	91.91 %	Cumulative Planned Unavailability Factor (PUF)	:	8.05 %
Cumulative Load Factor (LF)	:	85.53 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	87.89 %			

Electricity Production (net) [GWh]

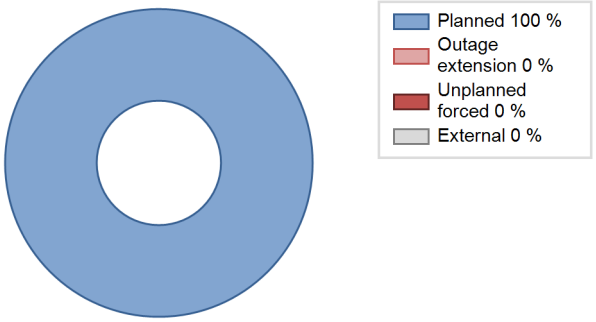


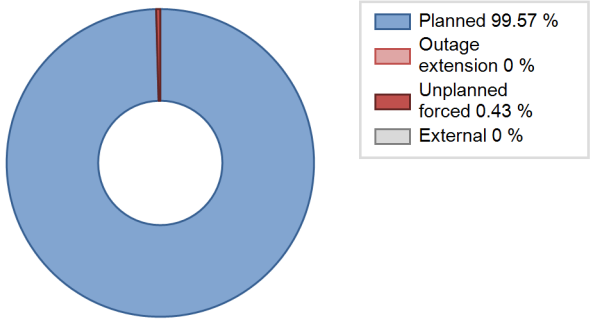
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	3694.87	3786	1018	99.87	99.87	91.83	95.92	0.12	0.12	0.00	0.00
2017	5303.77	5739	1018	84.33	84.33	59.47	65.51	0.12	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling	751			639		
J. Grid limitation, failure or grid unavailability						237
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						186
Subtotal	751			639		423
Total	**751**			**1062**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
Total		

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2020 Operating Experience

CN-4 QINSHAN 2-1 CHINA

Status at end of year	:	**Operational**
Operator	:	NPQJVC (NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY LTD.)
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)	:	610 MWe

Key Dates

Construction Date	:	1996-06-02
Grid Date	:	2002-02-06
Commercial Date	:	2002-04-15
Age at end of year	:	18 years

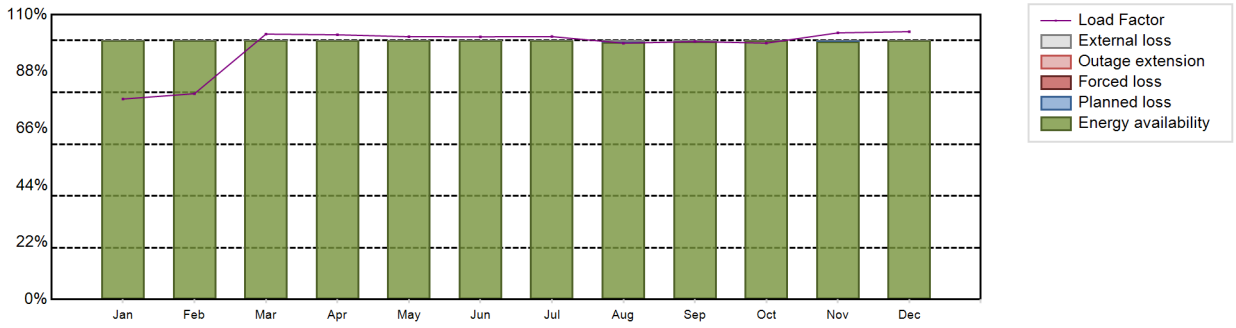
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.25
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	33.3
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]	:	0.45
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	:	none

Annual Production Results (2020)

Net Energy Production	:	5228.19 GW(e).h
Energy Availability Factor (EAF)	:	99.88 %
Unit Capability Factor (UCF)	:	99.95 %
Load Factor (LF)	:	97.57 %
Operating Factor (OF)	:	100 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	0.05 %
Externally cause unavailability (XUF)	:	0.07 %
Total off-line time	:	0 hours

Annual Summary



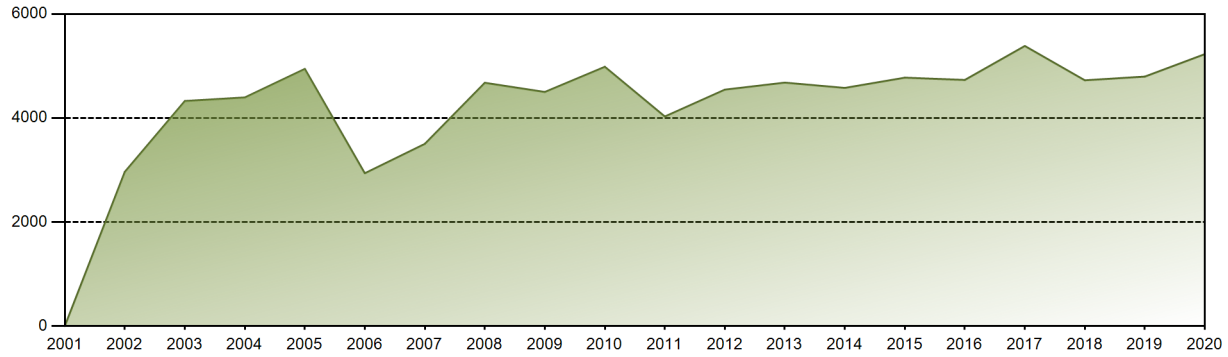
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	351.37	337.47	465.24	449.04	460.61	445.64	460.85	449.27	437.54	449.39	452.29	469.47	5228.19
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.29	99.58	100.00	99.73	100.00	99.88
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.71	100.00	100.00	99.73	100.00	99.95
LF [%]	77.42	79.49	102.51	102.24	101.49	101.47	101.54	98.99	99.62	99.02	102.98	103.45	97.57
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	0.29	0.00	0.00	0.27	0.00	0.05
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.42	0.00	0.00	0.00	0.07

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Historical Summary

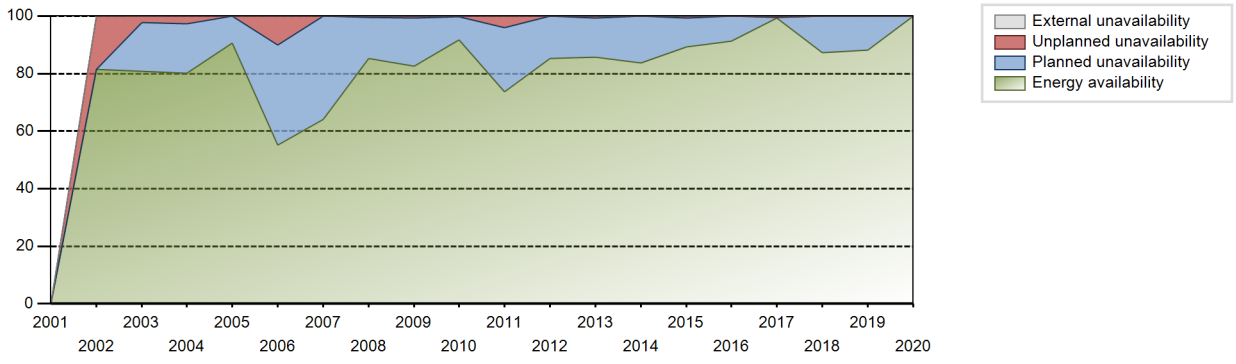
Lifetime energy generation	:	84998.69 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.11 %
Cumulative Energy Availability Factor (EAF)	:	84.01 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.93 %
Cumulative Unit Capability Factor (UCF)	:	84.04 %	Cumulative Planned Unavailability Factor (PUF)	:	14.03 %
Cumulative Load Factor (LF)	:	84.48 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	83.96 %			

Electricity Production (net) [GWh]



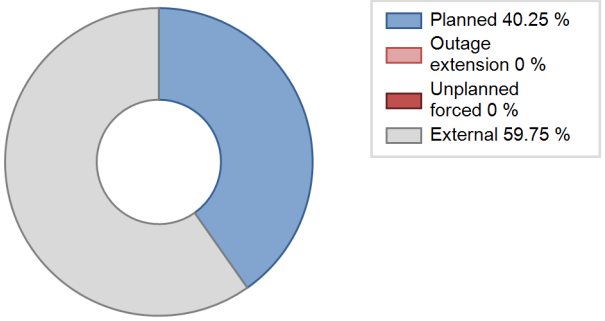
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	2965.29	4631	610	81.56	81.56	73.64	70.16	18.44	18.44	0.00	0.00
2003	4327.30	7123	610	80.90	80.95	80.98	81.31	2.61	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

Key Factors in Last 20 Years [%]

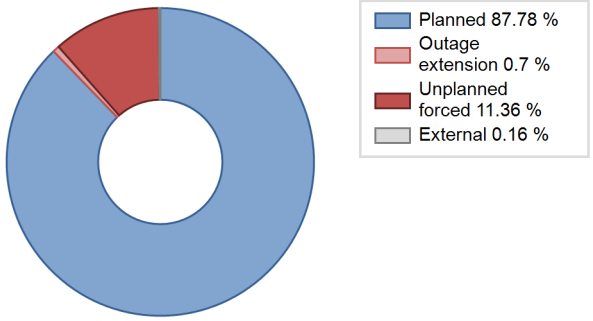


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2002 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					90	
C. Inspection, maintenance or repair combined with refuelling				1008		
D. Inspection, maintenance or repair without refuelling				25		
E. Testing of plant systems or components					1	
G. Major backfitting, refurbishment or upgrading activities without refuelling				219		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						11
Z. Other					8	
Subtotal				1252	99	11
Total		**0**			**1362**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2002 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		2
13. Reactor Auxiliary Systems		40
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		17
32. Feedwater and Main Steam System		3
41. Main Generator Systems		28
42. Electrical Power Supply Systems		2
Total		**94**

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2020 Operating Experience

CN-5 QINSHAN 2-2 CHINA

Status at end of year	:	**Operational**
Operator	:	NPQJVC (NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY LTD.)
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)	:	610 MWe

Key Dates

Construction Date	:	1997-04-01
Grid Date	:	2004-03-11
Commercial Date	:	2004-05-03
Age at end of year	:	16 years

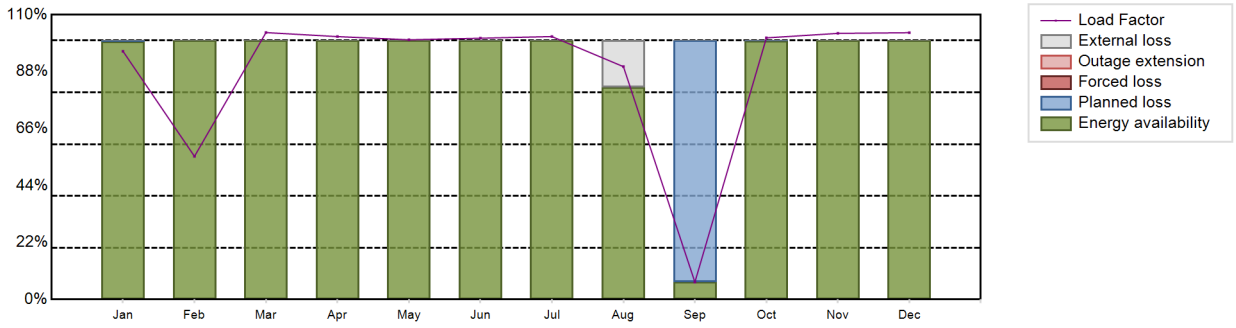
Design Characteristics

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]	:	0.450
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	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 (2020)

Net Energy Production	:	4758.46 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	90.79 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	92.31 %	Planned Unavailability Factor (PUF)	:	7.69 %
Load Factor (LF)	:	88.81 %	Externally cause unavailability (XUF)	:	1.52 %
Operating Factor (OF)	:	92.85 %	Total off-line time	:	628 hours

Annual Summary



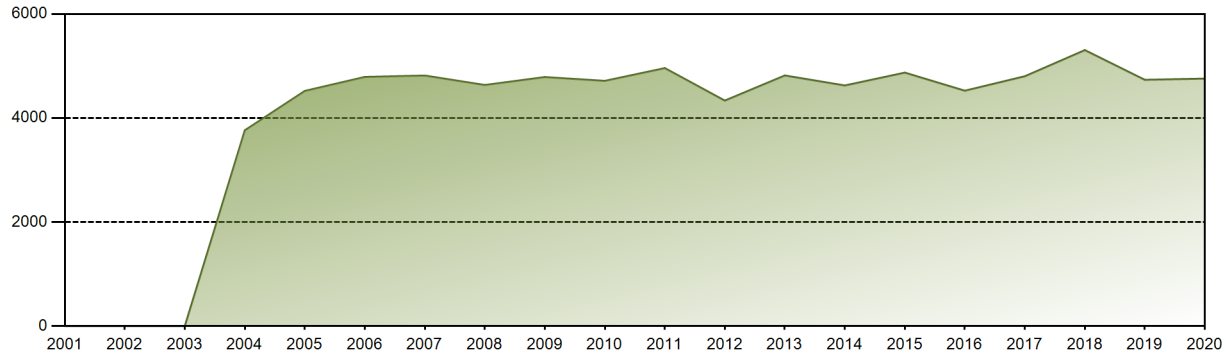
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	435.15	234.75	467.87	445.96	455.19	443.25	460.89	408.19	29.49	458.58	451.45	467.68	4758.46
EAF [%]	99.58	100.00	100.00	100.00	100.00	100.00	100.00	82.07	6.73	99.90	100.00	100.00	90.79
UCF [%]	99.58	100.00	100.00	100.00	100.00	100.00	100.00	100.00	6.73	99.90	100.00	100.00	92.31
LF [%]	95.88	55.29	103.09	101.54	100.30	100.92	101.55	89.94	6.71	101.05	102.79	103.05	88.81
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	12.78	100.00	100.00	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 [%]	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.27	0.10	0.00	0.00	7.69
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	17.93	0.00	0.00	0.00	0.00	1.52

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Historical Summary

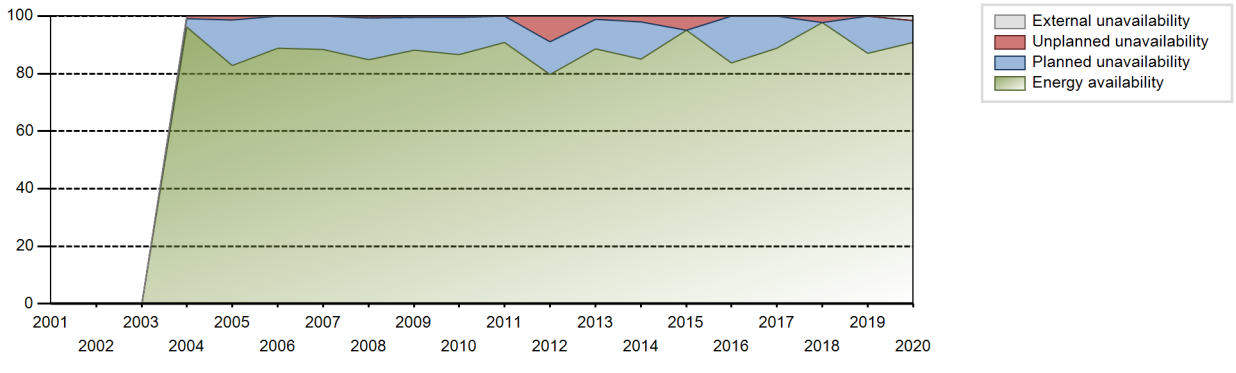
Lifetime energy generation	:	79774.2 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.5 %
Cumulative Energy Availability Factor (EAF)	:	88.27 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.34 %
Cumulative Unit Capability Factor (UCF)	:	88.39 %	Cumulative Planned Unavailability Factor (PUF)	:	10.26 %
Cumulative Load Factor (LF)	:	89.21 %	Cumulative Externally cause unavailability (XUF)	:	0.12 %
Cumulative Operating Factor (OF)	:	88.73 %			

Electricity Production (net) [GWh]



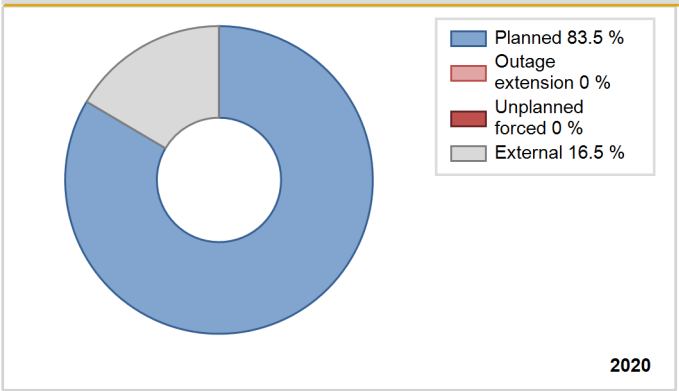
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2004	3764.39	6381	610	96.24	96.24	97.96	96.62	0.90	0.87	2.88	0.00
2005	4521.51	7331	610	82.69	82.77	84.62	83.69	1.65	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

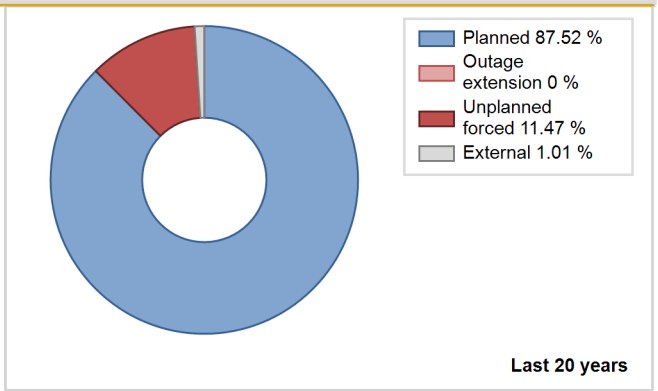
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2004 to 2020 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	627			845		
D. Inspection, maintenance or repair without refuelling				23		
G. Major backfitting, refurbishment or upgrading activities without refuelling				5		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						24
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
Subtotal	627			873	108	25
Total	**627**			**1006**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2004 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		6
15. Reactor Cooling Systems		11
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		86
32. Feedwater and Main Steam System		2
42. Electrical Power Supply Systems		3
Total		**109**

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2020 Operating Experience

CN-14 QINSHAN 2-3 CHINA

Status at end of year	:	**Operational**
Operator	:	NPQJVC (NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY LTD.)
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	:	660 MWe
Reference unit power (net)	:	619 MWe

Key Dates

Construction Date	:	2006-04-28
Grid Date	:	2010-08-01
Commercial Date	:	2010-10-05
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]	:	3.25
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	33.3
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

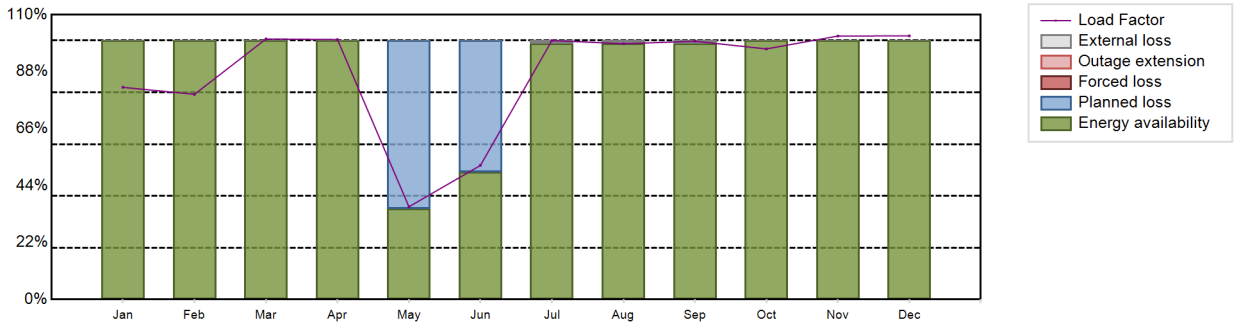
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	315.2
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.45
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP 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	:	3
Number of on-site safety related diesel generators	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	4753.88 GW(e).h
Energy Availability Factor (EAF)	:	90.05 %
Unit Capability Factor (UCF)	:	90.36 %
Load Factor (LF)	:	87.43 %
Operating Factor (OF)	:	89.59 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	9.64 %
Externally cause unavailability (XUF)	:	0.31 %
Total off-line time	:	914 hours

Annual Summary



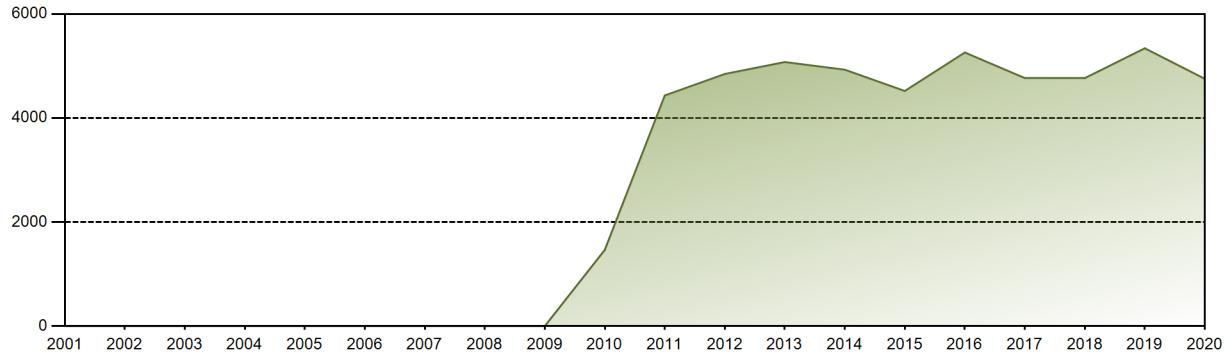
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	377.35	341.46	463.35	447.53	165.01	230.80	460.75	454.84	444.62	445.72	453.51	468.94	4753.88
EAF [%]	100.00	100.00	100.00	100.00	35.17	49.36	98.76	98.76	98.76	100.00	100.00	100.00	90.05
UCF [%]	100.00	100.00	100.00	100.00	35.17	49.36	100.00	100.00	100.00	100.00	100.00	100.00	90.36
LF [%]	81.94	79.26	100.61	100.42	35.83	51.79	100.05	98.76	99.76	96.78	101.76	101.82	87.43
OF [%]	83.20	100.00	100.00	100.00	35.35	57.22	100.00	100.00	100.00	100.00	100.00	100.00	89.59
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	64.83	50.64	0.00	0.00	0.00	0.00	0.00	0.00	9.64
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	1.24	1.24	1.24	0.00	0.00	0.00	0.31

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Historical Summary

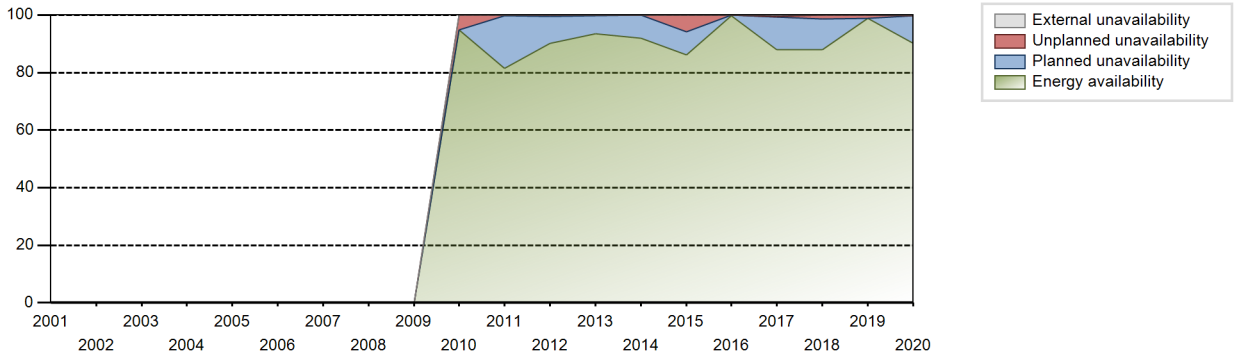
Lifetime energy generation	:	50161.11 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.17 %
Cumulative Energy Availability Factor (EAF)	:	90.88 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.07 %
Cumulative Unit Capability Factor (UCF)	:	90.97 %	Cumulative Planned Unavailability Factor (PUF)	:	7.96 %
Cumulative Load Factor (LF)	:	90.28 %	Cumulative Externally cause unavailability (XUF)	:	0.08 %
Cumulative Operating Factor (OF)	:	90.97 %			

Electricity Production (net) [GWh]



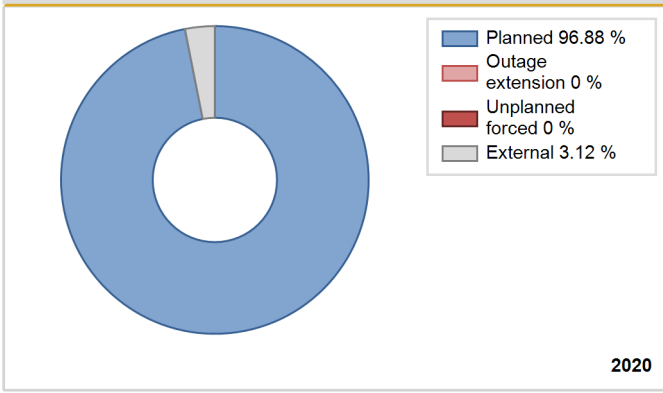
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2010	1465.17	2685	610	94.75	94.75	96.66	97.55	5.22	5.21	0.04	0.00
2011	4434.13	7226	610	81.55	81.56	82.98	82.49	0.21	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

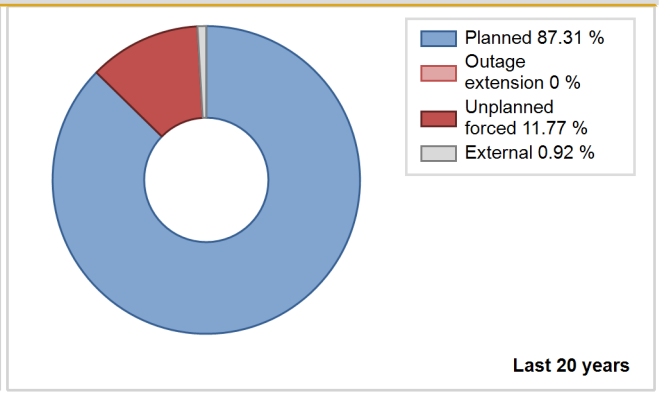
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			2010 to 2020		
	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	789			679		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			125			47
L. Human factor related					0	
Subtotal	789		125	679	82	47
Total	**914**			**808**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2010 to 2020
	Hours Lost	Average hours lost per reactor-year
15. Reactor Cooling Systems		12
16. Steam generation systems		11
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		51
32. Feedwater and Main Steam System		0
34. Miscellaneous Systems	125	12
42. Electrical Power Supply Systems		4
Total	**125**	**92**

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2020 Operating Experience

CN-15 QINSHAN 2-4 CHINA

Status at end of year	:	**Operational**
Operator	:	NPQJVC (NUCLEAR POWER PLANT QINSHAN JOINT VENTURE COMPANY LTD.)
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	:	660 MWe
Reference unit power (net)	:	619 MWe

Key Dates

Construction Date	:	2007-01-28
Grid Date	:	2011-11-25
Commercial Date	:	2011-12-30
Age at end of year	:	9 years

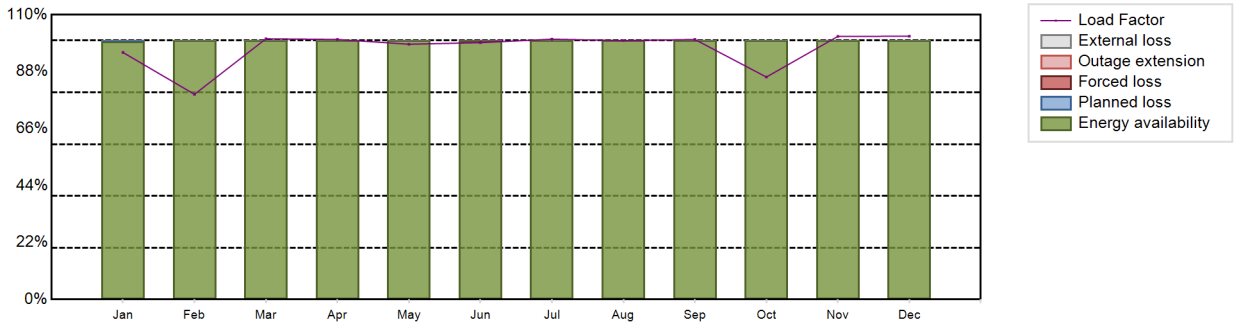
Design Characteristics

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 [%]	:	33.3
Average discharge burnup [MWd/t]	:	50000
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]	:	0.45
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	:	none

Annual Production Results (2020)

Net Energy Production	:	5276.68 GW(e).h
Energy Availability Factor (EAF)	:	99.97 %
Unit Capability Factor (UCF)	:	99.97 %
Load Factor (LF)	:	97.05 %
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



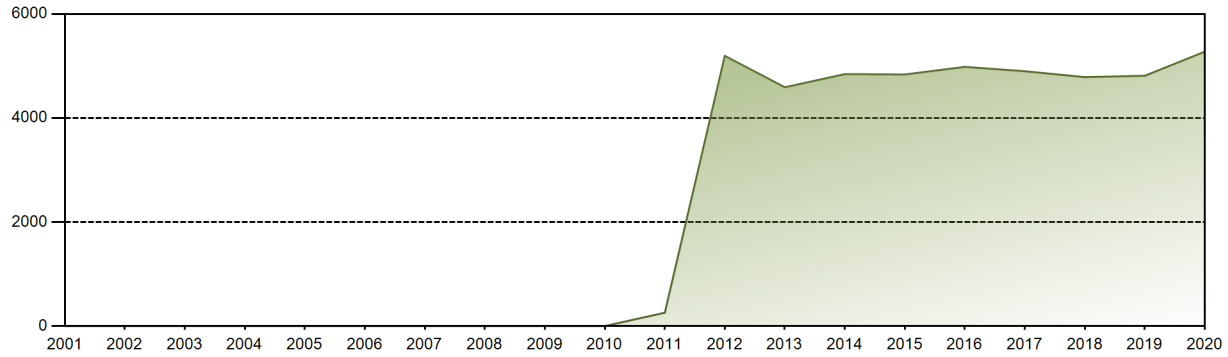
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	439.43	341.44	463.74	447.66	454.10	442.14	463.10	460.54	447.62	395.70	452.88	468.35	5276.68
EAF [%]	99.69	100.00	100.00	100.00	100.00	99.90	100.00	100.00	100.00	100.00	100.00	100.00	99.97
UCF [%]	99.69	100.00	100.00	100.00	100.00	99.90	100.00	100.00	100.00	100.00	100.00	100.00	99.97
LF [%]	95.42	79.25	100.70	100.45	98.60	99.21	100.56	100.00	100.43	85.92	101.61	101.70	97.05
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	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01
PUF [%]	0.31	0.00	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

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Historical Summary

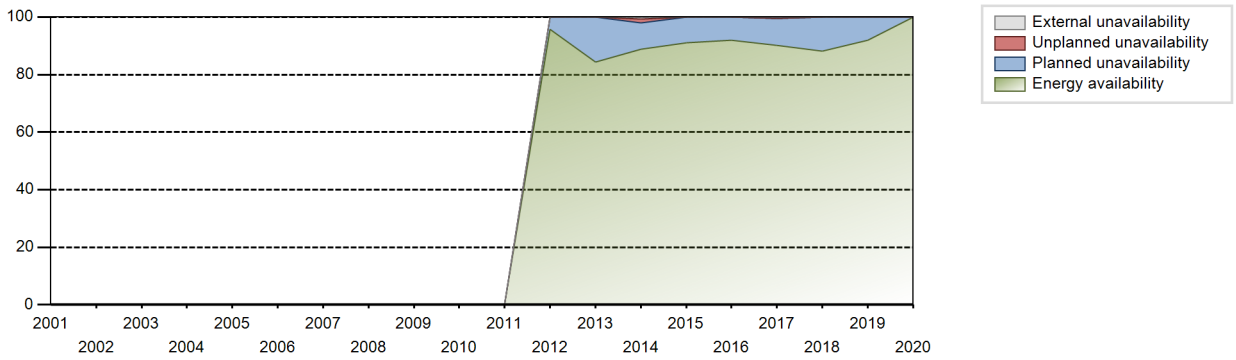
Lifetime energy generation	:	44484.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.17 %
Cumulative Energy Availability Factor (EAF)	:	91.35 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.15 %
Cumulative Unit Capability Factor (UCF)	:	91.49 %	Cumulative Planned Unavailability Factor (PUF)	:	8.36 %
Cumulative Load Factor (LF)	:	91.28 %	Cumulative Externally cause unavailability (XUF)	:	0.14 %
Cumulative Operating Factor (OF)	:	91.55 %			

Electricity Production (net) [GWh]



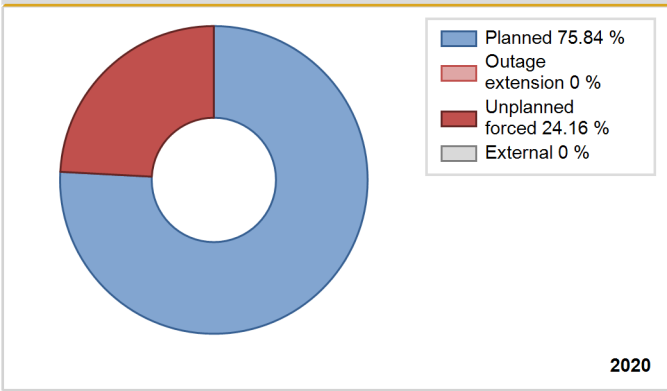
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2011	257.02	614	610	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	5195.81	8438	610	95.79	95.79	96.97	96.06	0.04	0.04	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

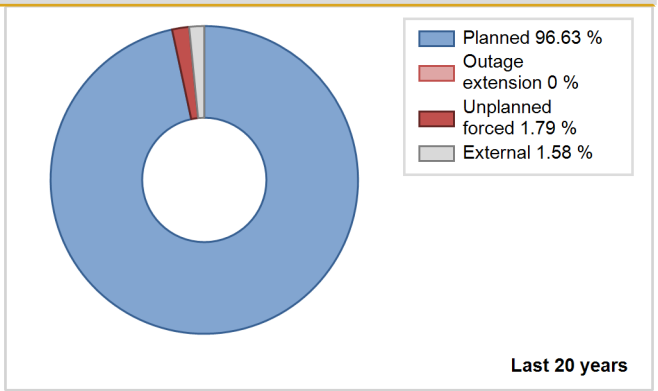
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2011 to 2020 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				662		
D. Inspection, maintenance or repair without refuelling				29		
E. Testing of plant systems or components				9		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						30
Subtotal				700	1	30
Total		**0**			**731**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2011 to 2020 Average hours lost per reactor-year
35. All other I&C Systems		1
Total		**1**

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2020 Operating Experience

CN-8 QINSHAN 3-1 CHINA

Status at end of year	:	**Operational**
Operator	:	TQNPC (The Third Qinshan Joint Venture Company, LTD.)
Owner	:	TQNPC (The Third Qinshan Joint Venture Company, 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	:	18 years

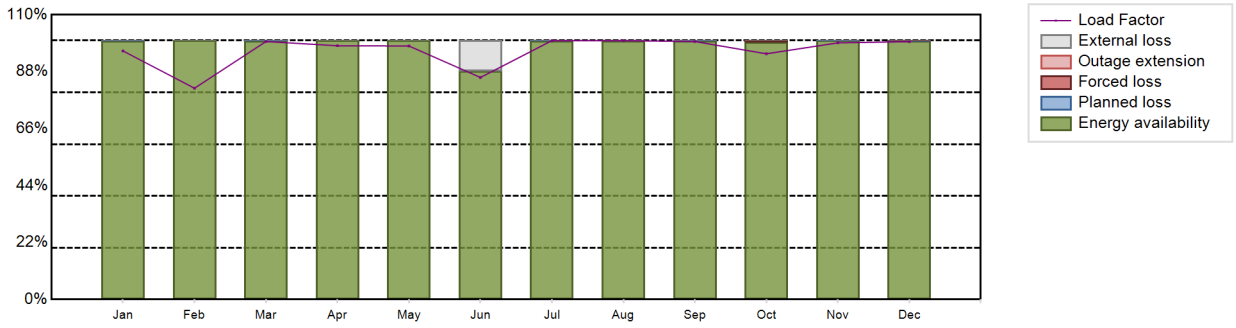
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	9.89
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]	:	0.124
Average fuel enrichment [% of U235]	:	0.71	**Secondary systems**		
Refuelling frequency [month]	:	60	Number of turbine-generators per unit/reactor	:	-
Part of the core refuelled [%]	:	NA	Turbine speed [rpm]	:	-
Average discharge burnup [MWd/t]	:	7186	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	6.28	HP cylinder inlet steam pressure [MPa]	:	-
Active core height/length [m]	:	5.94	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	4560	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	25.35	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 (2020)

Net Energy Production	:	5714.7 GW(e).h	Forced Loss Rate (FLR)	:	0.07 %
Energy Availability Factor (EAF)	:	98.95 %	Unplanned Capability Loss Factor (UCL)	:	0.07 %
Unit Capability Factor (UCF)	:	99.92 %	Planned Unavailability Factor (PUF)	:	0.01 %
Load Factor (LF)	:	96.1 %	Externally cause unavailability (XUF)	:	0.97 %
Operating Factor (OF)	:	99.03 %	Total off-line time	:	85 hours

Annual Summary



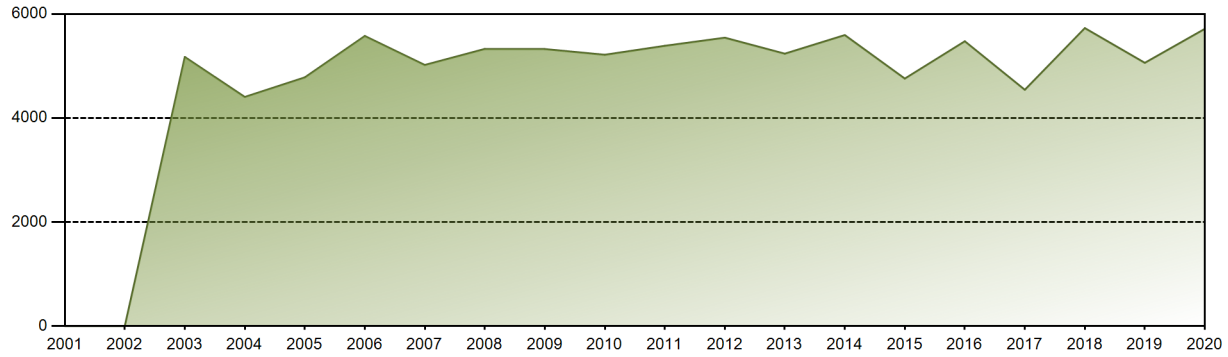
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	483.60	384.54	501.87	477.74	493.20	418.03	503.60	503.60	485.67	478.02	483.19	501.64	5714.70
EAF [%]	99.98	100.00	99.98	100.00	100.00	88.14	99.98	99.98	99.98	99.28	99.99	99.93	98.95
UCF [%]	99.98	100.00	99.98	100.00	100.00	100.00	99.98	99.98	99.98	99.28	99.99	99.93	99.92
LF [%]	96.01	81.61	99.64	98.01	97.92	85.76	99.98	99.98	99.64	94.90	99.13	99.59	96.10
OF [%]	100.00	100.00	100.00	100.00	100.00	88.19	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	0.72	0.00	0.06	0.07
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.06	0.07
PUF [%]	0.02	0.00	0.02	0.00	0.00	0.00	0.02	0.02	0.02	0.00	0.01	0.01	0.01
XUF [%]	0.00	0.00	0.00	0.00	0.00	11.86	0.00	0.00	0.00	0.00	0.00	0.00	0.97

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Historical Summary

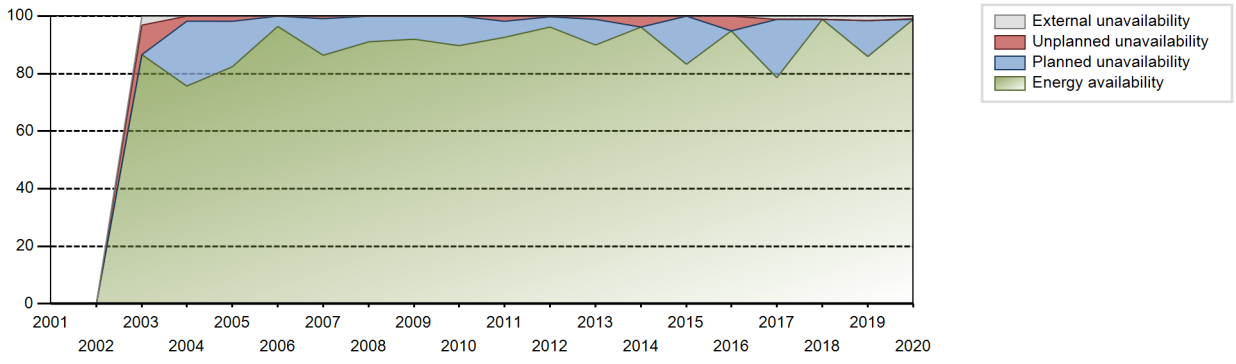
Lifetime energy generation	:	94198.51 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.64 %
Cumulative Energy Availability Factor (EAF)	:	89.75 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.5 %
Cumulative Unit Capability Factor (UCF)	:	90.21 %	Cumulative Planned Unavailability Factor (PUF)	:	8.29 %
Cumulative Load Factor (LF)	:	90.28 %	Cumulative Externally cause unavailability (XUF)	:	0.46 %
Cumulative Operating Factor (OF)	:	90.47 %			

Electricity Production (net) [GWh]



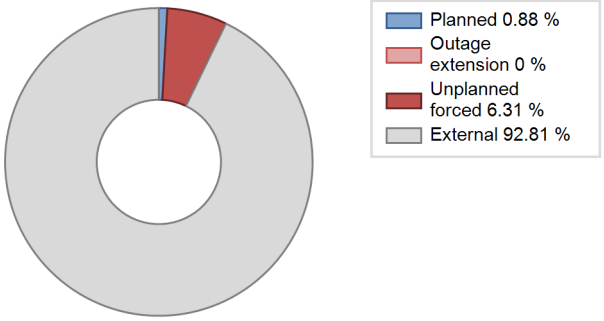
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	Data not provided										
2003	5174.75	7977	650	86.59	89.65	90.88	91.06	10.35	10.35	0.00	3.06
2004	4405.52	6745	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

Key Factors in Last 20 Years [%]

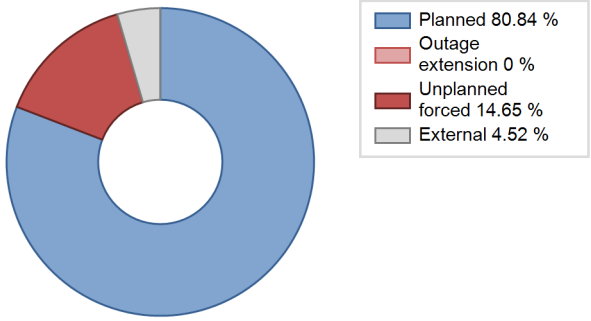


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2002 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					114	
D. Inspection, maintenance or repair without refuelling				709		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						6
Z. Other			85			5
Subtotal			85	709	114	11
Total		**85**			**834**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2002 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		4
12. Reactor I&C Systems		7
15. Reactor Cooling Systems		39
16. Steam generation systems		10
21. Fuel Handling and Storage Facilities		11
32. Feedwater and Main Steam System		2
34. Miscellaneous Systems	85	5
42. Electrical Power Supply Systems		41
Total	**85**	**119**

Highlights (2020)

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2020 Operating Experience

CN-9 QINSHAN 3-2 CHINA



Status at end of year	:	**Operational**
Operator	:	TQNPC (The Third Qinshan Joint Venture Company, LTD.)
Owner	:	TQNPC (The Third Qinshan Joint Venture Company, 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	:	1998-09-25
Grid Date	:	2003-06-12
Commercial Date	:	2003-07-24
Age at end of year	:	17 years

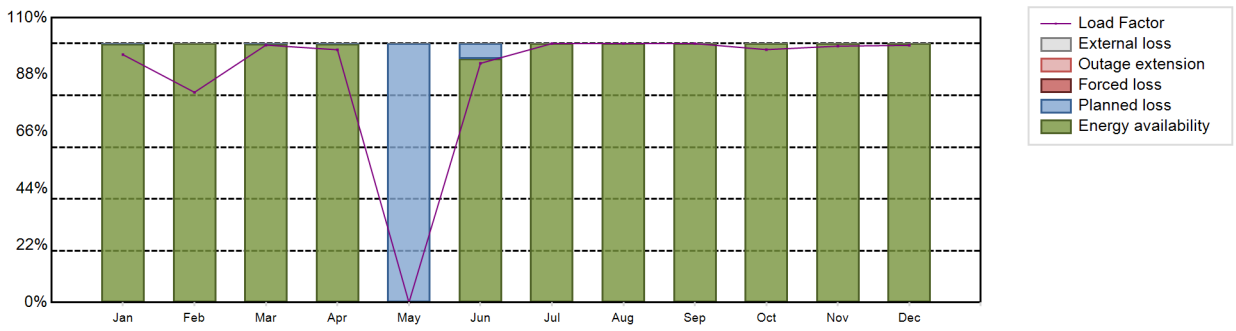
Design Characteristics

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	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	4.51
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	5261.05 GW(e).h
Energy Availability Factor (EAF)	:	91.04 %
Unit Capability Factor (UCF)	:	91.04 %
Load Factor (LF)	:	88.47 %
Operating Factor (OF)	:	91.23 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.96 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	770 hours

Annual Summary



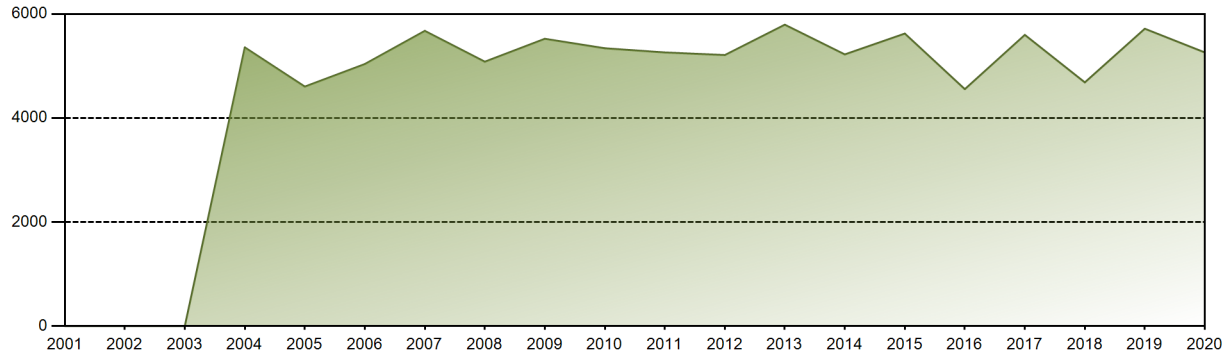
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	482.14	382.49	500.78	475.73	0.06	450.23	503.69	503.69	487.44	491.93	482.64	500.23	5261.05
EAF [%]	99.98	100.00	99.99	99.75	0.09	94.25	100.00	100.00	100.00	100.00	100.00	100.00	91.04
UCF [%]	99.98	100.00	99.99	99.75	0.09	94.25	100.00	100.00	100.00	100.00	100.00	100.00	91.04
LF [%]	95.72	81.18	99.42	97.60	0.01	92.37	100.00	100.00	100.00	97.66	99.02	99.31	88.47
OF [%]	100.00	100.00	100.00	100.00	0.13	96.25	100.00	100.00	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	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	0.01	0.25	99.91	5.75	0.00	0.00	0.00	0.00	0.00	0.00	8.96
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

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Historical Summary

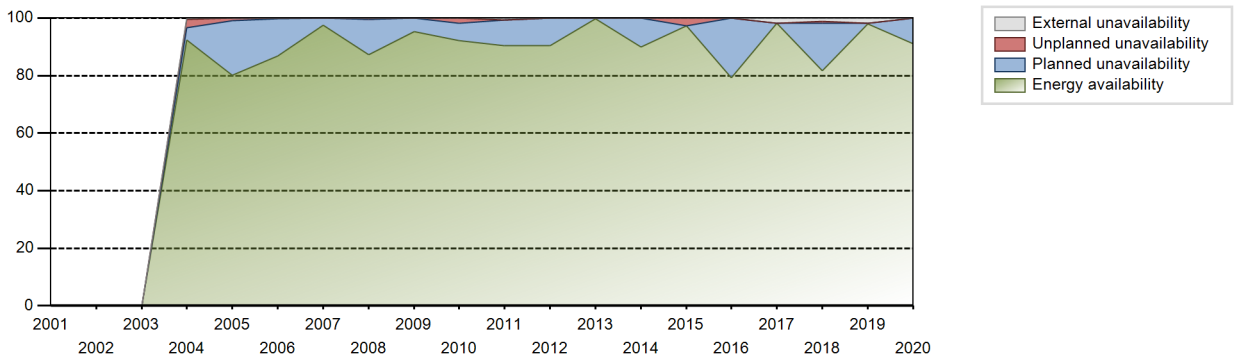
Lifetime energy generation	:	91675.32 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.61 %
Cumulative Energy Availability Factor (EAF)	:	91.01 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.56 %
Cumulative Unit Capability Factor (UCF)	:	91.37 %	Cumulative Planned Unavailability Factor (PUF)	:	8.06 %
Cumulative Load Factor (LF)	:	90.86 %	Cumulative Externally cause unavailability (XUF)	:	0.36 %
Cumulative Operating Factor (OF)	:	91.43 %			

Electricity Production (net) [GWh]



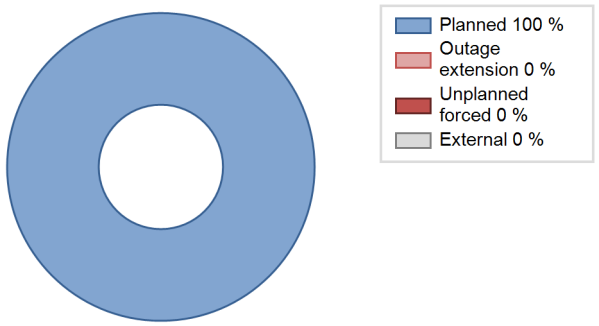
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2003	Data not provided										
2004	5358.59	8236	665	92.43	93.00	91.74	93.76	2.84	2.72	4.28	0.57
2005	4604.65	7014	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

Key Factors in Last 20 Years [%]

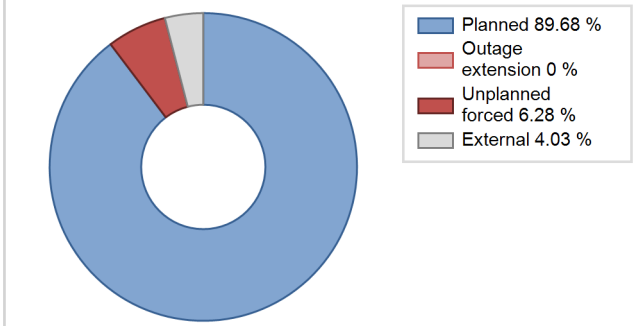


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2003 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					37	
C. Inspection, maintenance or repair combined with refuelling				106		
D. Inspection, maintenance or repair without refuelling	770			573		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						21
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
Subtotal	770			679	43	27
Total	**770**			**749**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2003 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		12
12. Reactor I&C Systems		6
14. Safety Systems		10
16. Steam generation systems		3
21. Fuel Handling and Storage Facilities		3
31. Turbine and auxiliaries		3
32. Feedwater and Main Steam System		4
42. Electrical Power Supply Systems		5
Total		**46**

Highlights (2020)

Unit was shutdown for 10th planned outage from April 30 to June 4.

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2020 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

Reactor type and model	:	PWR / CNP-300
Thermal power	:	966 MWth
Gross electrical power	:	330 MWe
Reference unit power (net)	:	308 MWe

Key Dates

Construction Date	:	1985-03-20
Grid Date	:	1991-12-15
Commercial Date	:	1994-04-01
Age at end of year	:	29 years

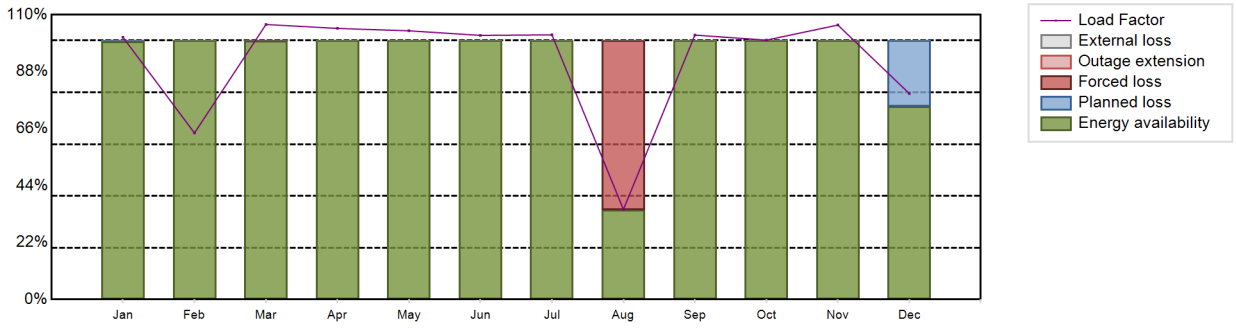
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.4
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	33.33
Average discharge burnup [MWd/t]	:	33000
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]	:	13.5
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]	:	308.5
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	2.65
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]	:	5.45
Output voltage [kV]	:	18
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 (2020)

Net Energy Production	:	2496.95 GW(e).h
Energy Availability Factor (EAF)	:	92.28 %
Unit Capability Factor (UCF)	:	92.28 %
Load Factor (LF)	:	92.29 %
Operating Factor (OF)	:	92.58 %
Forced Loss Rate (FLR)	:	5.67 %
Unplanned Capability Loss Factor (UCL)	:	5.54 %
Planned Unavailability Factor (PUF)	:	2.18 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	652 hours

Annual Summary



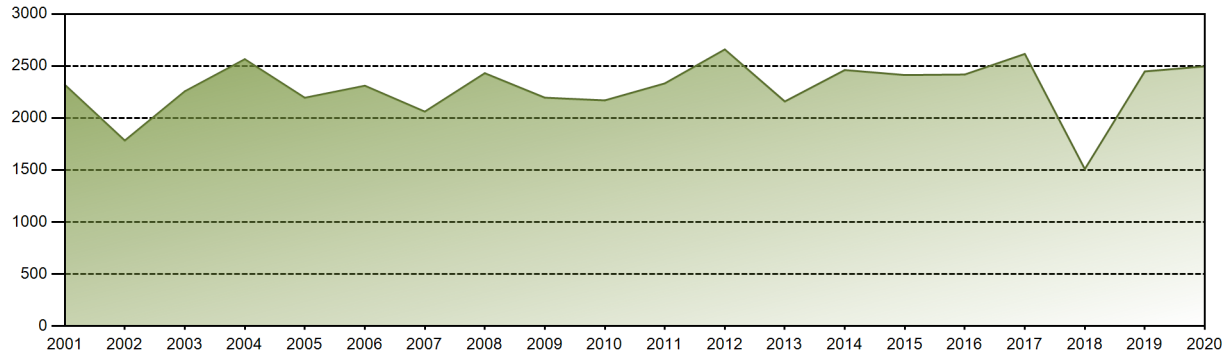
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	232.06	137.88	243.41	232.19	237.81	226.21	234.27	79.74	226.50	229.57	235.08	182.23	2496.95
EAF [%]	99.69	100.00	99.95	100.00	100.00	100.00	100.00	34.61	100.00	100.00	100.00	74.60	92.28
UCF [%]	99.69	100.00	99.95	100.00	100.00	100.00	100.00	34.61	100.00	100.00	100.00	74.60	92.28
LF [%]	101.27	64.32	106.22	104.70	103.78	102.01	102.23	34.80	102.14	100.18	106.01	79.52	92.29
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	36.69	100.00	100.00	100.00	75.67	92.58
FLR [%]	0.00	0.00	0.05	0.00	0.00	0.00	0.00	65.39	0.00	0.00	0.00	0.00	5.67
UCL [%]	0.00	0.00	0.05	0.00	0.00	0.00	0.00	65.39	0.00	0.00	0.00	0.00	5.54
PUF [%]	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.40	2.18
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

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Historical Summary

Lifetime energy generation	:	59202.75 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.99 %
Cumulative Energy Availability Factor (EAF)	:	81.99 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.78 %
Cumulative Unit Capability Factor (UCF)	:	82.97 %	Cumulative Planned Unavailability Factor (PUF)	:	13.26 %
Cumulative Load Factor (LF)	:	83.26 %	Cumulative Externally cause unavailability (XUF)	:	0.98 %
Cumulative Operating Factor (OF)	:	83.66 %			

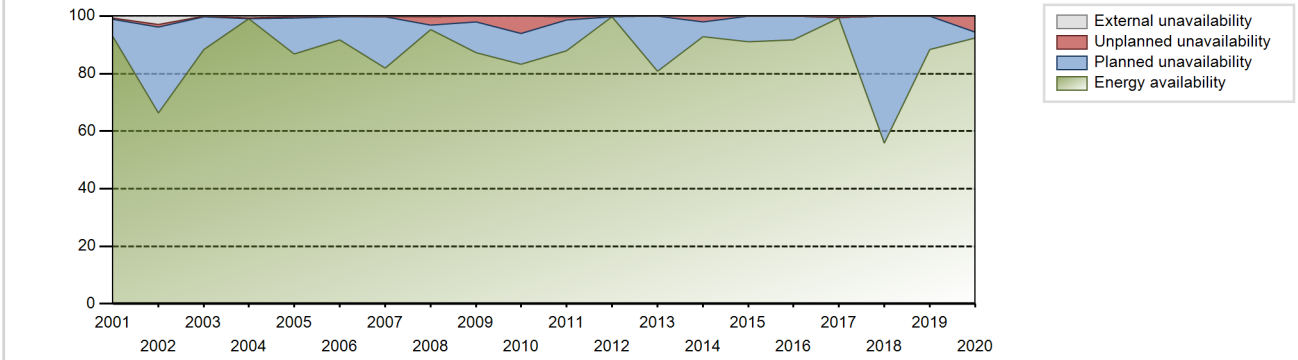
Electricity Production (net) [GWh]



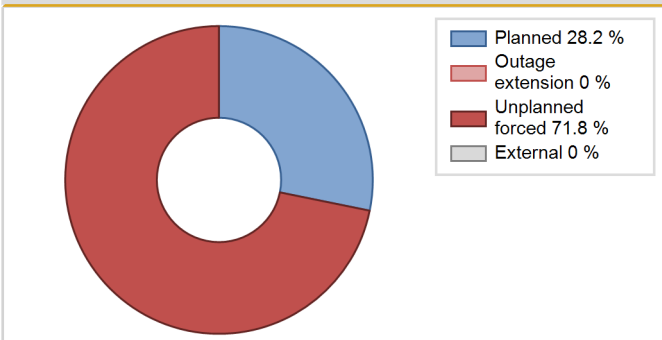
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1994	1648.58	6439	279	62.02	67.45	62.67	70.06	3.98	2.80	29.75	5.44
1995	2063.90	7886	300	82.32	86.80	78.53	90.02	2.25	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

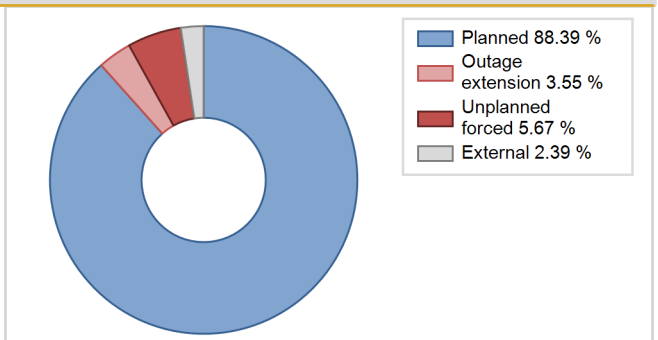
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1994 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		471			77	
C. Inspection, maintenance or repair combined with refuelling	180			1058		
D. Inspection, maintenance or repair without refuelling				47		
E. Testing of plant systems or components	2			0	2	
L. Human factor related					14	
Z. Other					232	2
Subtotal	182	471		1105	325	2
Total	**653**			**1432**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1994 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		3
15. Reactor Cooling Systems		7
16. Steam generation systems		0
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		5
32. Feedwater and Main Steam System		10
33. Circulating Water System		3
34. Miscellaneous Systems		2
35. All other I&C Systems		1
41. Main Generator Systems	471	18
Total	**471**	**79**

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RUP revision during the year (2020) due to power uprate

RUP at the end of previous year : 298 [MWe]

Month	Capacity [MWe]	Power Uprate	Main modifications	Description
January	308	Extended power uprate (>7%)	Balance of plant	power Uprate

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2020 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	:	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]	:	2.7239
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

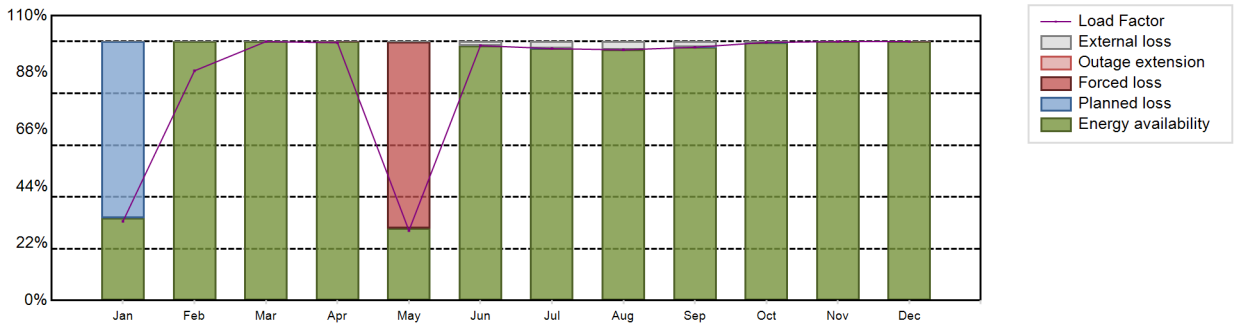
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	321
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.407
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	8757.82 GW(e).h
Energy Availability Factor (EAF)	:	87.29 %
Unit Capability Factor (UCF)	:	88.13 %
Load Factor (LF)	:	86.17 %
Operating Factor (OF)	:	89.16 %

Forced Loss Rate (FLR)	:	6.47 %
Unplanned Capability Loss Factor (UCL)	:	6.09 %
Planned Unavailability Factor (PUF)	:	5.78 %
Externally cause unavailability (XUF)	:	0.84 %
Total off-line time	:	952 hours

Annual Summary



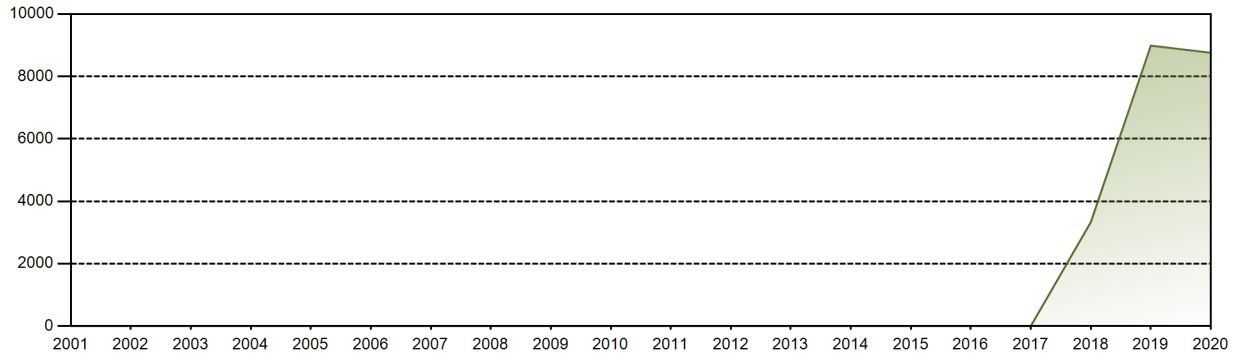
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	263.41	714.42	860.81	829.46	232.46	820.03	837.41	833.22	814.78	858.09	833.00	860.73	8757.82
EAF [%]	31.84	100.00	100.00	100.00	27.98	98.44	97.28	96.80	97.81	99.68	100.00	99.99	87.29
UCF [%]	31.84	100.00	100.00	100.00	28.05	100.00	100.00	100.00	100.00	100.00	100.00	99.99	88.13
LF [%]	30.60	88.72	100.00	99.57	27.00	98.44	97.28	96.80	97.81	99.68	100.00	99.99	86.17
OF [%]	42.20	100.00	100.00	100.00	29.84	100.00	100.00	100.00	100.00	100.00	100.00	100.00	89.16
FLR [%]	0.00	0.00	0.00	0.00	71.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.47
UCL [%]	0.00	0.00	0.00	0.00	71.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.09
PUF [%]	68.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	5.78
XUF [%]	0.00	0.00	0.00	0.00	0.07	1.56	2.71	3.20	2.19	0.31	0.00	0.00	0.84

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Historical Summary

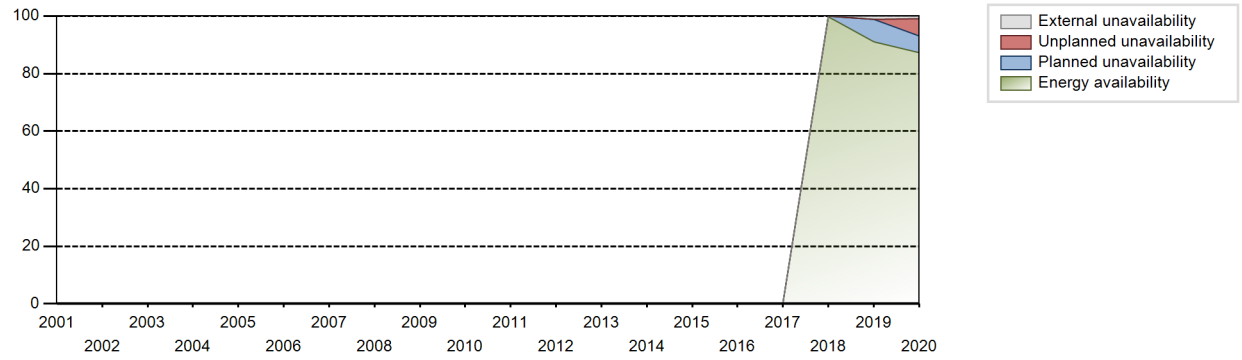
Lifetime energy generation	:	21075.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.88 %
Cumulative Energy Availability Factor (EAF)	:	90.4 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.71 %
Cumulative Unit Capability Factor (UCF)	:	91.29 %	Cumulative Planned Unavailability Factor (PUF)	:	6 %
Cumulative Load Factor (LF)	:	88.76 %	Cumulative Externally cause unavailability (XUF)	:	0.89 %
Cumulative Operating Factor (OF)	:	90.87 %			

Electricity Production (net) [GWh]

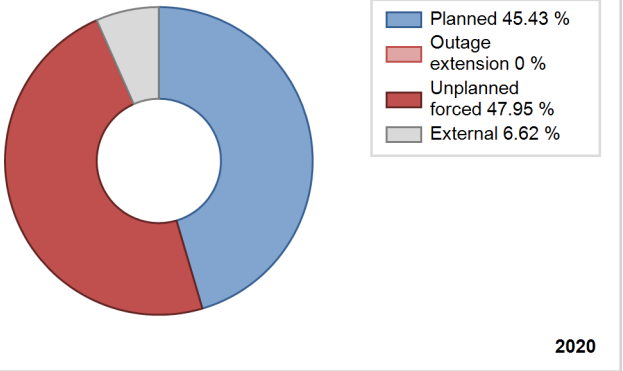


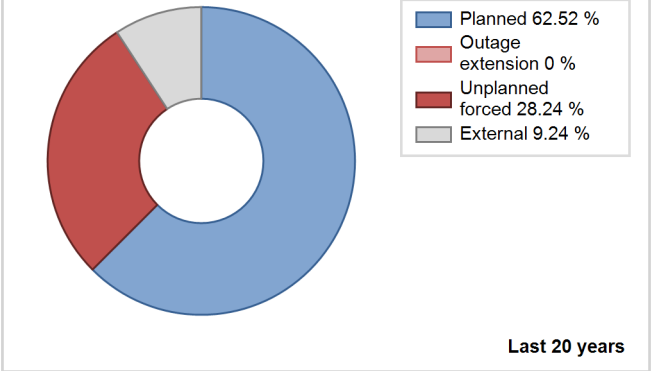
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	3330.63	3840	1157	99.85	99.98	99.39	100.00	0.00	0.00	0.02	0.13
2019	8987.29	7909	1157	91.14	92.26	88.67	90.29	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2018 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		522			232	
C. Inspection, maintenance or repair combined with refuelling	429			491		
D. Inspection, maintenance or repair without refuelling				126		
E. Testing of plant systems or components				138		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						77
Subtotal	429	522		755	232	77
Total	**951**			**1064**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2018 to 2020 Average hours lost per reactor-year
15. Reactor Cooling Systems	522	202
Total	**522**	**202**

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2020 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	:	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]	:	2.7239
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

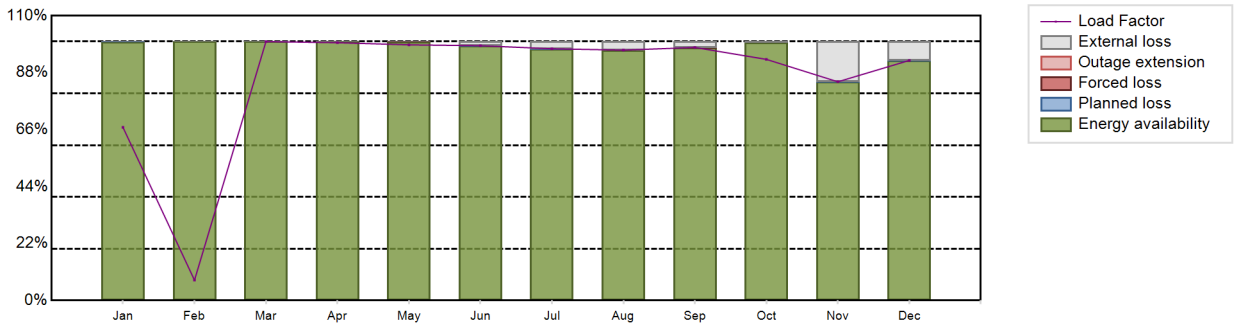
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	321
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.407
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	8786.18 GW(e).h
Energy Availability Factor (EAF)	:	97.25 %
Unit Capability Factor (UCF)	:	99.99 %
Load Factor (LF)	:	86.45 %
Operating Factor (OF)	:	89.61 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	0.01 %
Externally cause unavailability (XUF)	:	2.74 %
Total off-line time	:	913 hours

Annual Summary



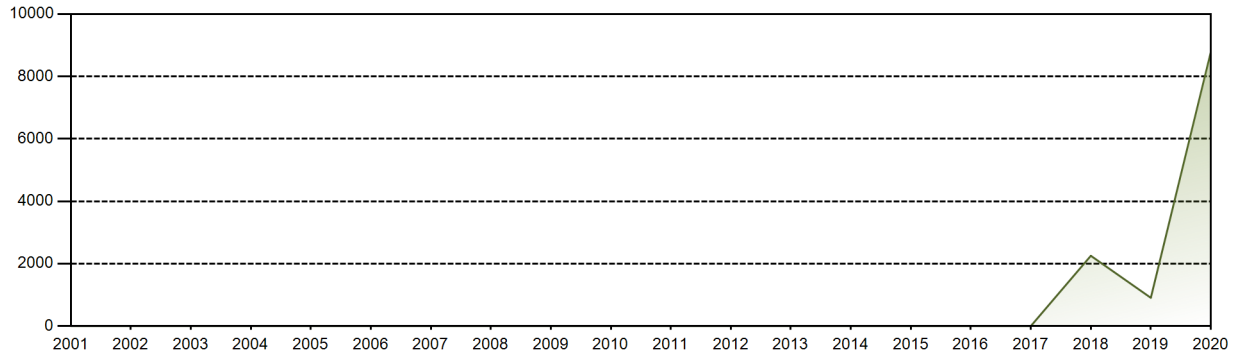
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	575.52	63.32	860.81	829.48	849.90	819.76	837.03	832.50	814.20	801.71	703.77	798.18	8786.18
EAF [%]	99.88	100.00	100.00	100.00	99.98	98.41	97.24	96.71	97.74	99.71	84.48	92.72	97.25
UCF [%]	99.88	100.00	100.00	100.00	99.98	100.00	99.99	100.00	100.00	100.00	99.99	100.00	99.99
LF [%]	66.86	7.86	100.00	99.57	98.73	98.41	97.24	96.71	97.74	93.14	84.48	92.72	86.45
OF [%]	68.01	9.77	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.68	100.00	100.00	89.61
FLR [%]	0.00	0.00	0.00	0.00	0.02	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	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PUF [%]	0.12	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01
XUF [%]	0.00	0.00	0.00	0.00	0.00	1.59	2.75	3.29	2.26	0.29	15.51	7.27	2.74

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Historical Summary

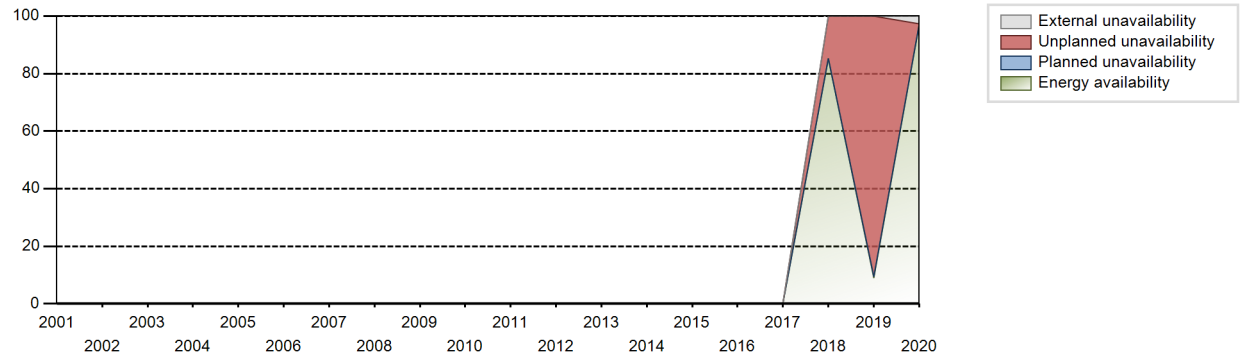
Lifetime energy generation	:	11944.91 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	43 %
Cumulative Energy Availability Factor (EAF)	:	55.62 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	42.92 %
Cumulative Unit Capability Factor (UCF)	:	56.88 %	Cumulative Planned Unavailability Factor (PUF)	:	0.2 %
Cumulative Load Factor (LF)	:	50.68 %	Cumulative Externally cause unavailability (XUF)	:	1.27 %
Cumulative Operating Factor (OF)	:	52.27 %			

Electricity Production (net) [GWh]

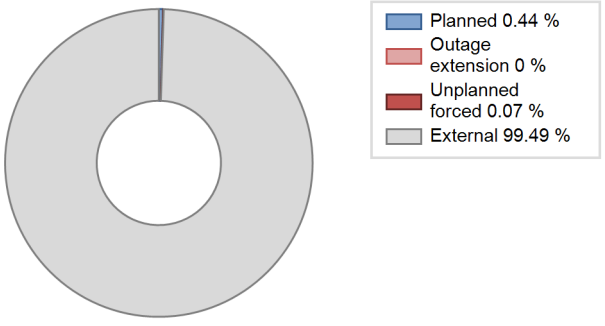


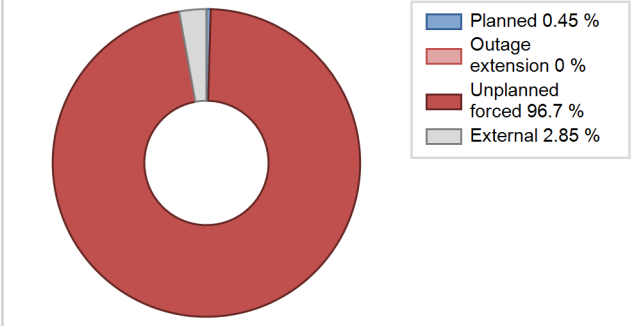
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	2252.77	2381	1157	85.14	85.14	85.84	85.18	14.85	14.84	0.02	0.00
2019	905.96	817	1157	8.94	8.94	8.94	9.33	91.02	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2018 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					3765	
D. Inspection, maintenance or repair without refuelling				145		
E. Testing of plant systems or components				89		
O. Load dispatching, prioritization			913			421
Subtotal			913	234	3765	421
Total		**913**			**4420**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2018 to 2020
	Hours Lost	Average hours lost per reactor-year
15. Reactor Cooling Systems		3376
Total		**3376**

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2020 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	:	2 years

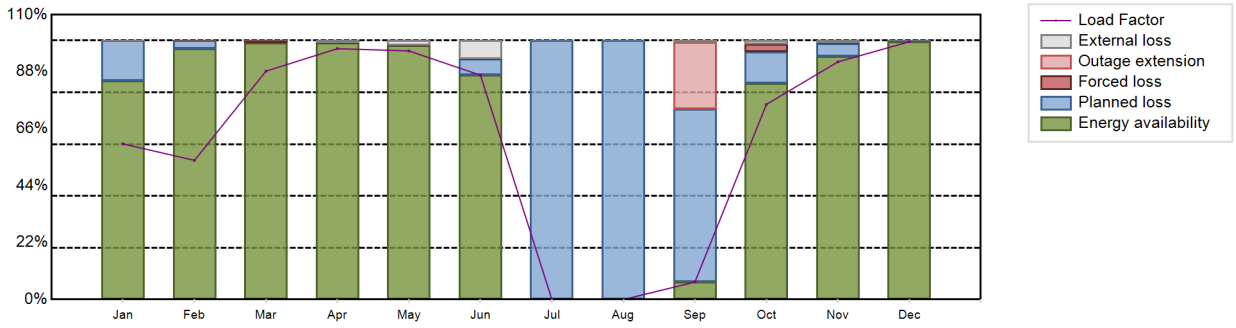
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.98
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 (2020)

Net Energy Production	:	9169.83 GW(e).h
Energy Availability Factor (EAF)	:	70.53 %
Unit Capability Factor (UCF)	:	71.56 %
Load Factor (LF)	:	62.89 %
Operating Factor (OF)	:	72.6 %
Forced Loss Rate (FLR)	:	0.53 %
Unplanned Capability Loss Factor (UCL)	:	2.49 %
Planned Unavailability Factor (PUF)	:	25.95 %
Externally cause unavailability (XUF)	:	1.03 %
Total off-line time	:	2407 hours

Annual Summary



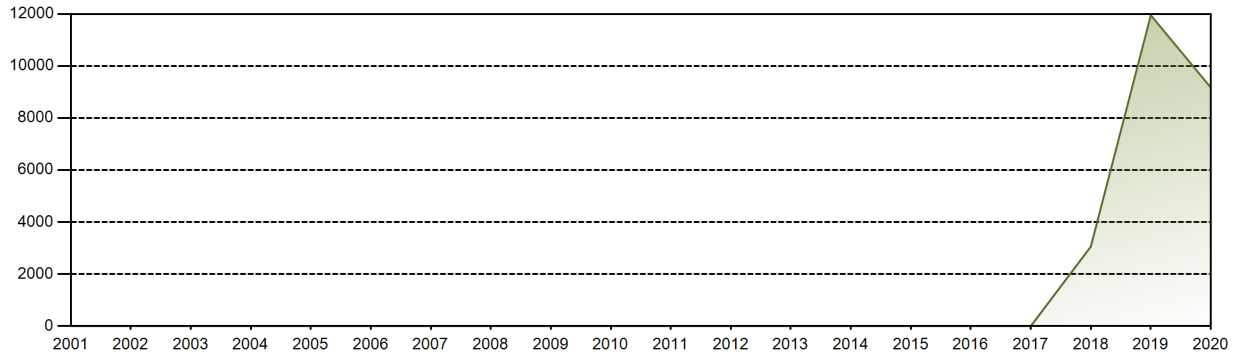
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	742.41	620.98	1089.20	1158.14	1185.79	1035.69	0.00	0.00	80.54	930.59	1096.94	1229.57	9169.83
EAF [%]	84.40	96.98	99.09	99.13	98.18	86.65	0.00	0.00	6.74	83.59	93.91	99.56	70.53
UCF [%]	84.41	96.98	99.09	99.99	99.93	93.70	0.00	0.00	7.44	84.87	94.67	99.56	71.56
LF [%]	60.11	53.75	88.19	96.90	96.01	86.65	0.00	0.00	6.74	75.35	91.78	99.56	62.89
OF [%]	74.19	84.34	100.00	100.00	100.00	94.03	0.00	0.00	20.14	100.00	100.00	100.00	72.60
FLR [%]	0.00	0.00	0.91	0.00	0.06	0.04	0.00	0.00	0.00	3.49	0.46	0.00	0.53
UCL [%]	0.00	0.00	0.91	0.00	0.06	0.03	0.00	0.00	25.78	3.07	0.44	0.00	2.49
PUF [%]	15.59	3.02	0.00	0.01	0.00	6.27	100.00	100.00	66.79	12.06	4.89	0.44	25.95
XUF [%]	0.01	0.00	0.00	0.87	1.75	7.05	0.00	0.00	0.70	1.28	0.76	0.00	1.03

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Historical Summary

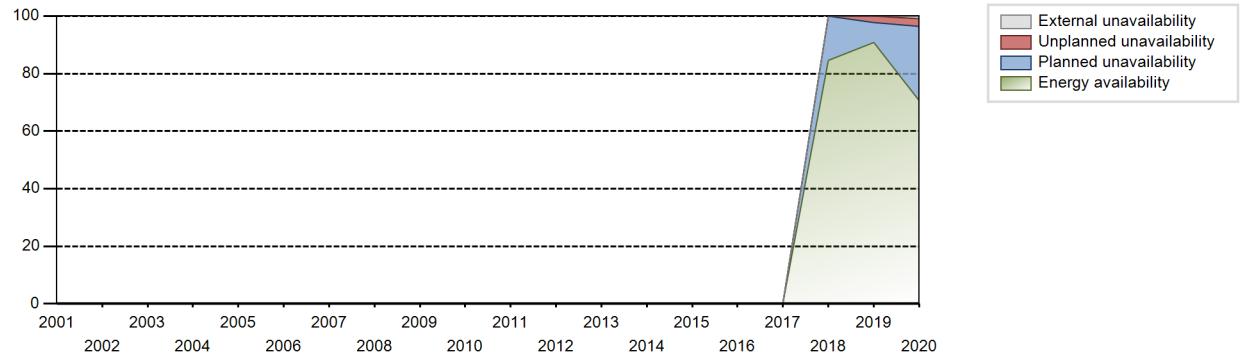
Lifetime energy generation	:	24178.65 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.62 %
Cumulative Energy Availability Factor (EAF)	:	80.79 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.28 %
Cumulative Unit Capability Factor (UCF)	:	81.29 %	Cumulative Planned Unavailability Factor (PUF)	:	16.43 %
Cumulative Load Factor (LF)	:	72.98 %	Cumulative Externally cause unavailability (XUF)	:	0.49 %
Cumulative Operating Factor (OF)	:	81.79 %			

Electricity Production (net) [GWh]

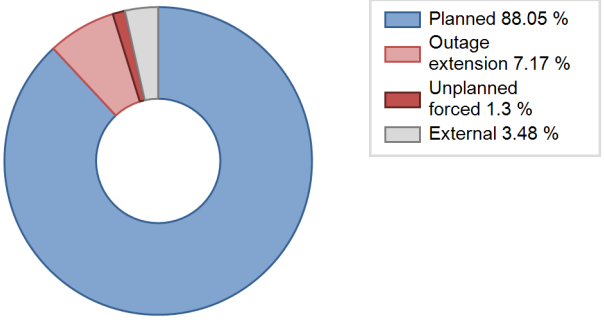


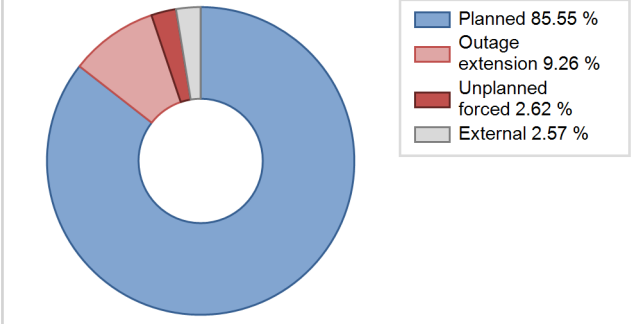
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	3056.09	3958	1660	84.52	84.52	83.51	100.00	0.00	0.00	15.48	0.00
2019	11952.73	7836	1660	90.77	90.77	82.20	89.45	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2018 to 2020		
	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	1920			922		
D. Inspection, maintenance or repair without refuelling	137			335		
E. Testing of plant systems or components				15		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			164			159
L. Human factor related					206	
Z. Other		186			89	
Subtotal	2057	186	164	1272	402	159
Total		**2407**			**1833**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2018 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
15. Reactor Cooling Systems		30
16. Steam generation systems		31
31. Turbine and auxiliaries		32
32. Feedwater and Main Steam System		120
33. Circulating Water System		36
34. Miscellaneous Systems	349	135
Total	**349**	**386**

Highlights (2020)

There was no unplanned shutdown and scram in CN32 in 2020, and CN32 shutdown for T101 outage from June to Spetember. CN32 reduced power daily and during holiday according to the requirement of the Grid.

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2020 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

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	:	2010-04-15
Grid Date	:	2019-06-23
Commercial Date	:	
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]	:	2.98
Refuelling frequency [month]	:	18
Part of the core refuelled [%]	:	29.8755
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 (2020)

Net Energy Production	:	12454.8 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	:	117 hours

Annual Summary

No data found

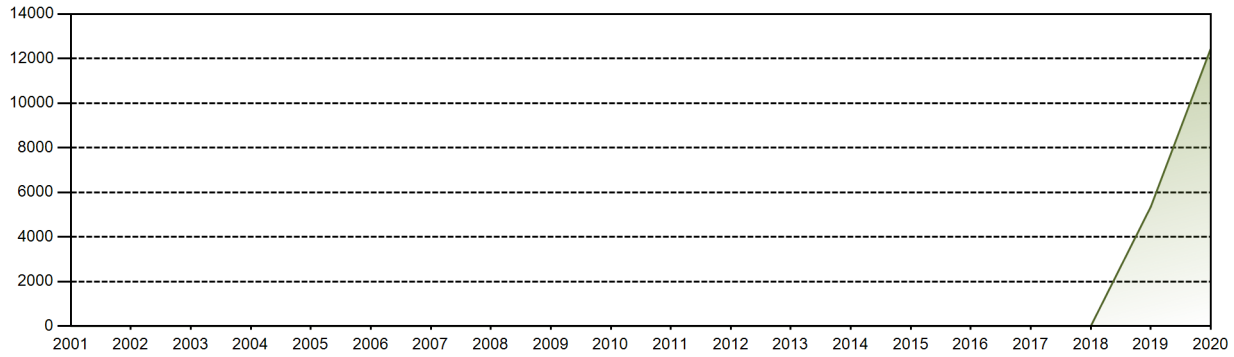
	Jan	Oct	Nov	Dec	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
GW(e)-h												
EAF [%]												
UCF [%]												
LF [%]												
OF [%]												
FLR [%]												
UCL [%]												
PUF [%]												
XUF [%]												

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Historical Summary

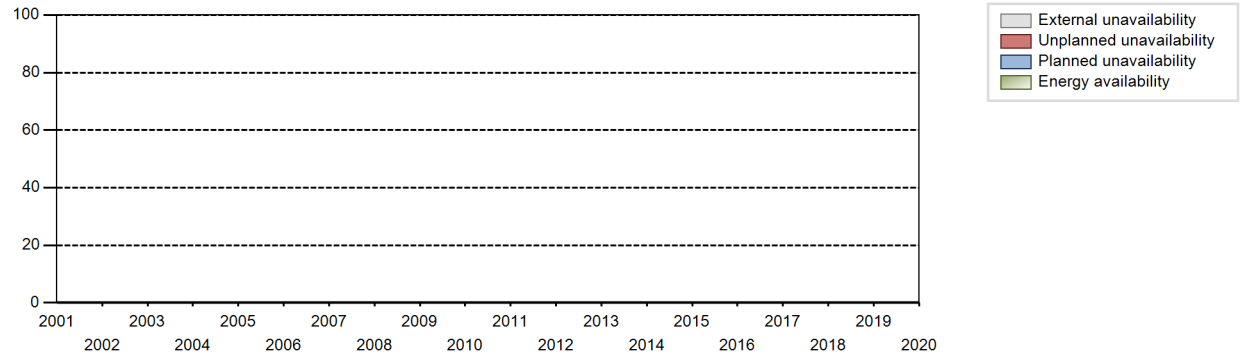
Lifetime energy generation	:	17810.94 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	0 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	0 %	Cumulative Planned Unavailability Factor (PUF)	:	0 %
Cumulative Load Factor (LF)	:	0 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	0 %			

Electricity Production (net) [GWh]

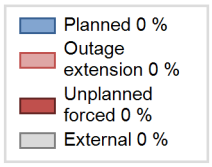


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]

Key Factors in Last 20 Years [%]



Energy Losses by Type



2020

No Data Available

Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
D. Inspection, maintenance or repair without refuelling	63					
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			54			
Subtotal	63		54			
Total	**117**			**0**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1 to 2020
	Hours Lost	Average hours lost per reactor-year
34. Miscellaneous Systems	54	79
Total	**54**	**79**

Highlights (2020)

There was no unplanned shutdown and scram in CN33 in 2020, and CN33 shutdown according to the requirement of the Grid during National holiday. CN33 reduced power dailiy and during holiday according to the requirement of the Grid.

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2020 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

Reactor type and model	:	PWR / VVER V-428
Thermal power	:	3000 MWth
Gross electrical power	:	1060 MWe
Reference unit power (net)	:	990 MWe

Key Dates

Construction Date	:	1999-10-20
Grid Date	:	2006-05-12
Commercial Date	:	2007-05-17
Age at end of year	:	14 years

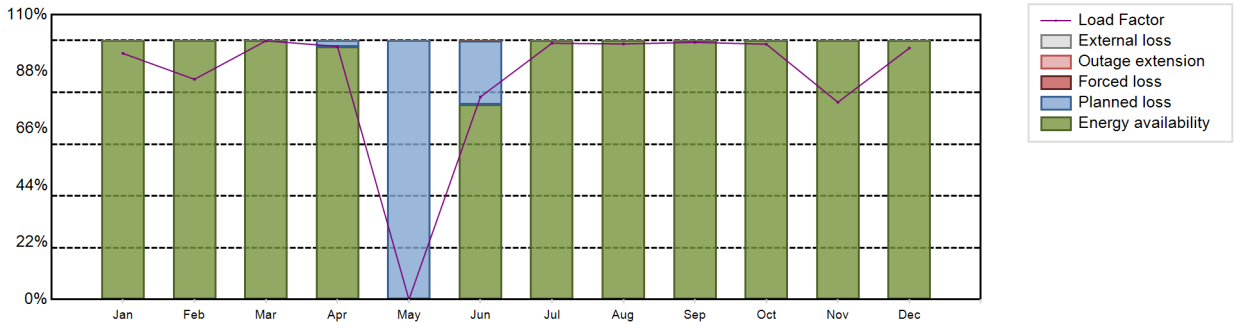
Design Characteristics

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]	:	-
Active core diameter [m]	:	3.16
Active core height/length [m]	:	-
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	:	Double
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 (2020)

Net Energy Production	:	7424.97 GW(e).h
Energy Availability Factor (EAF)	:	89.31 %
Unit Capability Factor (UCF)	:	89.31 %
Load Factor (LF)	:	85.38 %
Operating Factor (OF)	:	89.41 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	10.69 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	930 hours

Annual Summary



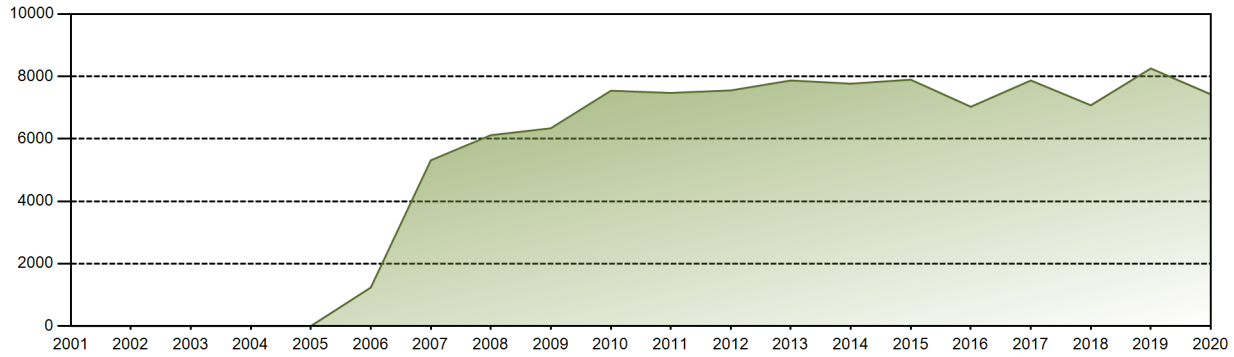
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	700.11	586.01	735.87	696.78	0.00	557.68	729.03	727.06	707.89	726.32	543.07	715.18	7424.97
EAF [%]	100.00	100.00	100.00	97.59	0.00	75.27	100.00	100.00	100.00	100.00	100.00	100.00	89.31
UCF [%]	100.00	100.00	100.00	97.59	0.00	75.27	100.00	100.00	100.00	100.00	100.00	100.00	89.31
LF [%]	95.05	85.05	99.91	97.75	0.00	78.24	98.98	98.71	99.31	98.61	76.19	97.10	85.38
OF [%]	100.00	100.00	100.00	98.89	0.00	75.28	100.00	100.00	100.00	100.00	100.00	100.00	89.41
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.02	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	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PUF [%]	0.00	0.00	0.00	2.41	100.00	24.71	0.00	0.00	0.00	0.00	0.00	0.00	10.69
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

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Historical Summary

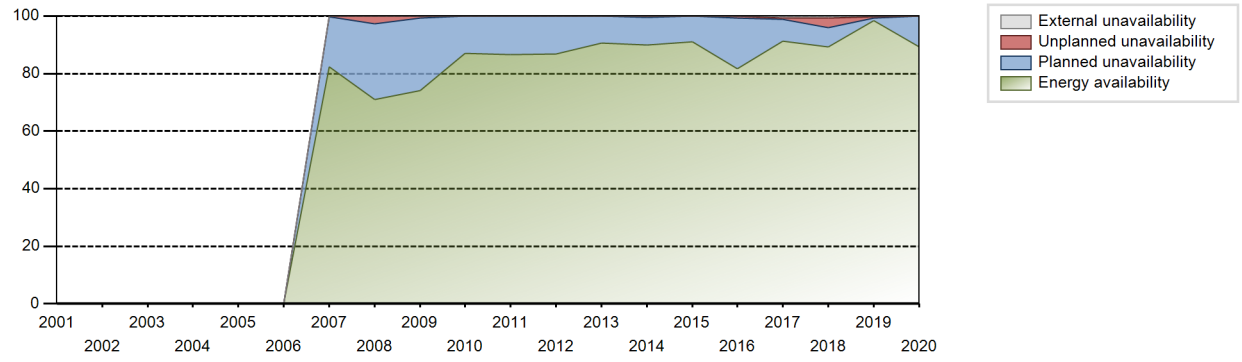
Lifetime energy generation	:	102764.97 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.73 %
Cumulative Energy Availability Factor (EAF)	:	86.64 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.67 %
Cumulative Unit Capability Factor (UCF)	:	86.76 %	Cumulative Planned Unavailability Factor (PUF)	:	12.57 %
Cumulative Load Factor (LF)	:	86.33 %	Cumulative Externally cause unavailability (XUF)	:	0.13 %
Cumulative Operating Factor (OF)	:	86.46 %			

Electricity Production (net) [GWh]



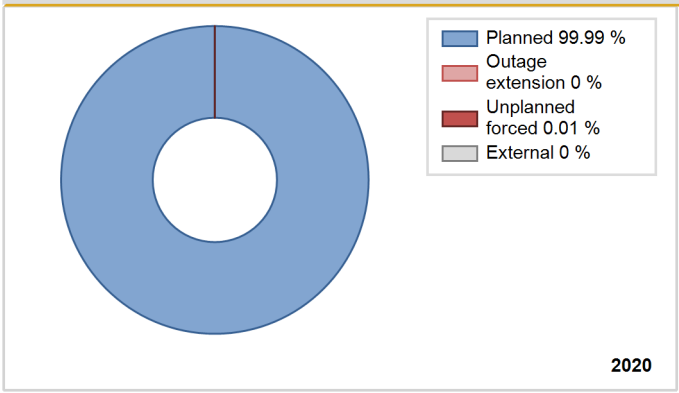
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2007	5311.00	5688	933	82.44	82.44	84.77	82.71	0.44	0.36	17.20	0.00
2008	6116.16	6270	933	70.97	70.97	74.63	71.38	3.60	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

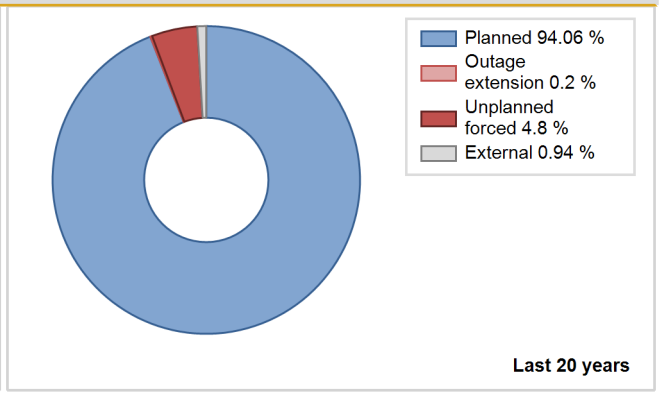
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2007 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		0			49	
C. Inspection, maintenance or repair combined with refuelling	934			990		
D. Inspection, maintenance or repair without refuelling				102		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						45
L. Human factor related					2	
Subtotal	934	0		1092	51	45
Total	**934**			**1188**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2007 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		4
17. Safety I&C Systems (excluding reactor I&C)		2
32. Feedwater and Main Steam System	0	2
41. Main Generator Systems		21
42. Electrical Power Supply Systems		18
Total	**0**	**47**

Highlights (2020)

This year, Unit 1 experienced the 12th refueling outage, cooperated with the power grid to reduce power for many times, and other time maintained power operation. The details are as follows: at 12:00 on April 30, 2020, the unit shut down and began refueling outage. At 00:50 on June 7, 2020, the unit was connected to the grid and the outage ended smoothly.

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2020 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)	:	990 MWe

Key Dates

Construction Date	:	2000-09-20
Grid Date	:	2007-05-14
Commercial Date	:	2007-08-16
Age at end of year	:	13 years

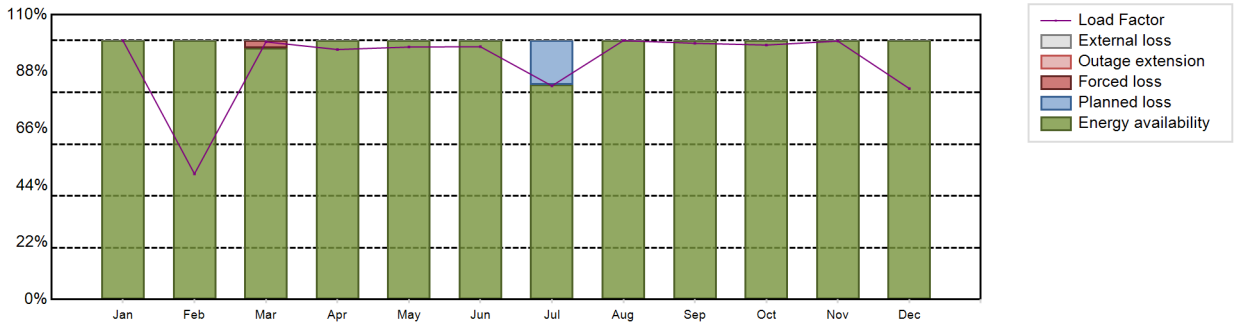
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	7991.08 GW(e).h
Energy Availability Factor (EAF)	:	98.32 %
Unit Capability Factor (UCF)	:	98.32 %
Load Factor (LF)	:	91.89 %
Operating Factor (OF)	:	98.85 %
Forced Loss Rate (FLR)	:	0.25 %
Unplanned Capability Loss Factor (UCL)	:	0.25 %
Planned Unavailability Factor (PUF)	:	1.43 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	101 hours

Annual Summary



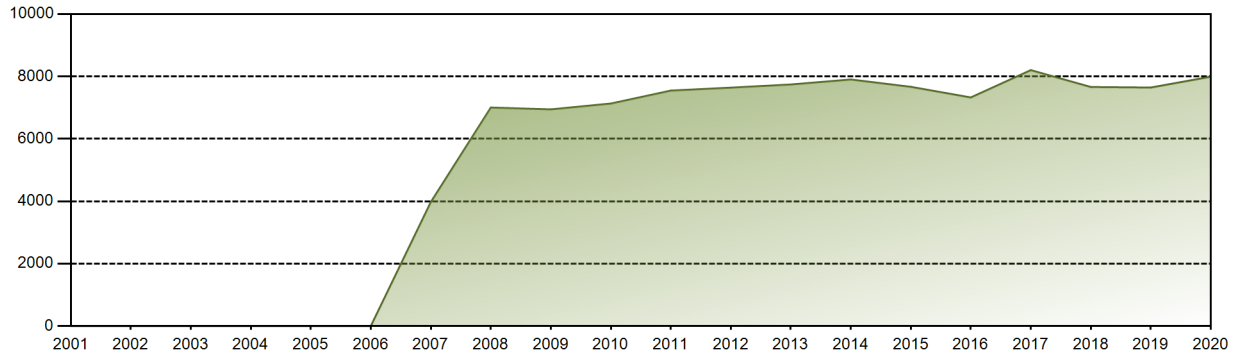
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	736.36	334.47	732.84	688.23	718.25	695.97	607.76	736.56	705.30	723.88	711.39	600.07	7991.08
EAF [%]	100.00	100.00	97.09	100.00	100.00	100.00	83.09	100.00	100.00	100.00	100.00	100.00	98.32
UCF [%]	100.00	100.00	97.09	100.00	100.00	100.00	83.09	100.00	100.00	100.00	100.00	100.00	98.32
LF [%]	99.97	48.54	99.49	96.55	97.51	97.64	82.51	100.00	98.95	98.28	99.80	81.47	91.89
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	86.42	100.00	100.00	100.00	100.00	100.00	98.85
FLR [%]	0.00	0.00	2.91	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	2.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	16.91	0.00	0.00	0.00	0.00	0.00	1.43
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

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Historical Summary

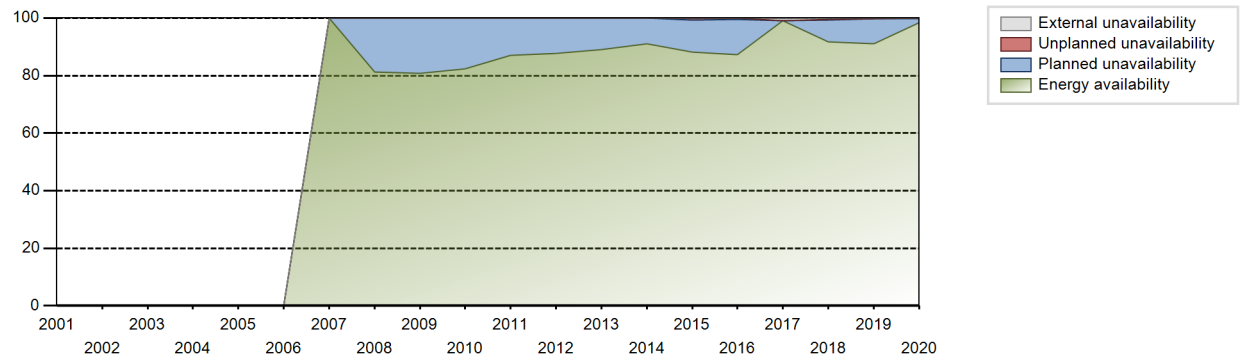
Lifetime energy generation	:	102371.08 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.15 %
Cumulative Energy Availability Factor (EAF)	:	89.2 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.13 %
Cumulative Unit Capability Factor (UCF)	:	89.33 %	Cumulative Planned Unavailability Factor (PUF)	:	10.54 %
Cumulative Load Factor (LF)	:	88.78 %	Cumulative Externally cause unavailability (XUF)	:	0.13 %
Cumulative Operating Factor (OF)	:	89 %			

Electricity Production (net) [GWh]



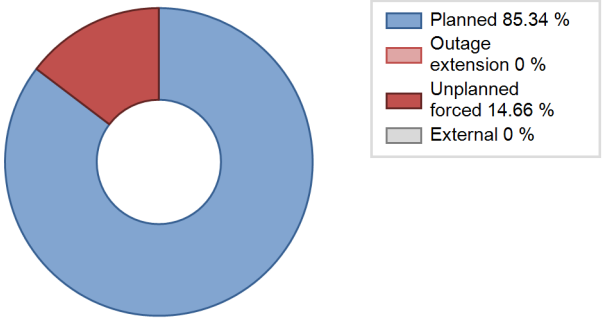
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2007	3974.00	4471	958	100.00	100.00	105.13	100.00	0.00	0.00	0.00	0.00
2008	7003.03	7193	933	81.20	81.20	85.45	81.89	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

Key Factors in Last 20 Years [%]

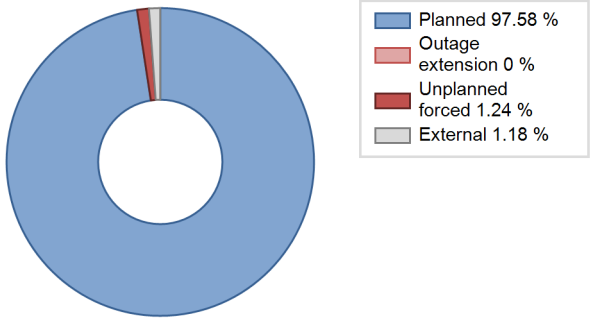


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2007 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		22			4	
C. Inspection, maintenance or repair combined with refuelling				801		
D. Inspection, maintenance or repair without refuelling	116			129		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						49
L. Human factor related					3	
Subtotal	116	22		930	7	49
Total	**138**			**986**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2007 to 2020 Average hours lost per reactor-year
31. Turbine and auxiliaries		3
32. Feedwater and Main Steam System	22	2
35. All other I&C Systems		2
Total	**22**	**7**

Highlights (2020)

In this year, unit 2 experienced a minor repair event of manual disconnection with the power grid, cooperated with the power grid to reduce power for many times, and other units kept power operation. The details are as follows: at 20:00 on July 13, 2020, the unit shut down and started minor repair. At 16:27 on July 18, 2020, the unit was connected to the grid and the minor repair was successfully completed.

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2020 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

Reactor type and model	:	PWR / VVER V-428M
Thermal power	:	3000 MWth
Gross electrical power	:	1126 MWe
Reference unit power (net)	:	1045 MWe

Key Dates

Construction Date	:	2012-12-27
Grid Date	:	2017-12-30
Commercial Date	:	2018-02-14
Age at end of year	:	3 years

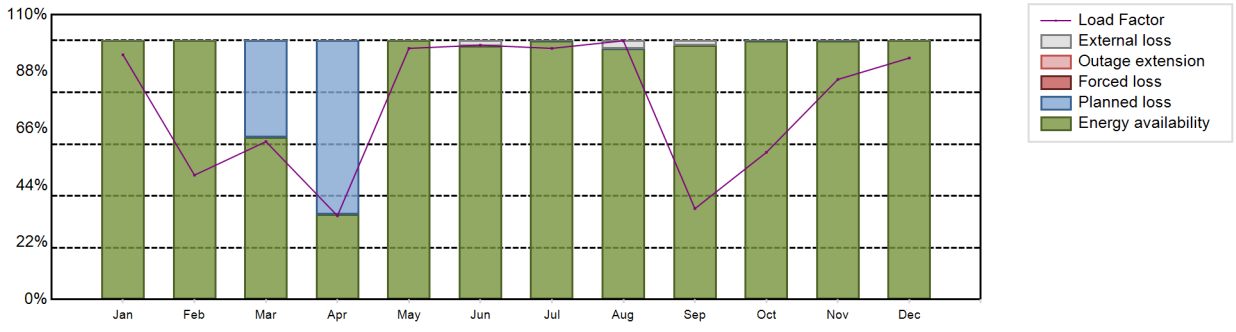
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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	:	none

Annual Production Results (2020)

Net Energy Production	:	6896.21 GW(e).h
Energy Availability Factor (EAF)	:	90.7 %
Unit Capability Factor (UCF)	:	91.29 %
Load Factor (LF)	:	75.13 %
Operating Factor (OF)	:	86.65 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.71 %
Externally cause unavailability (XUF)	:	0.58 %
Total off-line time	:	1173 hours

Annual Summary



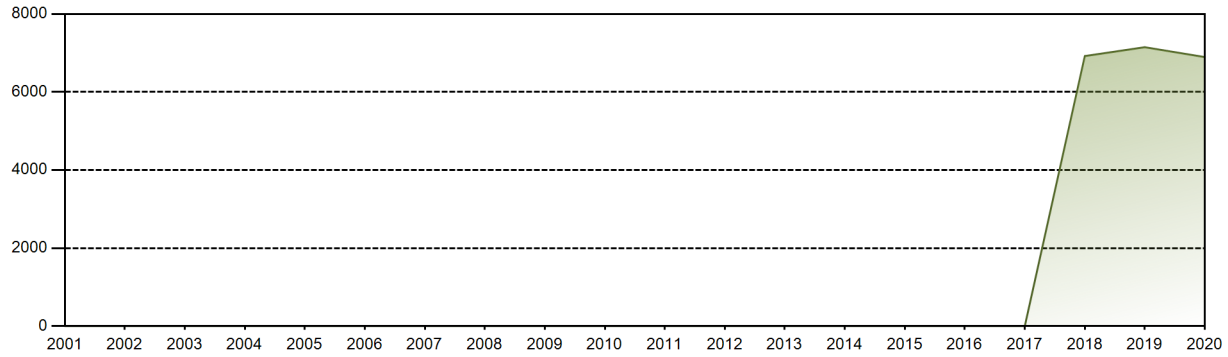
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	734.67	349.45	474.13	243.35	754.21	738.95	754.16	776.78	264.05	441.77	639.48	725.19	6896.21
EAF [%]	100.00	100.00	62.55	32.88	100.00	97.94	99.92	96.79	98.16	99.75	99.94	100.00	90.70
UCF [%]	100.00	100.00	62.55	32.88	100.00	100.00	99.92	99.91	100.00	99.75	99.94	100.00	91.29
LF [%]	94.49	48.05	60.98	32.34	97.01	98.21	97.00	99.91	35.09	56.82	84.99	93.27	75.13
OF [%]	100.00	100.00	63.17	37.92	100.00	100.00	100.00	100.00	37.22	100.00	100.00	100.00	86.65
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	37.45	67.12	0.00	0.00	0.08	0.09	0.00	0.25	0.06	0.00	8.71
XUF [%]	0.00	0.00	0.00	0.00	0.00	2.06	0.00	3.12	1.84	0.00	0.00	0.00	0.58

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Historical Summary

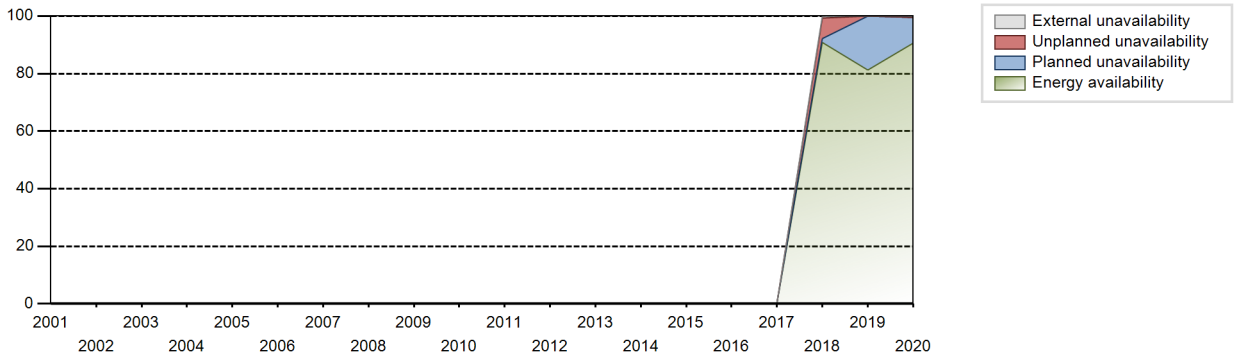
Lifetime energy generation	:	20970.21 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.5 %
Cumulative Energy Availability Factor (EAF)	:	87.5 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.25 %
Cumulative Unit Capability Factor (UCF)	:	87.92 %	Cumulative Planned Unavailability Factor (PUF)	:	9.83 %
Cumulative Load Factor (LF)	:	77.31 %	Cumulative Externally cause unavailability (XUF)	:	0.42 %
Cumulative Operating Factor (OF)	:	84.61 %			

Electricity Production (net) [GWh]

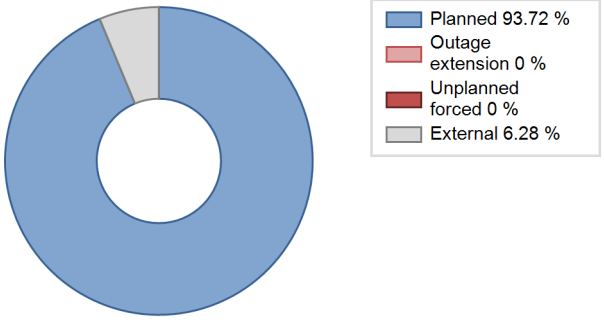


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	6922.47	7704	1045	90.85	91.48	78.83	86.83	7.27	7.18	1.34	0.63
2019	7149.36	7055	1045	81.24	81.29	78.10	80.54	0.00	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

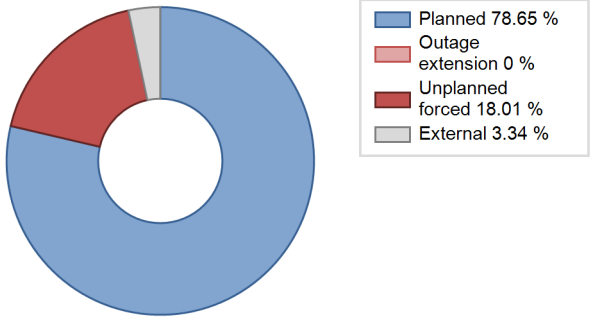
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2018 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					171	
C. Inspection, maintenance or repair combined with refuelling	722			803		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			464			371
Subtotal	722		464	803	171	371
Total	**1186**			**1345**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2018 to 2020
	Hours Lost	Average hours lost per reactor-year
13. Reactor Auxiliary Systems		122
16. Steam generation systems		44
34. Miscellaneous Systems	464	155
Total	**464**	**321**

Highlights (2020)

Unit 3 has undergone the second refuelling outage in this year, and according to the Jiangsu Province ,the unit reduced the power for many times.
The details are as follows:
At 11:40 on March 20, 2020, the unit was shut down and started the first refuelling outage; at 13:16 on April 19, 2020, the unit was successfully connected to the grid.

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2020 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)	:	1045 MWe

Key Dates

Construction Date	:	2013-09-27
Grid Date	:	2018-10-27
Commercial Date	:	2018-12-22
Age at end of year	:	2 years

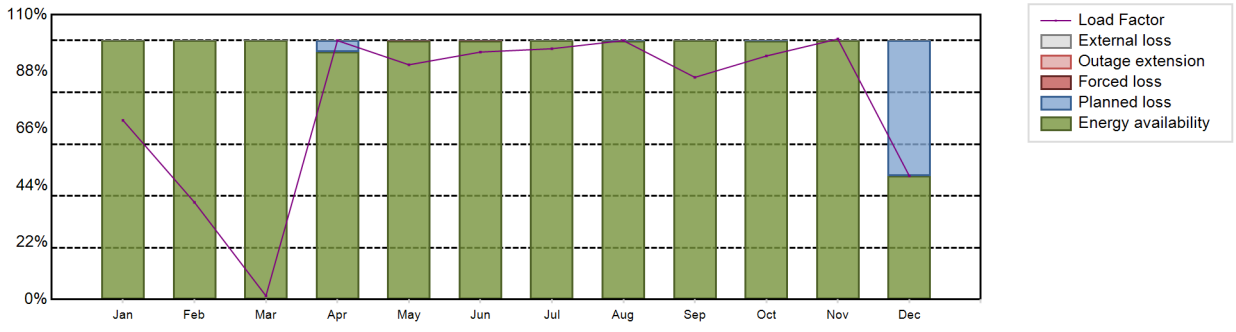
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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	:	none

Annual Production Results (2020)

Net Energy Production	:	7033.68 GW(e).h	Forced Loss Rate (FLR)	:	0.03 %
Energy Availability Factor (EAF)	:	95.17 %	Unplanned Capability Loss Factor (UCL)	:	0.02 %
Unit Capability Factor (UCF)	:	95.17 %	Planned Unavailability Factor (PUF)	:	4.8 %
Load Factor (LF)	:	76.63 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	79.72 %	Total off-line time	:	1781 hours

Annual Summary



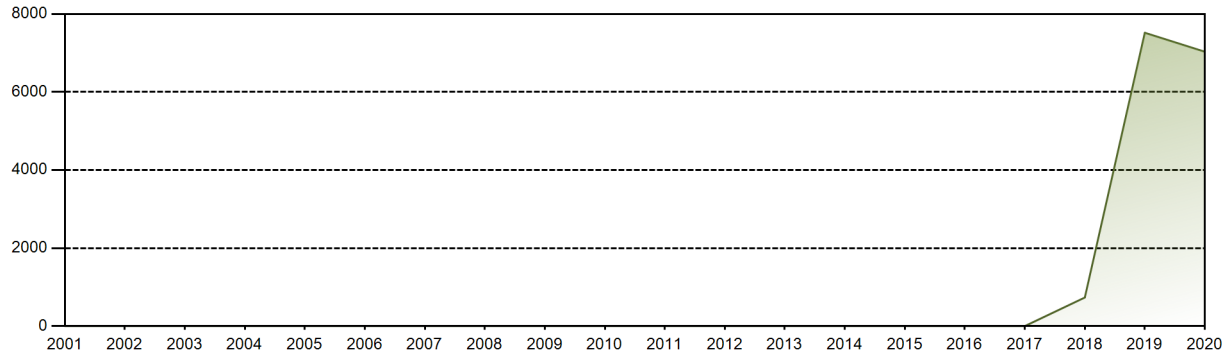
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	538.09	273.09	10.97	752.40	704.87	719.06	753.12	777.37	645.59	731.24	757.05	370.83	7033.68
EAF [%]	100.00	100.00	100.00	95.56	99.86	99.84	100.00	99.99	100.00	99.93	100.00	47.70	95.17
UCF [%]	100.00	100.00	100.00	95.56	99.86	99.84	100.00	99.99	100.00	99.93	100.00	47.70	95.17
LF [%]	69.21	37.55	1.41	100.00	90.66	95.57	96.87	99.99	85.80	94.05	100.62	47.70	76.63
OF [%]	71.91	39.37	1.34	100.00	100.00	100.00	100.00	100.00	100.00	95.83	100.00	48.25	79.72
FLR [%]	0.00	0.00	0.00	0.00	0.14	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.03
UCL [%]	0.00	0.00	0.00	0.00	0.14	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.02
PUF [%]	0.00	0.00	0.00	4.44	0.00	0.00	0.00	0.01	0.00	0.07	0.00	52.30	4.80
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

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Historical Summary

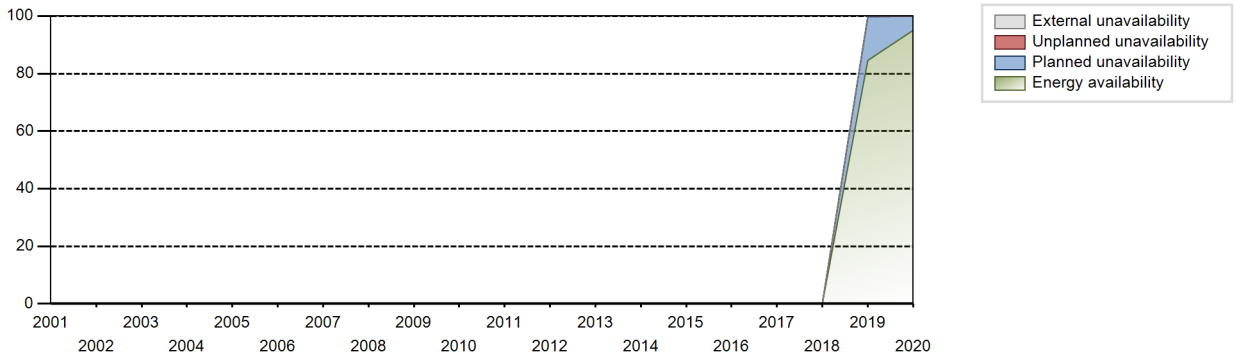
Lifetime energy generation	:	15285.68 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.1 %
Cumulative Energy Availability Factor (EAF)	:	89.91 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.09 %
Cumulative Unit Capability Factor (UCF)	:	89.95 %	Cumulative Planned Unavailability Factor (PUF)	:	9.96 %
Cumulative Load Factor (LF)	:	79.38 %	Cumulative Externally cause unavailability (XUF)	:	0.04 %
Cumulative Operating Factor (OF)	:	82.45 %			

Electricity Production (net) [GWh]

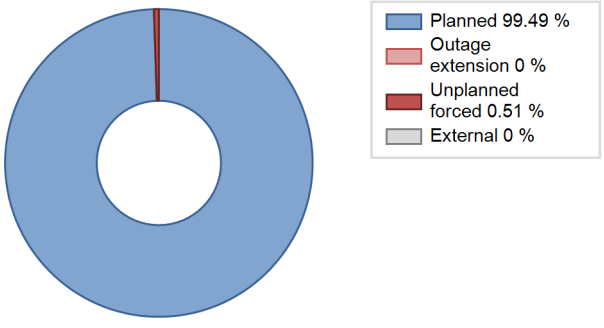


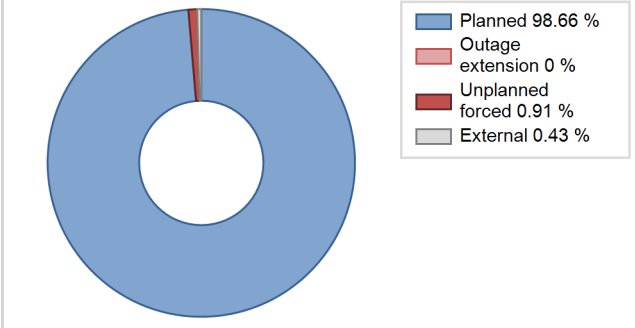
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	732.62	1035	1045	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2019	7519.47	7462	1045	84.63	84.71	82.14	85.18	0.19	0.16	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2018 to 2020		
	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	385			839		
E. Testing of plant systems or components				265		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			1396			698
Subtotal	385		1396	1104	2	698
Total	**1781**			**1804**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2018 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		1
34. Miscellaneous Systems	1396	620
Total	**1396**	**621**

Highlights (2020)

In this year, unit 4 experienced the second refuelling outage, and cooperated with the grid for power reduction for many times. Other time kept power operation, and no manual scram occurred. The details are as follows:

At 22:02 on November 15, 2020, the unit was shut down and started the second refueling outage;
At 22:42 January,9 2021, the unit was reconnected to the grid .

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2020 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

Reactor type and model	:	PWR / CNP-1000
Thermal power	:	2905 MWth
Gross electrical power	:	1118 MWe
Reference unit power (net)	:	1000 MWe

Key Dates

Construction Date	:	2015-12-27
Grid Date	:	2020-08-08
Commercial Date	:	2020-09-08
Age at end of year	:	0 years

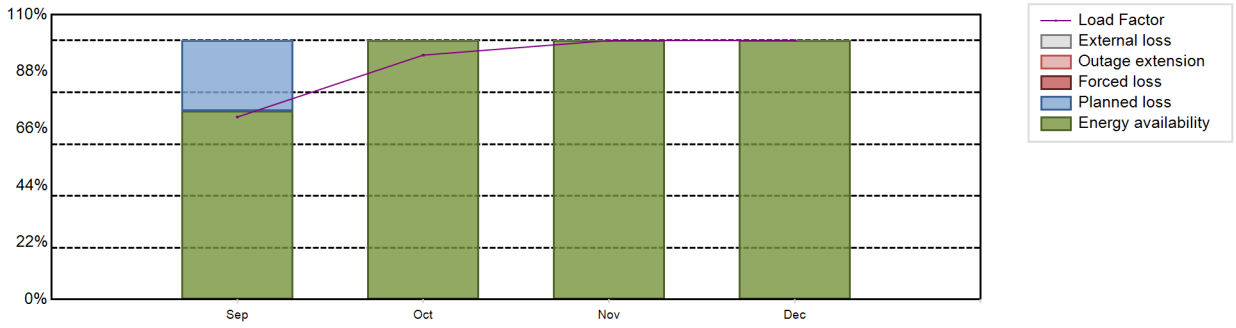
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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	:	none

Annual Production Results (2020)

Net Energy Production	:	2901.91 GW(e).h
Energy Availability Factor (EAF)	:	93.34 %
Unit Capability Factor (UCF)	:	93.34 %
Load Factor (LF)	:	91.31 %
Operating Factor (OF)	:	95.87 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	6.66 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	121 hours

Annual Summary



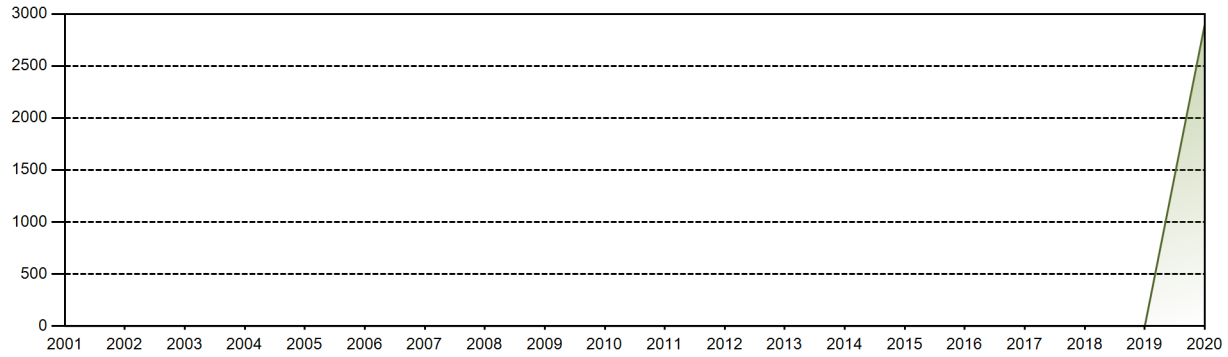
	Jan	Feb	Mar	Apr	Aug	May	Jun	Jul	Sep	Oct	Nov	Dec	Annual
GW(e)-h									507.39	702.30	720.00	744.00	2673.69
EAF [%]									72.92	100.00	100.00	100.00	93.34
UCF [%]									72.92	100.00	100.00	100.00	93.34
LF [%]									70.47	94.39	100.00	100.00	91.31
OF [%]									92.78	90.73	100.00	100.00	95.87
FLR [%]									0.00	0.00	0.00	0.00	0.00
UCL [%]									0.00	0.00	0.00	0.00	0.00
PUF [%]									27.08	0.00	0.00	0.00	6.66
XUF [%]									0.00	0.00	0.00	0.00	0.00

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Historical Summary

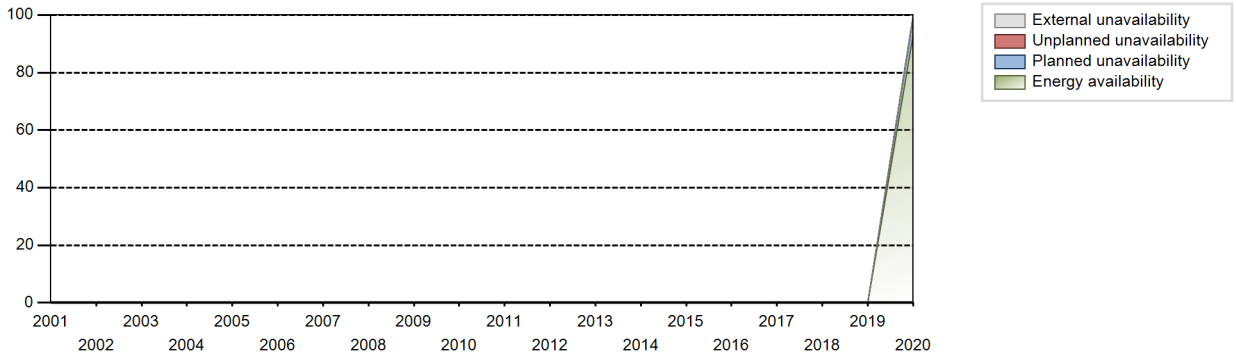
Lifetime energy generation	:	2901.91 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	93.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	93.34 %	Cumulative Planned Unavailability Factor (PUF)	:	6.66 %
Cumulative Load Factor (LF)	:	91.31 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	95.87 %			

Electricity Production (net) [GWh]

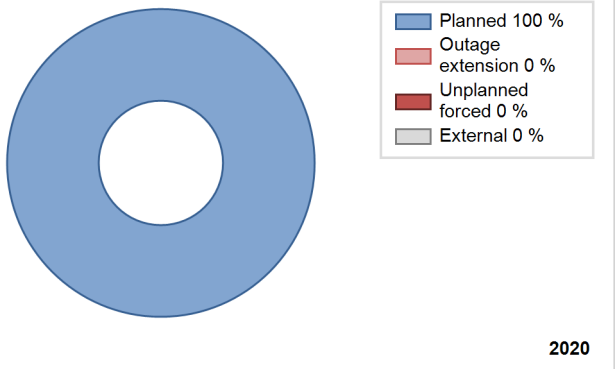


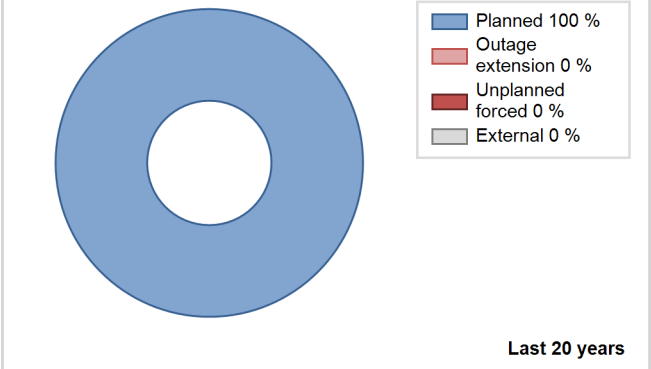
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2020	2901.91	3383	1000	93.34	93.34	91.31	95.87	0.00	0.00	6.66	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2020 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			121			363
Subtotal			121			363
Total		**121**			**363**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2020 to 2020
	Hours Lost	Average hours lost per reactor-year
34. Miscellaneous Systems	121	290
Total	**121**	**290**

Highlights (2020)

During this year, unit 5 was loaded and tested many times. It was connected to the grid on August 8 and was ready for commercial operation on September 8.

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2020 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	:	7 years

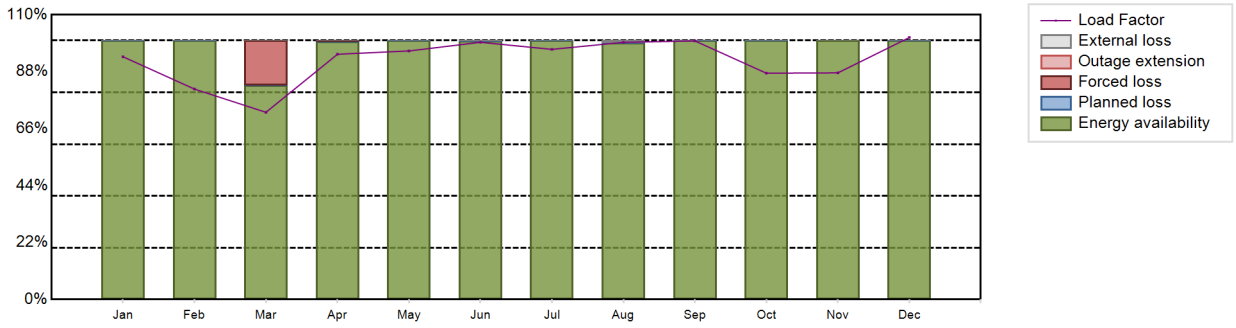
Design Characteristics

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 (2020)

Net Energy Production	:	8122.92 GW(e).h	Forced Loss Rate (FLR)	:	1.49 %
Energy Availability Factor (EAF)	:	98.42 %	Unplanned Capability Loss Factor (UCL)	:	1.49 %
Unit Capability Factor (UCF)	:	98.51 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	92.47 %	Externally cause unavailability (XUF)	:	0.09 %
Operating Factor (OF)	:	98.65 %	Total off-line time	:	119 hours

Annual Summary



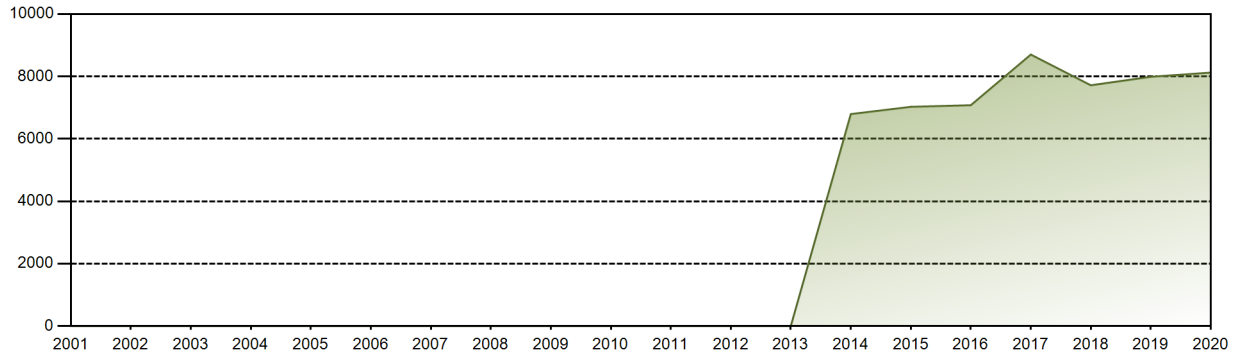
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	697.61	565.69	537.99	681.94	714.25	715.24	718.77	738.94	719.14	650.33	630.24	752.78	8122.92
EAF [%]	100.00	100.00	82.71	99.69	100.00	99.75	100.00	99.14	100.00	100.00	100.00	100.00	98.42
UCF [%]	100.00	100.00	82.71	99.69	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.51
LF [%]	93.76	81.28	72.31	94.71	96.00	99.34	96.61	99.32	99.88	87.41	87.53	101.18	92.47
OF [%]	100.00	100.00	84.01	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.65
FLR [%]	0.00	0.00	17.29	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.49
UCL [%]	0.00	0.00	17.29	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.49
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	0.25	0.00	0.86	0.00	0.00	0.00	0.00	0.09

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Historical Summary

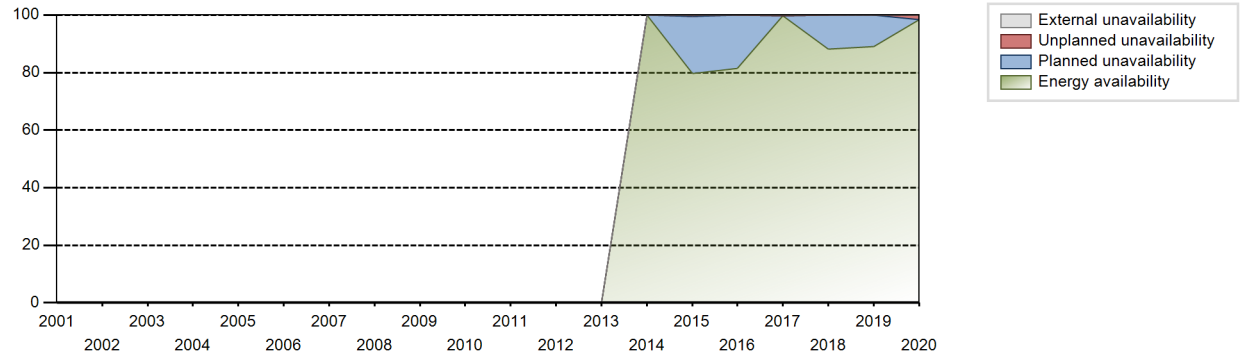
Lifetime energy generation	:	53874.92 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.35 %
Cumulative Energy Availability Factor (EAF)	:	90.62 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.31 %
Cumulative Unit Capability Factor (UCF)	:	90.68 %	Cumulative Planned Unavailability Factor (PUF)	:	9.01 %
Cumulative Load Factor (LF)	:	89.96 %	Cumulative Externally cause unavailability (XUF)	:	0.06 %
Cumulative Operating Factor (OF)	:	90.53 %			

Electricity Production (net) [GWh]

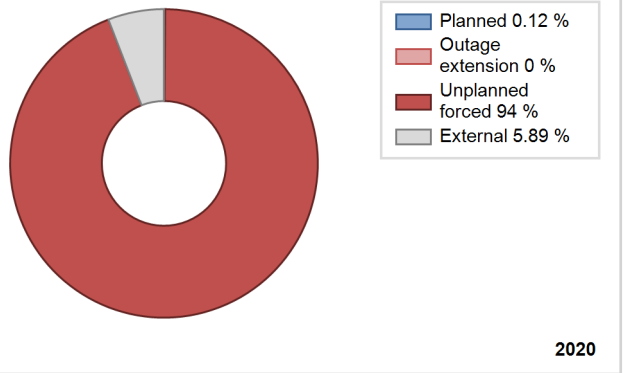


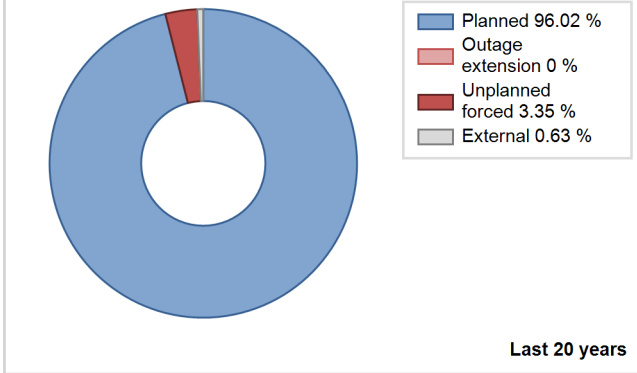
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2014	6793.37	6753	1000	99.93	99.93	100.54	100.00	0.05	0.05	0.02	0.00
2015	7025.37	7021	1000	79.73	79.73	80.20	80.15	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2014 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		119			28	
C. Inspection, maintenance or repair combined with refuelling				855		
E. Testing of plant systems or components				0		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						50
Subtotal		119		855	28	50
Total		**119**			**933**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2014 to 2020
	Hours Lost	Average hours lost per reactor-year
31. Turbine and auxiliaries		9
33. Circulating Water System	119	20
Total	**119**	**29**

Highlights (2020)

On March 25, 2020, the reactor was shut down manually as large shoals of acetes flooded into the water intake. On March 30, Unit 1 was resynchronized to the grid. It ran at reduced power in response to grid peak load regulation during holidays, and ran at full power during the rest time of the year.

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2020 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	:	5 years

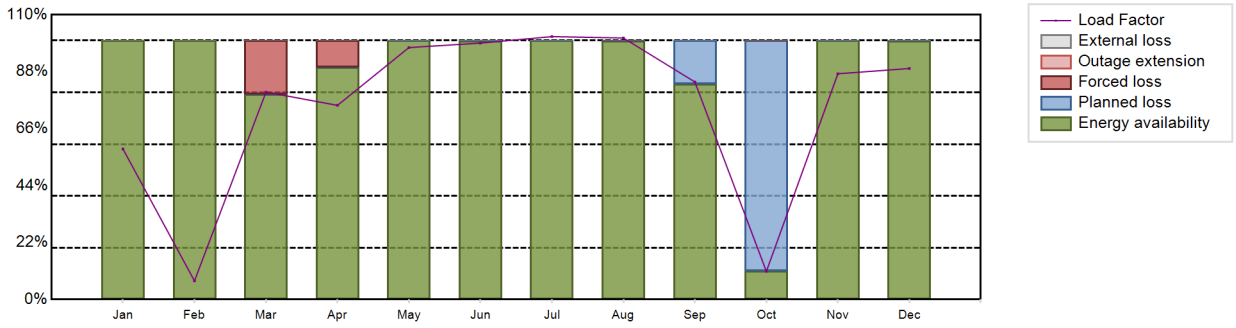
Design Characteristics

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 (2020)

Net Energy Production	:	6539.67 GW(e).h	Forced Loss Rate (FLR)	:	2.84 %
Energy Availability Factor (EAF)	:	88.49 %	Unplanned Capability Loss Factor (UCL)	:	2.59 %
Unit Capability Factor (UCF)	:	88.49 %	Planned Unavailability Factor (PUF)	:	8.92 %
Load Factor (LF)	:	74.45 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	78.03 %	Total off-line time	:	1930 hours

Annual Summary



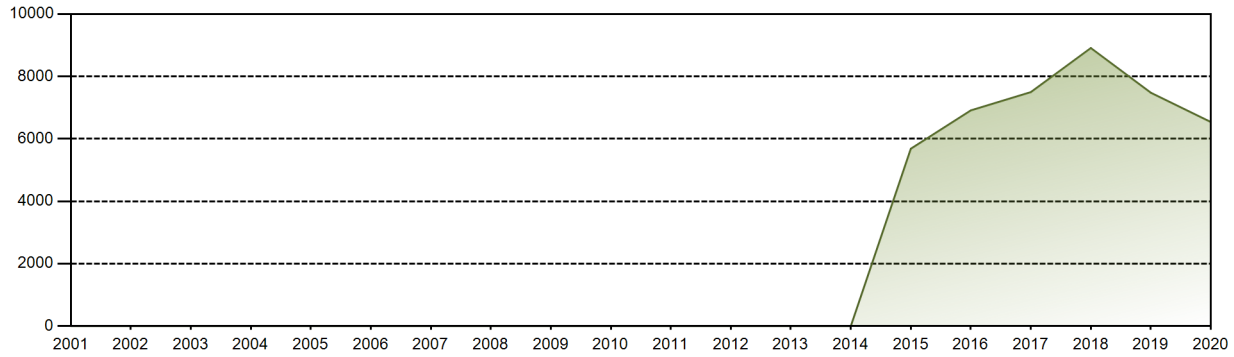
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	432.38	50.08	596.09	539.92	724.02	712.88	755.46	751.50	605.02	80.80	627.67	663.85	6539.67
EAF [%]	100.00	100.00	79.36	89.78	100.00	99.95	100.00	99.94	83.27	10.93	100.00	99.98	88.49
UCF [%]	100.00	100.00	79.36	89.78	100.00	99.95	100.00	99.94	83.27	10.93	100.00	99.98	88.49
LF [%]	58.12	7.20	80.12	74.99	97.31	99.01	101.54	101.01	84.03	10.86	87.18	89.23	74.45
OF [%]	67.61	9.20	79.70	75.83	100.00	100.00	100.00	100.00	83.75	17.34	100.00	100.00	78.03
FLR [%]	0.00	0.00	20.63	10.22	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	2.84
UCL [%]	0.00	0.00	20.63	10.22	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	2.59
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	16.73	89.07	0.00	0.02	8.92
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

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Historical Summary

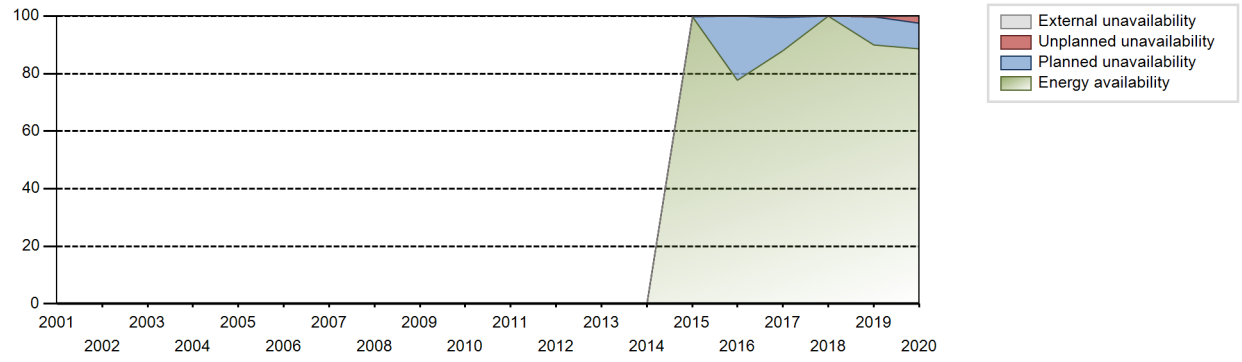
Lifetime energy generation	:	43020.67 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.63 %
Cumulative Energy Availability Factor (EAF)	:	89.94 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.57 %
Cumulative Unit Capability Factor (UCF)	:	90.02 %	Cumulative Planned Unavailability Factor (PUF)	:	9.41 %
Cumulative Load Factor (LF)	:	86.94 %	Cumulative Externally cause unavailability (XUF)	:	0.08 %
Cumulative Operating Factor (OF)	:	87.87 %			

Electricity Production (net) [GWh]

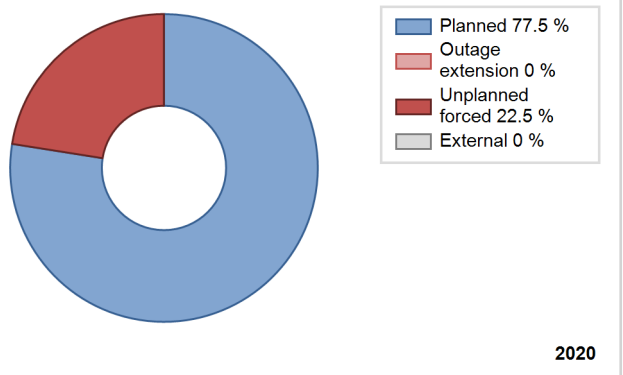


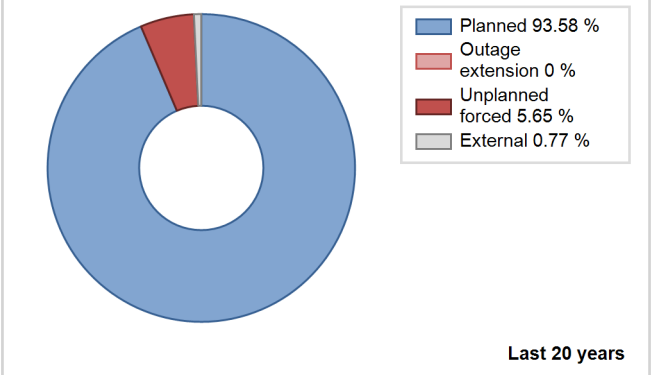
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2015	5683.72	6017	1000	99.79	99.79	102.21	100.00	0.20	0.20	0.01	0.00
2016	6911.71	6874	1000	77.59	77.69	78.69	78.26	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2015 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					7	
C. Inspection, maintenance or repair combined with refuelling	720			783		
D. Inspection, maintenance or repair without refuelling				4		
I. Grid capacity limitation			976			175
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						52
Z. Other	12	222		2	40	
Subtotal	732	222	976	789	47	227
Total	**1930**			**1063**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2015 to 2020
	Hours Lost	Average hours lost per reactor-year
32. Feedwater and Main Steam System		7
33. Circulating Water System	222	38
42. Electrical Power Supply Systems	976	167
Total	**1198**	**212**

Highlights (2020)

On March 25, 2020, the reactor was shut down automatically as large shoals of acetes flooded into the water intake. On April 8, Unit 2 was resynchronized to the grid. Unit 2 was disconnected for Y204 outage (the 4th outage of Unit 2) on September 26, 2020, and resynchronized, after an outage of 30.49 days, to the grid on October 26. It ran at reduced power in response to grid peak load regulation during holidays, including shutdown once for standby in response to grid requirements, and ran at full power during the rest time of the year.

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2020 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	:	5 years

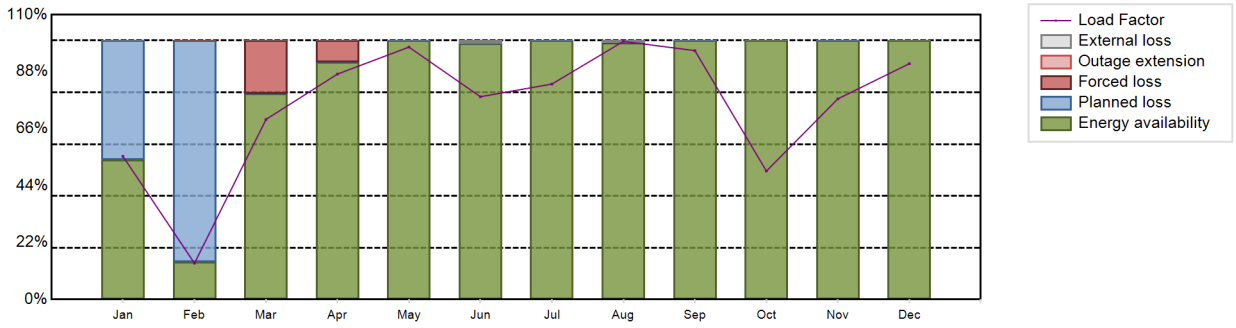
Design Characteristics

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 (2020)

Net Energy Production	:	6600.21 GW(e).h	Forced Loss Rate (FLR)	:	2.7 %
Energy Availability Factor (EAF)	:	86.76 %	Unplanned Capability Loss Factor (UCL)	:	2.41 %
Unit Capability Factor (UCF)	:	86.91 %	Planned Unavailability Factor (PUF)	:	10.68 %
Load Factor (LF)	:	75.14 %	Externally cause unavailability (XUF)	:	0.15 %
Operating Factor (OF)	:	80.13 %	Total off-line time	:	1745 hours

Annual Summary



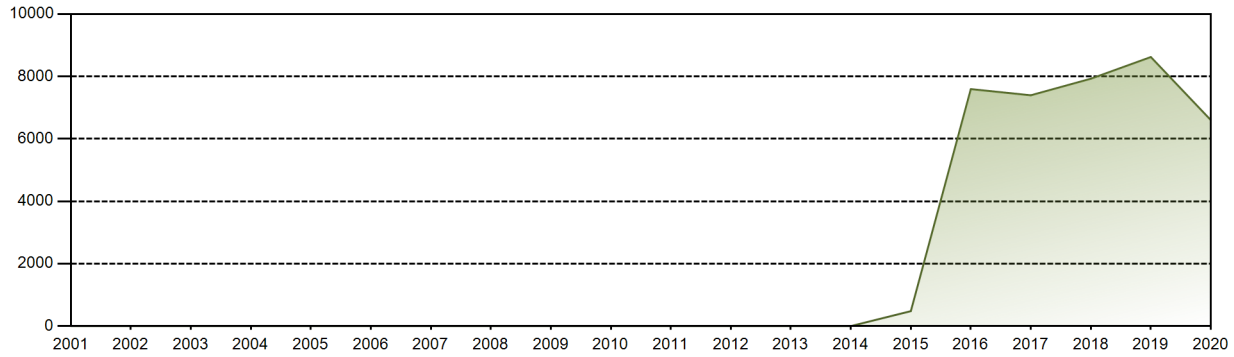
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	411.29	97.46	517.47	626.89	725.28	563.94	619.14	741.70	692.11	369.10	558.01	677.82	6600.21
EAF [%]	54.01	14.46	79.59	91.64	100.00	98.98	100.00	99.20	100.00	100.00	100.00	100.00	86.76
UCF [%]	54.01	14.46	79.59	91.64	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.91
LF [%]	55.28	14.00	69.55	87.07	97.48	78.33	83.22	99.69	96.13	49.61	77.50	91.10	75.14
OF [%]	55.11	19.25	79.57	92.08	100.00	80.42	82.80	100.00	100.00	61.69	88.06	100.00	80.13
FLR [%]	0.00	0.07	20.41	8.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.70
UCL [%]	0.00	0.01	20.41	8.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.41
PUF [%]	45.99	85.53	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.68
XUF [%]	0.00	0.00	0.00	0.00	0.00	1.02	0.00	0.80	0.00	0.00	0.00	0.00	0.15

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Historical Summary

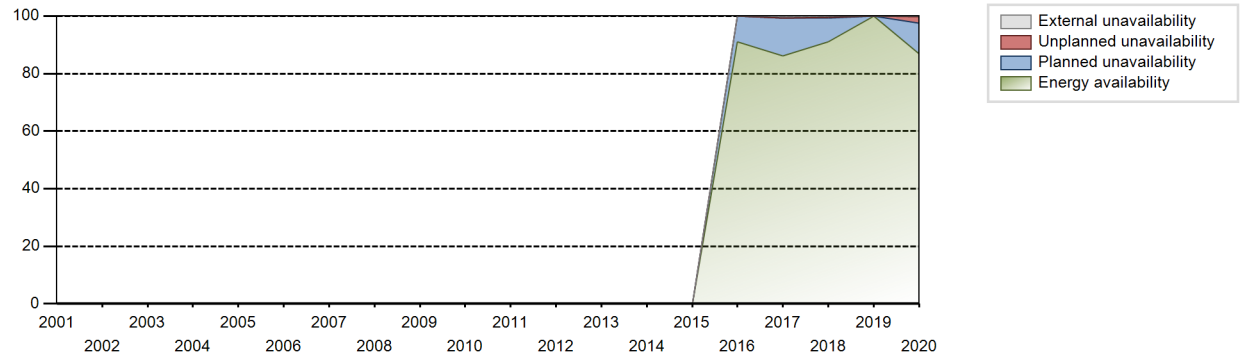
Lifetime energy generation	:	38617.14 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.57 %
Cumulative Energy Availability Factor (EAF)	:	91.01 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.52 %
Cumulative Unit Capability Factor (UCF)	:	91.3 %	Cumulative Planned Unavailability Factor (PUF)	:	8.17 %
Cumulative Load Factor (LF)	:	86.98 %	Cumulative Externally cause unavailability (XUF)	:	0.29 %
Cumulative Operating Factor (OF)	:	88.54 %			

Electricity Production (net) [GWh]

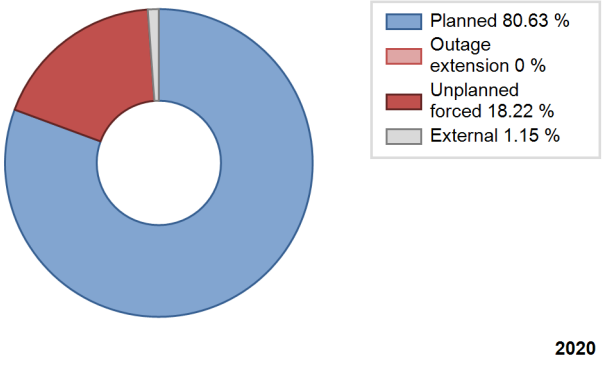


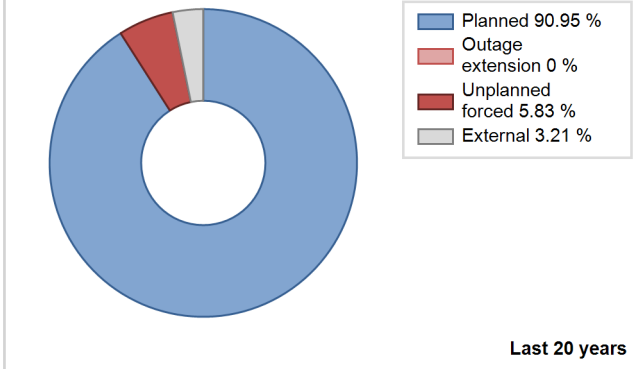
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	7593.85	7559	1000	91.12	91.24	86.45	86.05	0.01	0.01	8.75	0.12
2017	7396.07	7435	1000	86.14	86.87	84.43	84.87	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	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	892			689		
I. Grid capacity limitation			643			129
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						136
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						6
Z. Other		209			42	
Subtotal	892	209	643	689	45	271
Total	**1744**			**1005**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
31. Turbine and auxiliaries		3
33. Circulating Water System	209	42
42. Electrical Power Supply Systems	643	129
Total	**852**	**174**

Highlights (2020)

Unit 3 was disconnected for Y303 outage (the 3rd outage of Unit 3) on January 18, 2020, and resynchronized, after an outage of 37.15 days, to grid on February 24. On March 25, 2020, the reactor was shut down automatically as large shoals of acetes flooded into the water intake. On April 3, Unit 3 was resynchronized to the grid. It ran at reduced power in response to grid peak load regulation during holidays, including shutdown twice for standby in response to grid requirements, and ran at full power during the rest time of the year.

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2020 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

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	:	2012-11-17
Grid Date	:	2017-01-08
Commercial Date	:	2017-03-15
Age at end of year	:	3 years

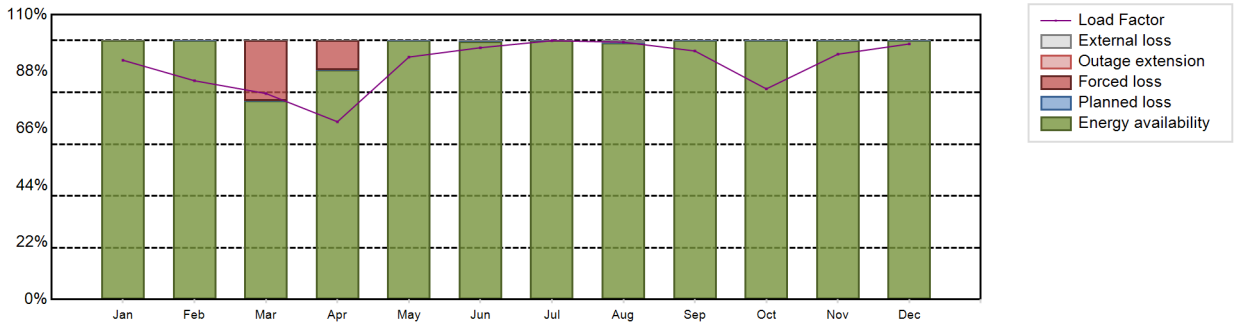
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	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 (2020)

Net Energy Production	:	7954.62 GW(e).h	Forced Loss Rate (FLR)	:	2.88 %
Energy Availability Factor (EAF)	:	97.02 %	Unplanned Capability Loss Factor (UCL)	:	2.88 %
Unit Capability Factor (UCF)	:	97.11 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	90.56 %	Externally cause unavailability (XUF)	:	0.09 %
Operating Factor (OF)	:	93.53 %	Total off-line time	:	568 hours

Annual Summary



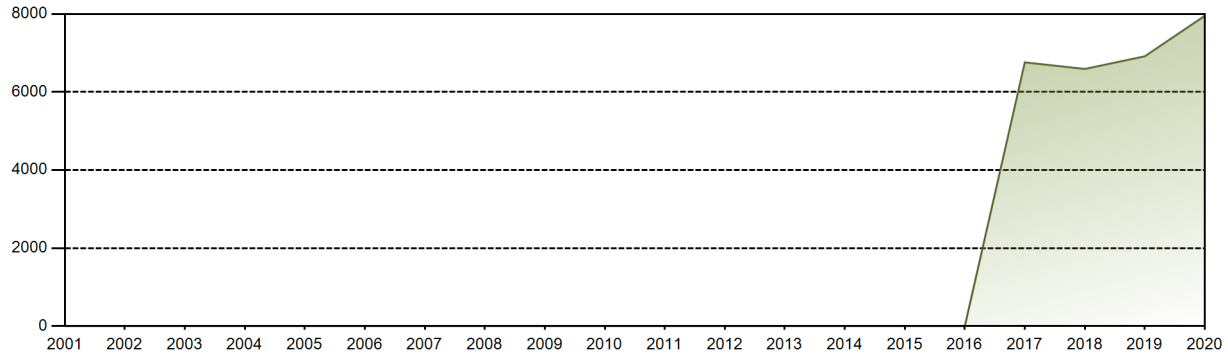
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	687.56	588.04	591.96	494.25	696.71	700.22	743.69	739.42	691.10	605.16	682.12	734.39	7954.62
EAF [%]	100.00	99.99	76.85	88.73	100.00	99.73	100.00	99.14	100.00	100.00	99.99	100.00	97.02
UCF [%]	100.00	99.99	76.85	88.73	100.00	99.98	100.00	99.99	100.00	100.00	99.99	100.00	97.11
LF [%]	92.41	84.49	79.56	68.65	93.64	97.25	99.96	99.38	95.99	81.34	94.74	98.71	90.56
OF [%]	95.97	100.00	77.15	72.50	100.00	100.00	100.00	100.00	97.22	79.84	100.00	100.00	93.53
FLR [%]	0.00	0.00	23.15	11.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.88
UCL [%]	0.00	0.00	23.15	11.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.88
PUF [%]	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.00
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.85	0.00	0.00	0.00	0.00	0.09

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Historical Summary

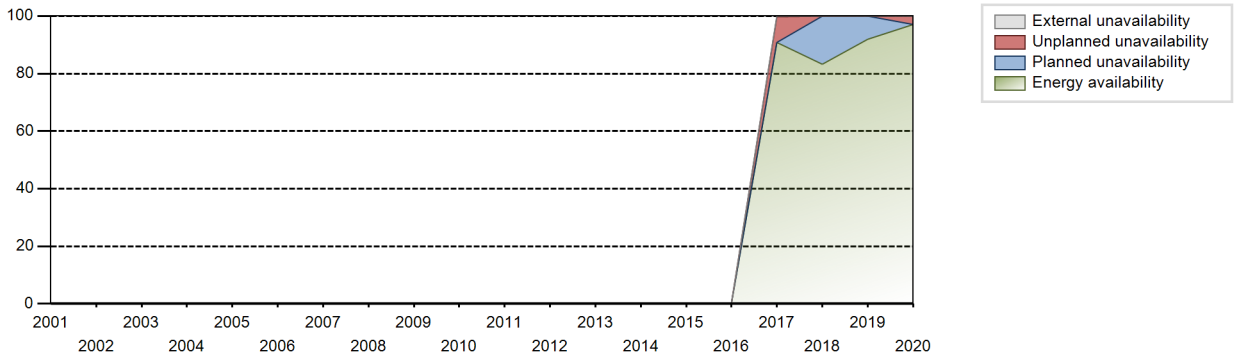
Lifetime energy generation	:	28222.17 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.9 %
Cumulative Energy Availability Factor (EAF)	:	90.75 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.72 %
Cumulative Unit Capability Factor (UCF)	:	90.86 %	Cumulative Planned Unavailability Factor (PUF)	:	6.43 %
Cumulative Load Factor (LF)	:	83.48 %	Cumulative Externally cause unavailability (XUF)	:	0.11 %
Cumulative Operating Factor (OF)	:	84.49 %			

Electricity Production (net) [GWh]

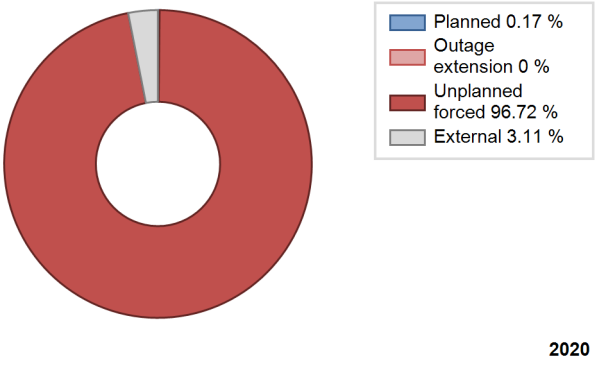


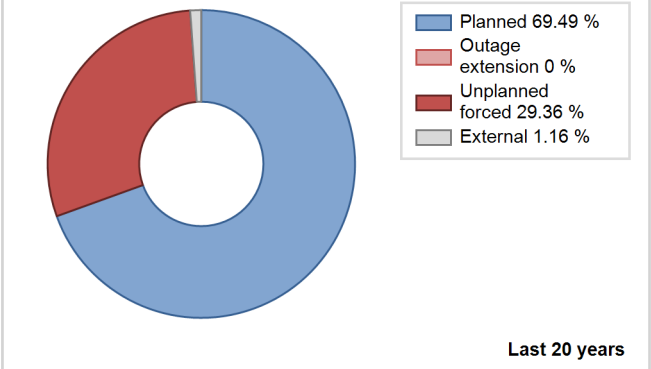
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2017	6759.71	6353	1000	90.72	91.02	90.26	86.51	8.98	8.98	0.01	0.30
2018	6591.93	6695	1000	83.35	83.43	75.25	76.43	0.01	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2017 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					171	
C. Inspection, maintenance or repair combined with refuelling				543		
I. Grid capacity limitation			320			83
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						411
Z. Other		249			65	
Subtotal		249	320	543	236	494
Total		**569**			**1273**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2017 to 2020
	Hours Lost	Average hours lost per reactor-year
33. Circulating Water System	249	62
42. Electrical Power Supply Systems	320	244
Total	**569**	**306**

Highlights (2020)

On March 24 and 25, 2020, the reactor was shut down automatically as large shoals of acetes flooded into the water intake. On April 9, Unit 4 was resynchronized to the grid. It ran at reduced power in response to grid peak load regulation during holidays, including shutdown twice for standby in response to grid requirements, and ran at full power during the rest time of the year.

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2020 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	:	2 years

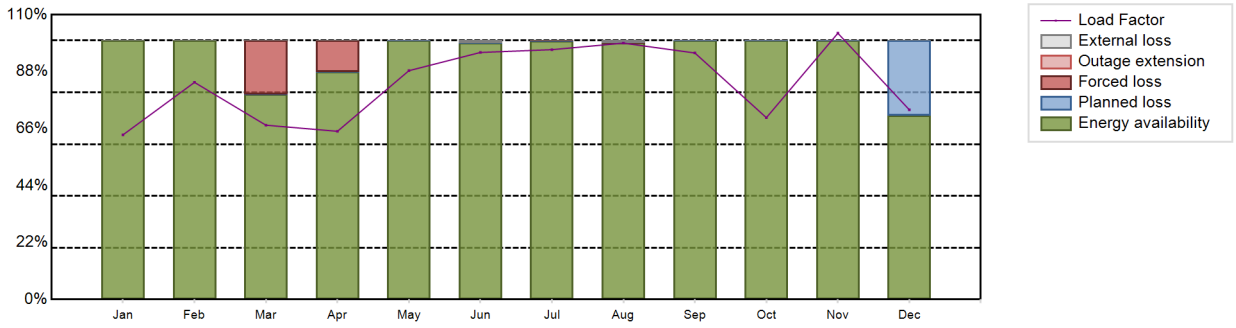
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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 (2020)

Net Energy Production	:	7318.68 GW(e).h
Energy Availability Factor (EAF)	:	94.64 %
Unit Capability Factor (UCF)	:	94.79 %
Load Factor (LF)	:	83.32 %
Operating Factor (OF)	:	87.73 %
Forced Loss Rate (FLR)	:	2.83 %
Unplanned Capability Loss Factor (UCL)	:	2.76 %
Planned Unavailability Factor (PUF)	:	2.45 %
Externally cause unavailability (XUF)	:	0.15 %
Total off-line time	:	1078 hours

Annual Summary



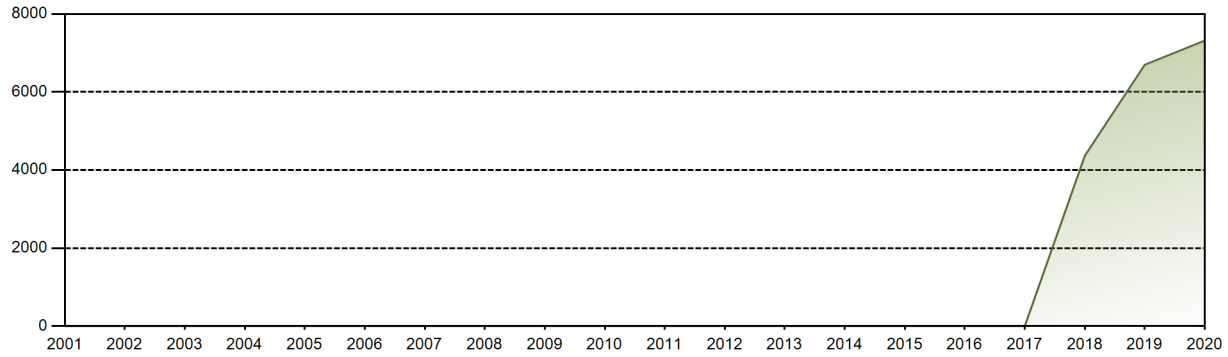
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	473.24	583.72	500.89	467.75	657.62	687.06	717.97	736.67	685.59	522.54	740.46	545.17	7318.68
EAF [%]	100.00	100.00	79.18	87.88	100.00	99.01	99.97	99.19	100.00	100.00	99.99	71.07	94.64
UCF [%]	100.00	100.00	79.18	87.88	100.00	100.00	99.97	100.00	100.00	100.00	99.99	71.07	94.79
LF [%]	63.61	83.87	67.32	64.97	88.39	95.42	96.50	99.01	95.22	70.23	102.84	73.28	83.32
OF [%]	75.13	100.00	79.70	65.83	92.20	100.00	100.00	100.00	100.00	69.62	100.00	71.51	87.73
FLR [%]	0.00	0.00	20.82	12.12	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	2.83
UCL [%]	0.00	0.00	20.82	12.12	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	2.76
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	28.93	2.45
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.81	0.00	0.00	0.00	0.00	0.15

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Historical Summary

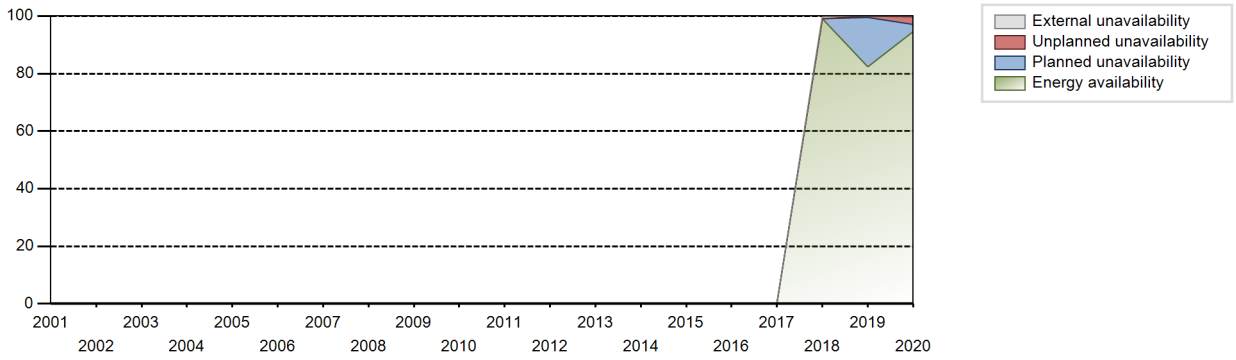
Lifetime energy generation	:	18383.45 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.45 %
Cumulative Energy Availability Factor (EAF)	:	90.64 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.34 %
Cumulative Unit Capability Factor (UCF)	:	90.87 %	Cumulative Planned Unavailability Factor (PUF)	:	7.79 %
Cumulative Load Factor (LF)	:	82.81 %	Cumulative Externally cause unavailability (XUF)	:	0.23 %
Cumulative Operating Factor (OF)	:	86.19 %			

Electricity Production (net) [GWh]

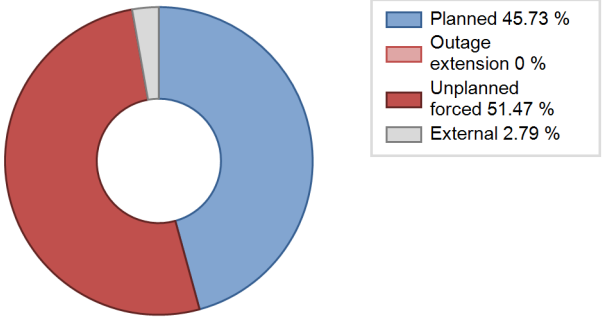


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	4365.35	4847	1000	99.11	99.94	94.36	97.26	0.06	0.06	0.00	0.83
2019	6699.42	6927	1000	82.36	82.36	76.48	79.08	0.68	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

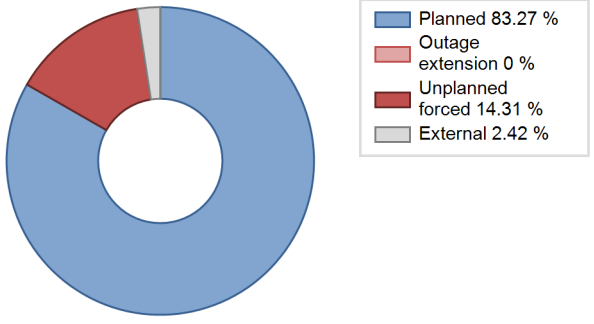
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2018 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					18	
C. Inspection, maintenance or repair combined with refuelling	212			664		
I. Grid capacity limitation			631			252
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						135
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						12
Z. Other		235			94	
Subtotal	212	235	631	664	112	399
Total	**1078**			**1175**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2018 to 2020
	Hours Lost	Average hours lost per reactor-year
14. Safety Systems		17
33. Circulating Water System	235	88
42. Electrical Power Supply Systems	631	236
Total	**866**	**341**

Highlights (2020)

On March 25, 2020, the reactor was shut down manually as large shoals of acetes flooded into the water intake. On April 11, Unit 5 was resynchronized to the grid. On December 23, 2020, Unit 5 was disconnected for Y502 outage (the 2nd outage of Unit 5). By December 31, the outage had not been completed yet. It ran at reduced power in response to grid peak load regulation during holidays, including shutdown three times for standby in response to grid requirements, and ran at full power during the rest time of the year.

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2020 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

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	:	2013-12-23
Grid Date	:	2019-06-29
Commercial Date	:	2019-07-24
Age at end of year	:	1 years

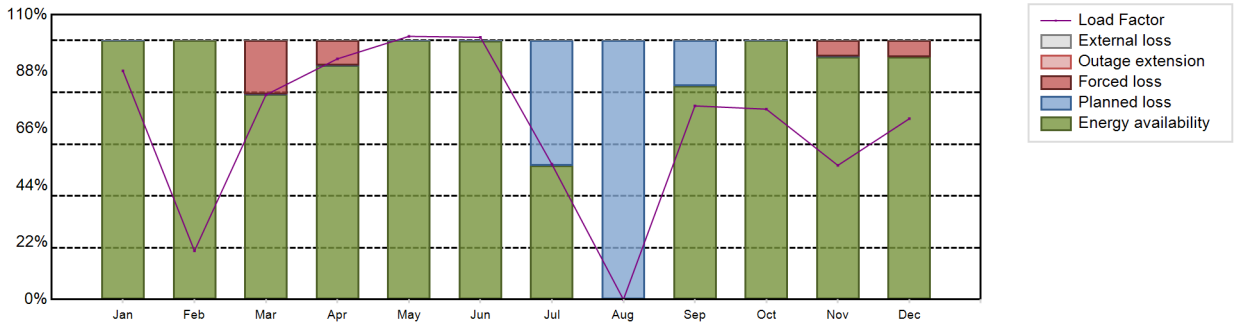
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	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 (2020)

Net Energy Production	:	5896.66 GW(e).h	Forced Loss Rate (FLR)	:	4.15 %
Energy Availability Factor (EAF)	:	82.41 %	Unplanned Capability Loss Factor (UCL)	:	3.57 %
Unit Capability Factor (UCF)	:	82.41 %	Planned Unavailability Factor (PUF)	:	14.02 %
Load Factor (LF)	:	67.13 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	74.29 %	Total off-line time	:	2258 hours

Annual Summary



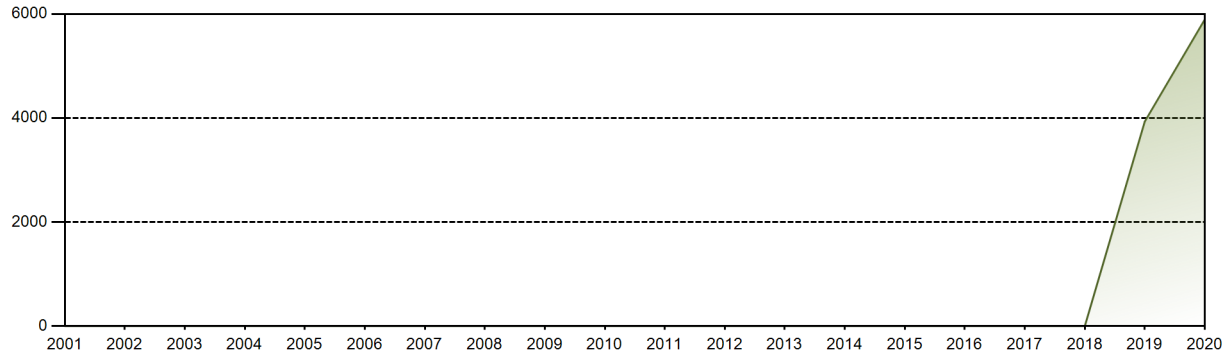
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	656.75	130.71	588.09	669.26	756.22	729.09	388.56	0.00	538.42	546.93	373.03	519.60	5896.66
EAF [%]	100.00	100.00	79.36	90.45	100.00	99.97	51.65	0.00	82.37	100.00	93.75	93.73	82.41
UCF [%]	100.00	100.00	79.36	90.45	100.00	99.97	51.65	0.00	82.37	100.00	93.75	93.73	82.41
LF [%]	88.27	18.78	79.04	92.95	101.64	101.26	52.23	0.00	74.78	73.51	51.81	69.84	67.13
OF [%]	98.79	22.99	79.57	90.97	100.00	100.00	52.02	0.00	87.08	87.50	70.97	100.00	74.29
FLR [%]	0.00	0.00	20.63	9.55	0.00	0.00	0.00	0.00	0.00	0.00	6.20	6.27	4.15
UCL [%]	0.00	0.00	20.63	9.55	0.00	0.00	0.00	0.00	0.00	0.00	6.20	6.27	3.57
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.03	48.35	100.00	17.63	0.00	0.05	0.00	14.02
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

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Historical Summary

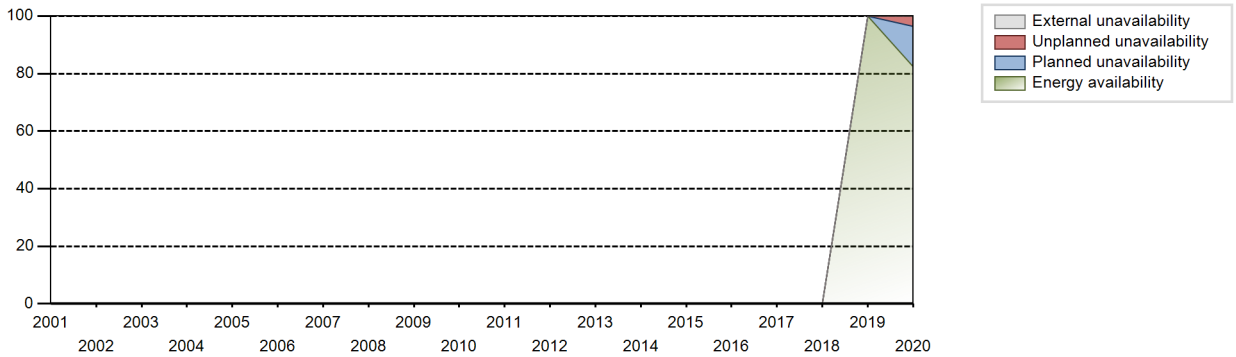
Lifetime energy generation	:	9830.84 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.79 %
Cumulative Energy Availability Factor (EAF)	:	87.6 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.52 %
Cumulative Unit Capability Factor (UCF)	:	87.6 %	Cumulative Planned Unavailability Factor (PUF)	:	9.89 %
Cumulative Load Factor (LF)	:	74.7 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	79.88 %			

Electricity Production (net) [GWh]

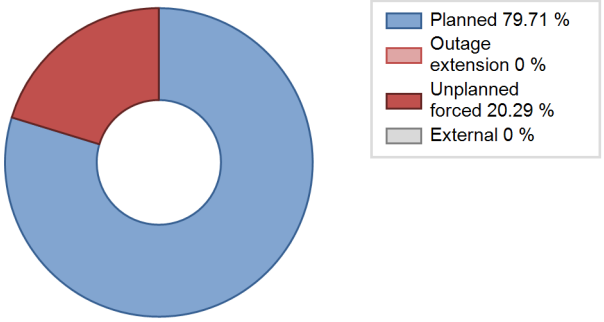


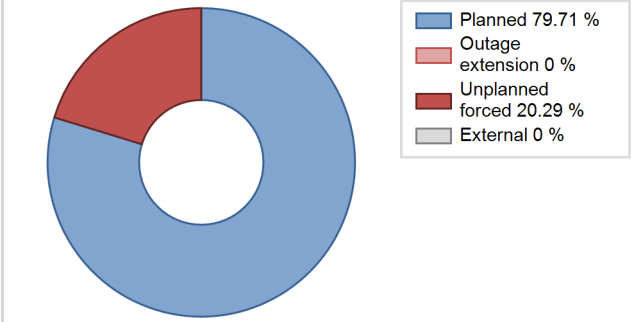
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2019	3934.18	3915	1000	100.00	100.00	92.83	93.25	0.00	0.00	0.00	0.00
2020	5896.66	6526	1000	82.41	82.41	67.13	74.29	4.15	3.57	14.02	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2019 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling	1193			842		
I. Grid capacity limitation			852			602
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						175
Z. Other		217			153	
Subtotal	1193	217	852	842	153	777
Total	**2262**			**1772**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2019 to 2020
	Hours Lost	Average hours lost per reactor-year
33. Circulating Water System	217	137
42. Electrical Power Supply Systems	852	538
Total	**1069**	**675**

Highlights (2020)

On March 25, 2020, the reactor was shut down automatically as large shoals of acetes flooded into the water intake. On April 3, Unit 6 was resynchronized to the grid. Unit 6 was disconnected for Y601 outage (the 1st outage of Unit 6) on July 17, 2020, and resynchronized, after an outage of 49.73 days, to the grid on September 4. On November 23-27 and December 1-5, 2020, Unit 6 was shut down for Y6CRF001PO (No.1 pump of circulating water system of Unit 6 of Yangjiang Nuclear Power Plant) maintenance. It ran at reduced power in response to grid peak load regulation during holidays, including shutdown twice for standby in response to grid requirements, and ran at full power during the rest time of the year.

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2020 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	:	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]	:	4.3
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

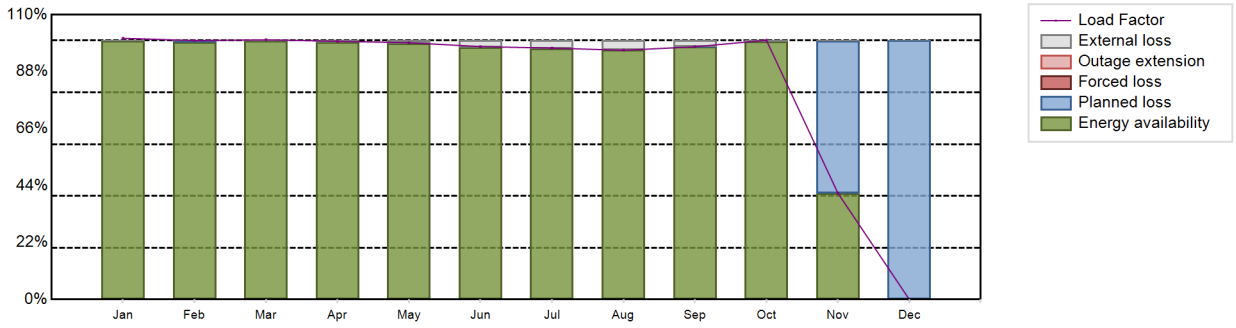
Operating coolant pressure [MPa]	:	12.26
Reactor outlet temperature [°C]	:	297
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.15
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	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 (2020)

Net Energy Production	:	3526.21 GW(e).h
Energy Availability Factor (EAF)	:	85.48 %
Unit Capability Factor (UCF)	:	86.67 %
Load Factor (LF)	:	85.78 %
Operating Factor (OF)	:	86.75 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	13.33 %
Externally cause unavailability (XUF)	:	1.19 %
Total off-line time	:	1164 hours

Annual Summary



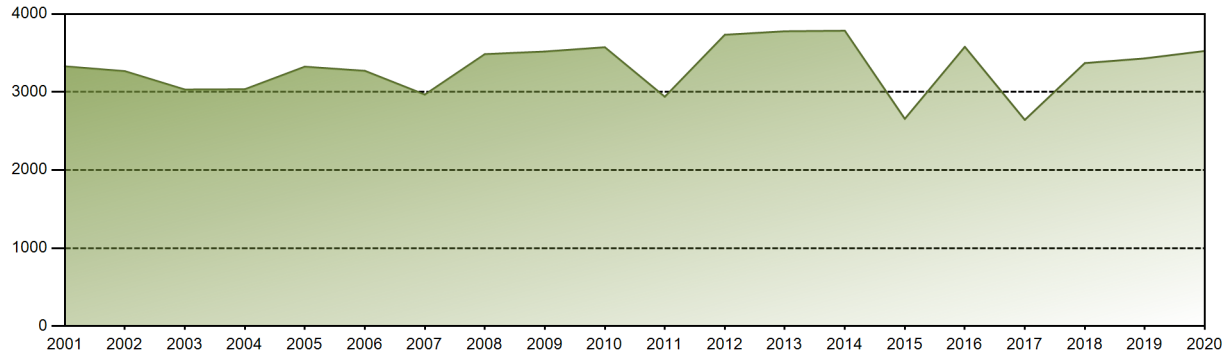
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	351.31	325.77	349.26	336.05	345.29	329.13	338.10	335.22	328.86	348.69	138.53	0.00	3526.21
EAF [%]	99.97	99.43	99.80	99.34	98.92	97.39	97.00	96.42	97.54	99.70	40.98	0.00	85.48
UCF [%]	100.00	99.58	100.00	100.00	100.00	100.00	100.00	100.00	99.91	100.00	41.20	0.00	86.67
LF [%]	100.89	100.01	100.31	99.73	99.17	97.68	97.10	96.27	97.60	100.14	41.11	0.00	85.78
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	41.67	0.00	86.75
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	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	58.80	100.00	13.33
XUF [%]	0.03	0.15	0.20	0.66	1.08	2.61	3.00	3.58	2.37	0.30	0.22	0.00	1.19

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Historical Summary

Lifetime energy generation	:	111960.15 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.35 %
Cumulative Energy Availability Factor (EAF)	:	83.02 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.18 %
Cumulative Unit Capability Factor (UCF)	:	83.86 %	Cumulative Planned Unavailability Factor (PUF)	:	13.97 %
Cumulative Load Factor (LF)	:	83.89 %	Cumulative Externally cause unavailability (XUF)	:	0.84 %
Cumulative Operating Factor (OF)	:	85.35 %			

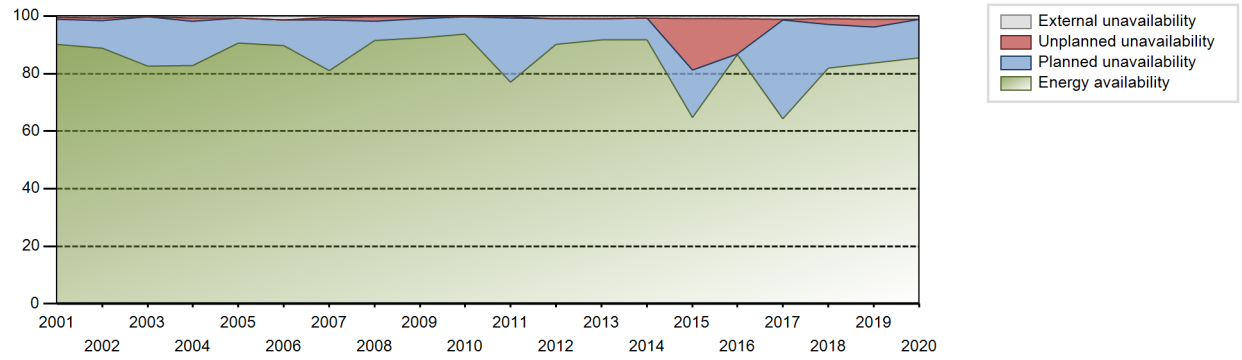
Electricity Production (net) [GWh]



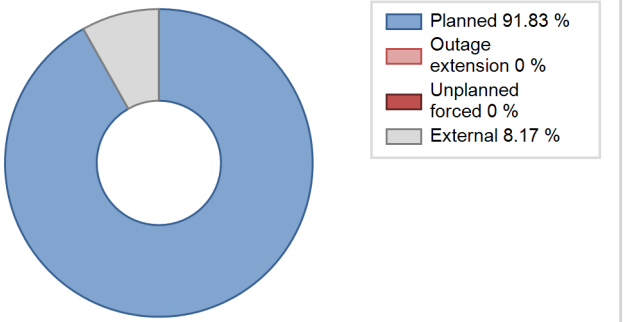
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	1993.92	5418	396	88.11	88.11	86.73	88.06	2.36	2.13	9.77	0.00
1986	2658.35	7094	403	76.12	76.15	75.30	80.98	1.22	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

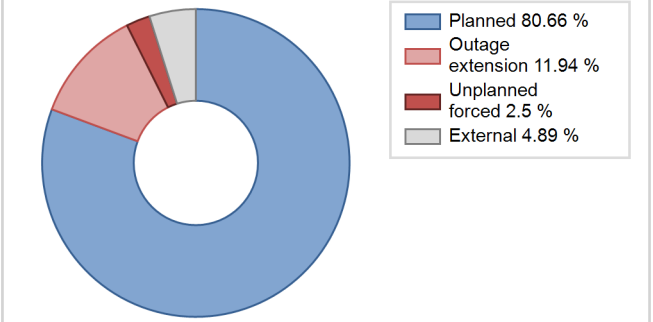
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					54	
C. Inspection, maintenance or repair combined with refuelling	1164			1115		
D. Inspection, maintenance or repair without refuelling				76		
J. Grid limitation, failure or grid unavailability						5
L. Human factor related					74	
Subtotal	1164			1191	128	5
Total	**1164**			**1324**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		3
14. Safety Systems		6
15. Reactor Cooling Systems		13
16. Steam generation systems		14
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		3
32. Feedwater and Main Steam System		0
41. Main Generator Systems		0
42. Electrical Power Supply Systems		13
Total		**53**

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2020 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	:	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]	:	4.3
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

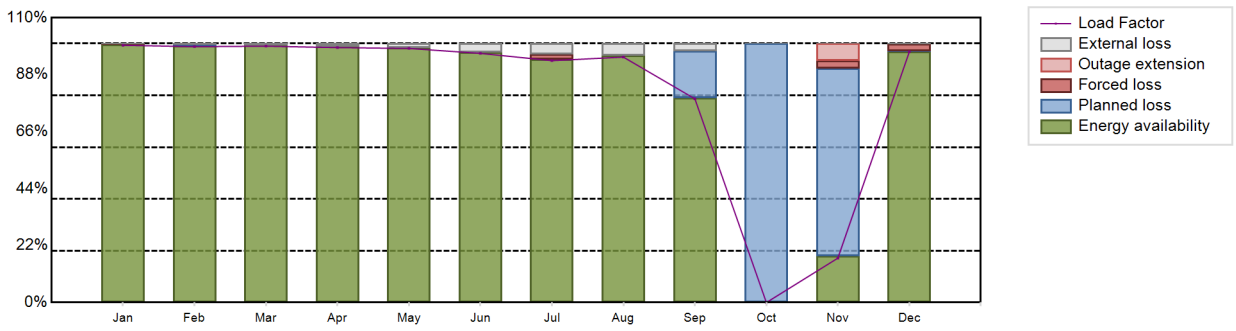
Operating coolant pressure [MPa]	:	12.26
Reactor outlet temperature [°C]	:	297
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.15
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	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 (2020)

Net Energy Production	:	3346.78 GW(e).h
Energy Availability Factor (EAF)	:	81.25 %
Unit Capability Factor (UCF)	:	82.83 %
Load Factor (LF)	:	80.89 %
Operating Factor (OF)	:	83.78 %

Forced Loss Rate (FLR)	:	0.8 %
Unplanned Capability Loss Factor (UCL)	:	1.21 %
Planned Unavailability Factor (PUF)	:	15.95 %
Externally cause unavailability (XUF)	:	1.58 %
Total off-line time	:	1425 hours

Annual Summary



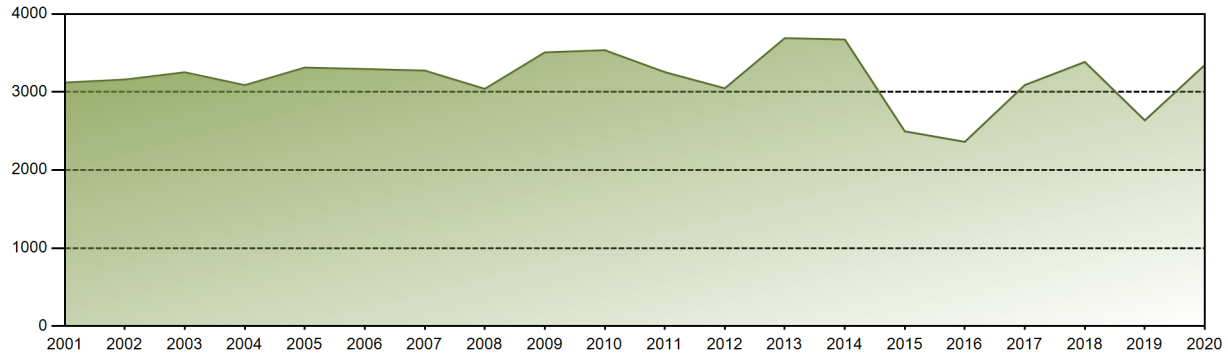
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	348.09	323.95	346.90	333.86	343.88	326.29	327.34	332.14	266.80	0.00	58.15	339.40	3346.78
EAF [%]	99.68	99.19	99.40	98.82	98.38	96.64	93.85	95.33	79.11	0.00	17.87	96.85	81.25
UCF [%]	99.81	99.69	100.00	100.00	100.00	100.00	97.88	100.00	81.96	0.00	17.87	96.88	82.83
LF [%]	99.33	98.82	98.99	98.45	98.13	96.22	93.41	94.78	78.67	0.00	17.15	96.85	80.89
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	99.19	100.00	82.64	0.00	23.61	100.00	83.78
FLR [%]	0.09	0.00	0.00	0.00	0.00	0.00	2.12	0.00	0.00	0.00	14.00	2.85	0.80
UCL [%]	0.09	0.00	0.00	0.00	0.00	0.00	2.12	0.00	0.00	0.00	9.57	2.85	1.21
PUF [%]	0.10	0.31	0.00	0.00	0.00	0.00	0.00	0.00	18.04	100.00	72.56	0.27	15.95
XUF [%]	0.13	0.50	0.60	1.18	1.62	3.36	4.02	4.67	2.85	0.00	0.00	0.03	1.58

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Historical Summary

Lifetime energy generation	:	107357.78 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.69 %
Cumulative Energy Availability Factor (EAF)	:	81.56 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.35 %
Cumulative Unit Capability Factor (UCF)	:	82.49 %	Cumulative Planned Unavailability Factor (PUF)	:	14.16 %
Cumulative Load Factor (LF)	:	82.32 %	Cumulative Externally cause unavailability (XUF)	:	0.92 %
Cumulative Operating Factor (OF)	:	84.09 %			

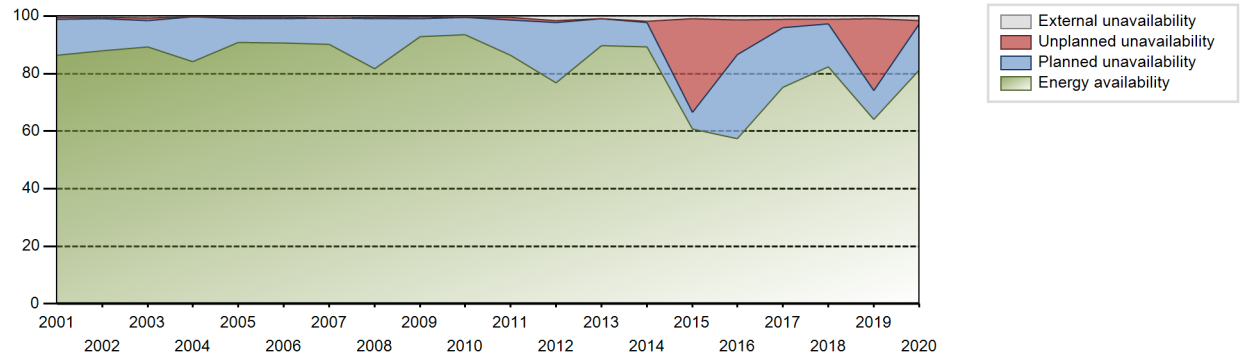
Electricity Production (net) [GWh]



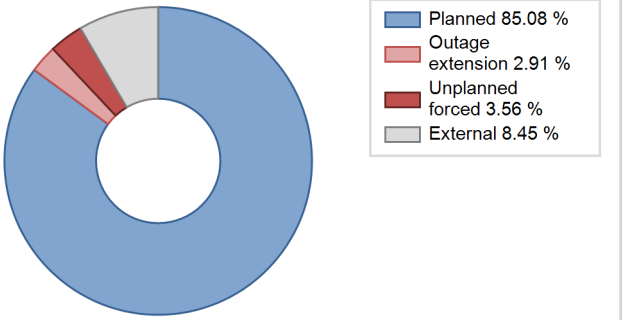
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	2792.72	7615	408	93.71	93.71	93.32	96.65	0.83	0.78	5.50	0.00
1987	2668.61	6997	408	71.57	76.57	74.67	79.87	0.21	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

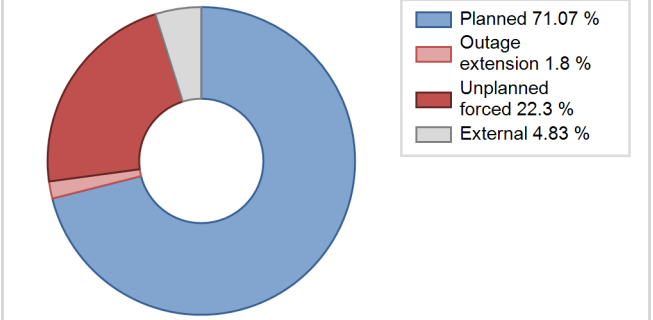
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		13			100	
C. Inspection, maintenance or repair combined with refuelling	1359			998		
D. Inspection, maintenance or repair without refuelling				68		
E. Testing of plant systems or components		48			3	
F. Major backfitting, refurbishment or upgrading activities with refuelling				125		
J. Grid limitation, failure or grid unavailability						4
L. Human factor related		6			121	
Subtotal	1359	67		1191	224	4
Total		**1426**			**1419**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		10
13. Reactor Auxiliary Systems		2
15. Reactor Cooling Systems		8
16. Steam generation systems	48	67
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		1
32. Feedwater and Main Steam System		11
33. Circulating Water System	13	1
34. Miscellaneous Systems		1
42. Electrical Power Supply Systems	6	6
Total	**67**	**110**

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2020 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	:	34 years

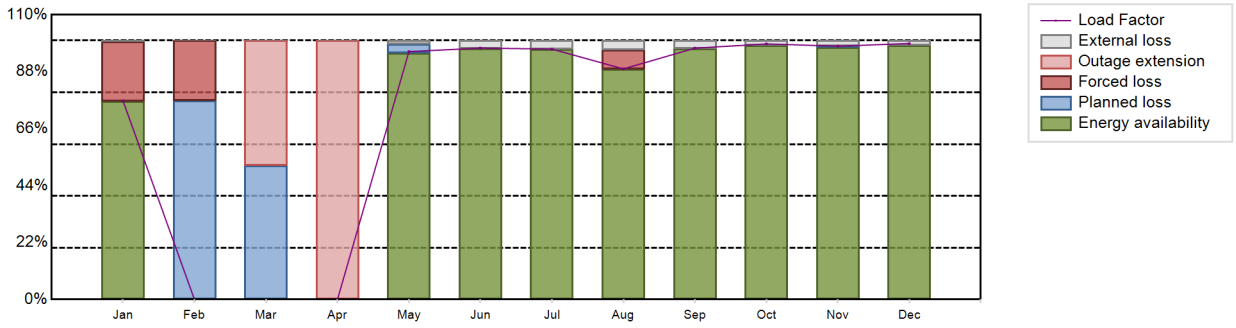
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	12.26
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	297
Fuel material	:	UO2	Number of SG	:	6
Refuelling type	:	OFF-line	Containment type	:	Confinement
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.15
Average fuel enrichment [% of U235]	:	4.3	**Secondary systems**		
Refuelling frequency [month]	:	12	Number of turbine-generators per unit/reactor	:	2
Part of the core refuelled [%]	:	20	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	44000	Number of LP cylinders per turbine	:	2
Active core diameter [m]	:	2.88	HP cylinder inlet steam pressure [MPa]	:	4.3
Active core height/length [m]	:	2.5	Output voltage [kV]	:	15.75
Number of fissile fuel assemblies/bundles	:	349	Primary means of condenser cooling	:	Cooling Towers
Fuel linear heat generation rate [kW/m]	:	13.1	Number of main condensate pumps	:	3
Number of control rod assemblies	:	37	Number of FW pumps for full power operation	:	4
Number of external reactor coolant loops	:	6	Number of on-site safety related diesel generators	:	3
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	2919.55 GW(e).h	Forced Loss Rate (FLR)	:	5.75 %
Energy Availability Factor (EAF)	:	70.76 %	Unplanned Capability Loss Factor (UCL)	:	16.72 %
Unit Capability Factor (UCF)	:	72.5 %	Planned Unavailability Factor (PUF)	:	10.78 %
Load Factor (LF)	:	71.02 %	Externally cause unavailability (XUF)	:	1.74 %
Operating Factor (OF)	:	73.45 %	Total off-line time	:	2332 hours

Annual Summary



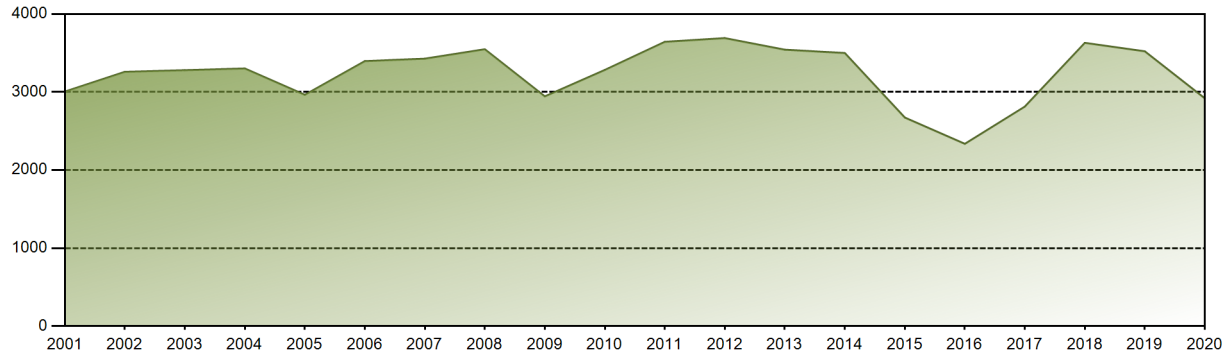
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	267.23	0.00	0.00	0.00	333.37	327.22	336.80	310.13	327.12	343.69	329.74	344.24	2919.55
EAF [%]	76.54	0.00	0.00	0.00	95.24	96.89	96.57	89.06	96.77	98.11	97.46	98.13	70.76
UCF [%]	76.85	0.00	0.00	0.00	96.54	100.00	100.00	92.68	100.00	100.00	99.51	100.00	72.50
LF [%]	76.75	0.00	0.00	0.00	95.74	97.11	96.73	89.07	97.08	98.71	97.86	98.87	71.02
OF [%]	77.96	0.00	0.00	0.00	100.00	100.00	100.00	98.92	100.00	100.00	100.00	100.00	73.45
FLR [%]	23.15	100.00	0.00	0.00	0.00	0.00	0.00	7.32	0.00	0.00	0.00	0.00	5.75
UCL [%]	23.15	23.28	48.39	100.00	0.00	0.00	0.00	7.32	0.00	0.00	0.00	0.00	16.72
PUF [%]	0.00	76.72	51.61	0.00	3.46	0.00	0.00	0.00	0.00	0.00	0.49	0.00	10.78
XUF [%]	0.31	0.00	0.00	0.00	1.30	3.11	3.43	3.63	3.23	1.89	2.05	1.87	1.74

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Historical Summary

Lifetime energy generation	:	106197.55 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.08 %
Cumulative Energy Availability Factor (EAF)	:	81.18 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.3 %
Cumulative Unit Capability Factor (UCF)	:	82.67 %	Cumulative Planned Unavailability Factor (PUF)	:	14.03 %
Cumulative Load Factor (LF)	:	82.13 %	Cumulative Externally cause unavailability (XUF)	:	1.48 %
Cumulative Operating Factor (OF)	:	84.18 %			

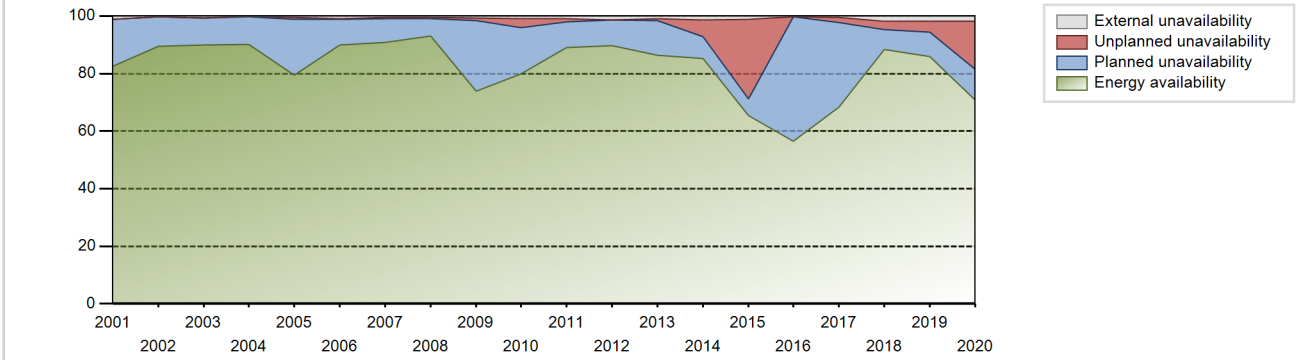
Electricity Production (net) [GWh]



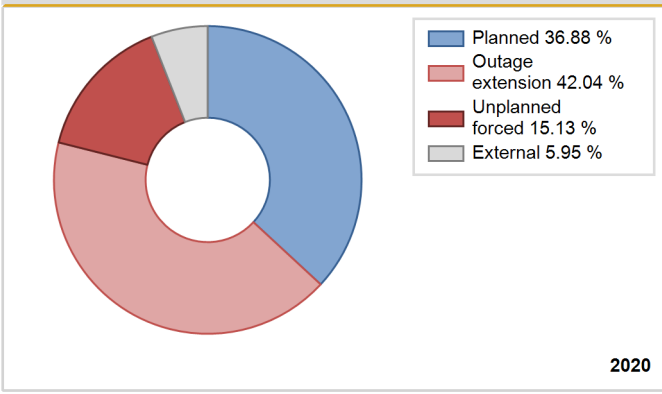
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	280.19	1356	408	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	3109.91	7644	408	84.32	86.35	87.01	87.26	0.46	0.40	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

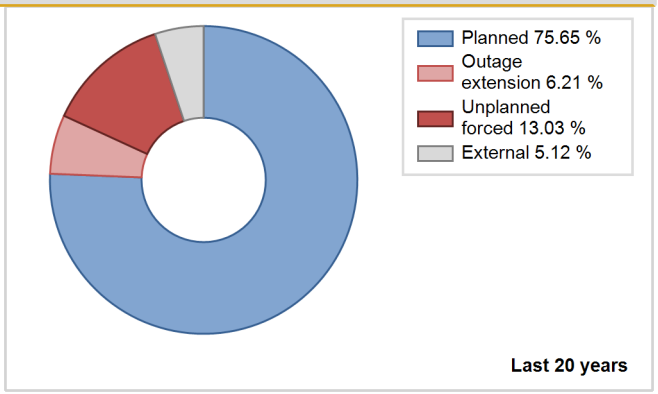
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		334			110	
C. Inspection, maintenance or repair combined with refuelling	918			1034		
D. Inspection, maintenance or repair without refuelling				36		
F. Major backfitting, refurbishment or upgrading activities with refuelling				111		
J. Grid limitation, failure or grid unavailability						3
L. Human factor related		1080			106	
Z. Other					5	
Subtotal	918	1414		1181	221	3
Total	**2332**			**1405**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		1
14. Safety Systems		4
15. Reactor Cooling Systems	326	45
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		3
32. Feedwater and Main Steam System		16
33. Circulating Water System		9
35. All other I&C Systems		0
41. Main Generator Systems		24
42. Electrical Power Supply Systems	8	3
Total	**334**	**114**

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2020 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	:	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]	:	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

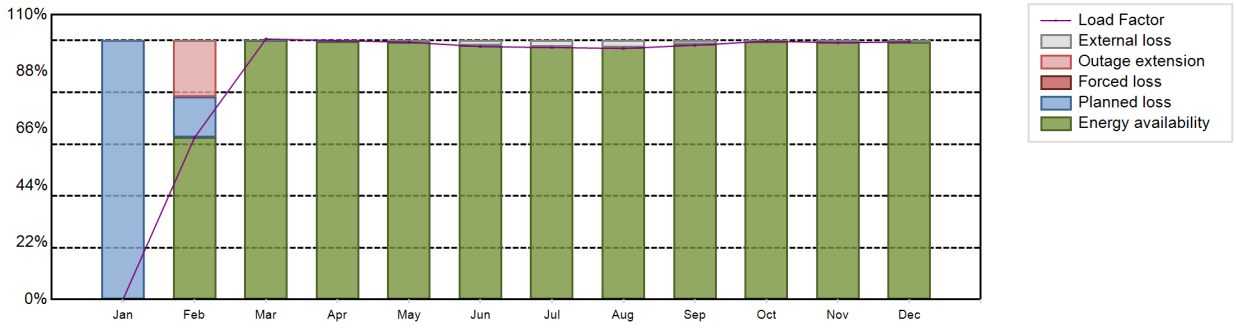
Operating coolant pressure [MPa]	:	12.26
Reactor outlet temperature [°C]	:	297
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.15
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	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 (2020)

Net Energy Production	:	3624.27 GW(e).h
Energy Availability Factor (EAF)	:	87.66 %
Unit Capability Factor (UCF)	:	88.53 %
Load Factor (LF)	:	87.6 %
Operating Factor (OF)	:	88.8 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	1.73 %
Planned Unavailability Factor (PUF)	:	9.73 %
Externally cause unavailability (XUF)	:	0.88 %
Total off-line time	:	984 hours

Annual Summary



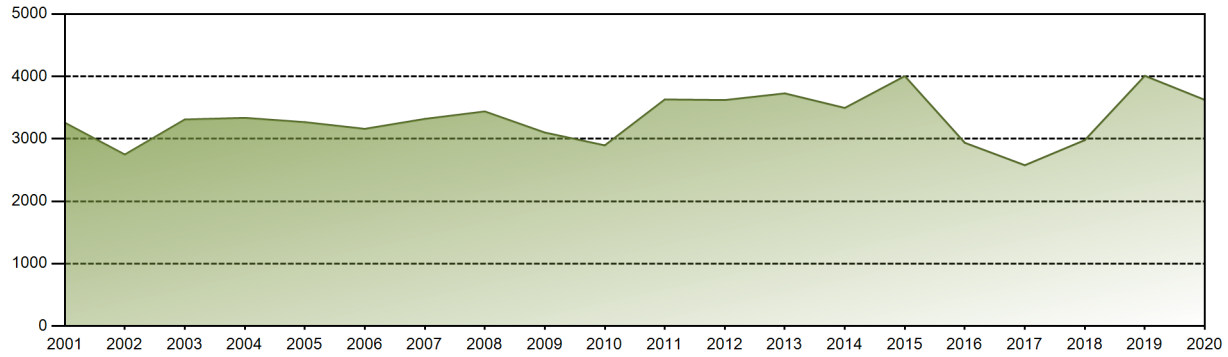
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	204.87	352.56	339.03	348.31	331.18	341.06	339.74	332.93	349.62	336.33	348.65	3624.27
EAF [%]	0.00	62.61	99.99	99.62	99.42	98.05	97.68	97.40	98.56	99.62	99.36	99.41	87.66
UCF [%]	0.00	62.62	99.99	99.65	100.00	99.96	100.00	100.00	100.00	100.00	100.00	100.00	88.53
LF [%]	0.00	62.49	100.61	99.97	99.40	97.66	97.33	96.95	98.18	99.77	99.18	99.49	87.60
OF [%]	0.00	65.52	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	88.80
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	21.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.73
PUF [%]	100.00	15.54	0.01	0.35	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	9.73
XUF [%]	0.00	0.01	0.00	0.02	0.58	1.90	2.32	2.60	1.44	0.38	0.64	0.59	0.88

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Historical Summary

Lifetime energy generation	:	107399.27 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.19 %
Cumulative Energy Availability Factor (EAF)	:	83.54 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.02 %
Cumulative Unit Capability Factor (UCF)	:	84.43 %	Cumulative Planned Unavailability Factor (PUF)	:	13.55 %
Cumulative Load Factor (LF)	:	84.68 %	Cumulative Externally cause unavailability (XUF)	:	0.89 %
Cumulative Operating Factor (OF)	:	86.08 %			

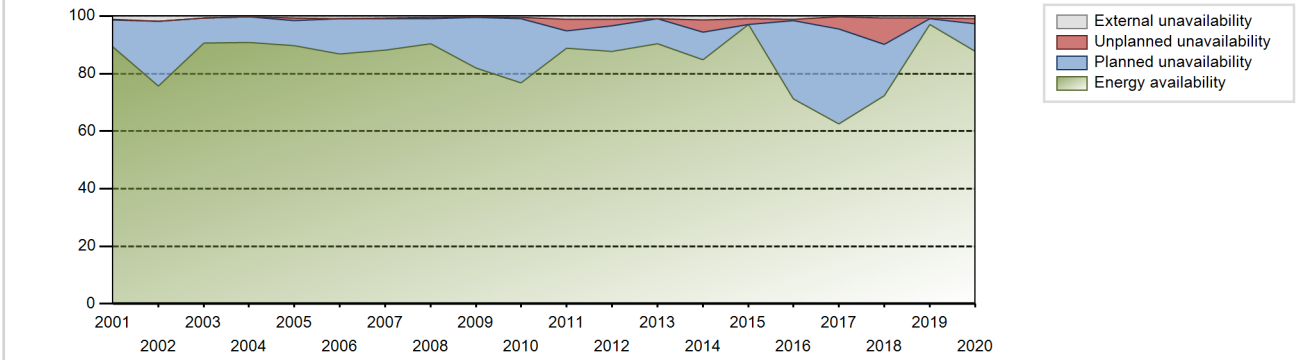
Electricity Production (net) [GWh]



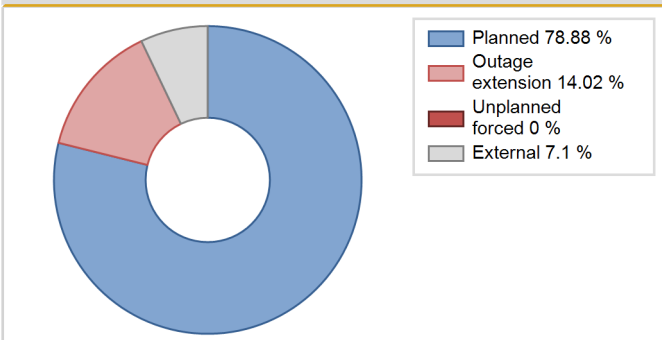
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	1624.94	4643	408	97.85	99.92	90.09	94.34	0.08	0.08	0.00	2.08
1988	2764.01	7092	408	73.78	74.45	77.12	80.74	3.05	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

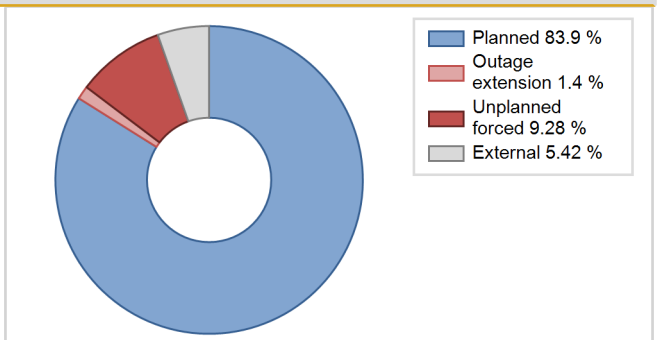
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					72	
C. Inspection, maintenance or repair combined with refuelling	832			971		
D. Inspection, maintenance or repair without refuelling				56		
E. Testing of plant systems or components		152			5	
F. Major backfitting, refurbishment or upgrading activities with refuelling				71		
J. Grid limitation, failure or grid unavailability						4
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						3
L. Human factor related					7	
Subtotal	832	152		1098	84	7
Total	**984**			**1189**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		5
14. Safety Systems		6
15. Reactor Cooling Systems		12
16. Steam generation systems	152	18
17. Safety I&C Systems (excluding reactor I&C)		11
32. Feedwater and Main Steam System		13
33. Circulating Water System		11
35. All other I&C Systems		1
42. Electrical Power Supply Systems		1
Total	**152**	**78**

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2020 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	:	20 years

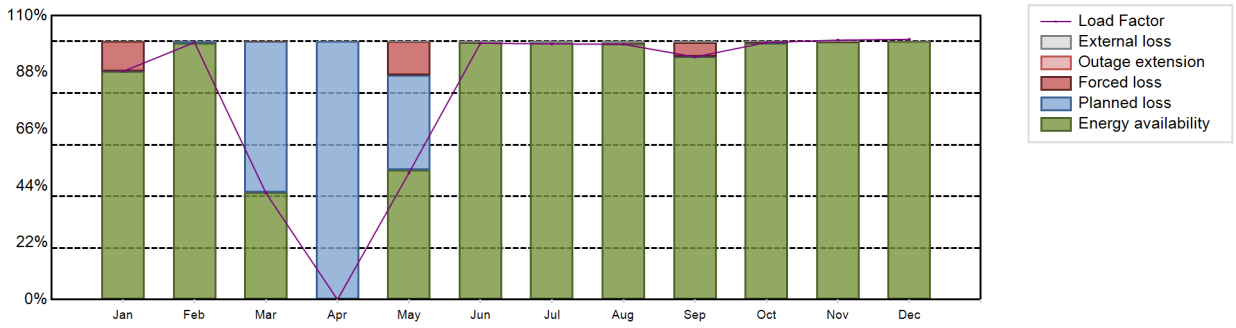
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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 (2020)

Net Energy Production	:	7294.1 GW(e).h
Energy Availability Factor (EAF)	:	80.89 %
Unit Capability Factor (UCF)	:	81.08 %
Load Factor (LF)	:	80.86 %
Operating Factor (OF)	:	81.72 %
Equivalent non-electrical energy generated (NEG)	:	105 GW(e).h
Forced Loss Rate (FLR)	:	3.08 %
Unplanned Capability Loss Factor (UCL)	:	2.58 %
Planned Unavailability Factor (PUF)	:	16.34 %
Externally cause unavailability (XUF)	:	0.19 %
Total off-line time	:	1606 hours

Annual Summary



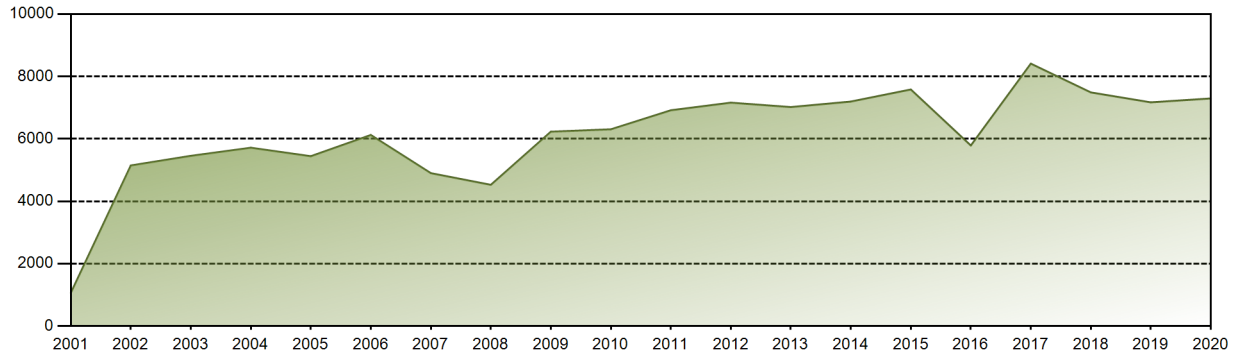
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	675.43	712.00	315.40	0.00	374.91	734.26	756.81	755.71	695.10	760.80	743.32	770.35	7294.10
EAF [%]	88.39	99.45	41.45	0.00	50.14	99.55	99.32	99.17	94.17	99.34	99.98	100.00	80.89
UCF [%]	88.39	99.45	41.45	0.00	50.15	99.95	99.97	99.91	94.57	99.36	100.00	100.00	81.08
LF [%]	88.40	99.61	41.28	0.00	49.07	99.30	99.05	98.90	94.00	99.57	100.52	100.82	80.86
OF [%]	89.25	100.00	41.53	0.00	54.84	100.00	100.00	100.00	95.14	100.00	100.00	100.00	81.72
FLR [%]	11.49	0.00	0.01	0.00	20.69	0.00	0.00	0.00	5.42	0.63	0.00	0.00	3.08
UCL [%]	11.48	0.00	0.00	0.00	13.08	0.00	0.00	0.00	5.42	0.63	0.00	0.00	2.58
PUF [%]	0.13	0.55	58.55	100.00	36.77	0.05	0.03	0.09	0.01	0.01	0.00	0.00	16.34
XUF [%]	0.00	0.00	0.00	0.00	0.01	0.40	0.65	0.74	0.40	0.02	0.02	0.00	0.19

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Historical Summary

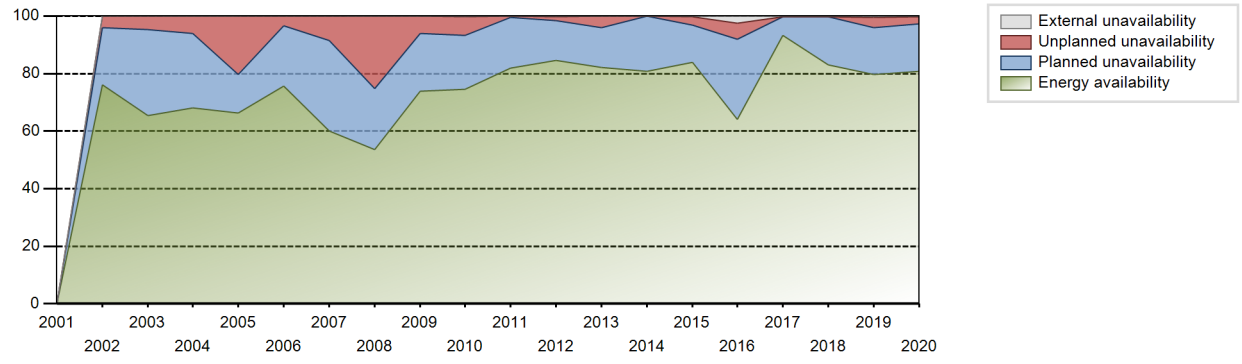
Lifetime energy generation	:	123249.1 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.59 %
Cumulative Energy Availability Factor (EAF)	:	75.32 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.49 %
Cumulative Unit Capability Factor (UCF)	:	75.6 %	Cumulative Planned Unavailability Factor (PUF)	:	18.92 %
Cumulative Load Factor (LF)	:	75.58 %	Cumulative Externally cause unavailability (XUF)	:	0.28 %
Cumulative Operating Factor (OF)	:	76.09 %			

Electricity Production (net) [GWh]



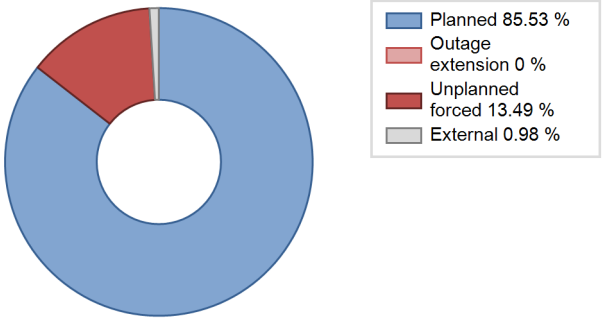
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	5147.87	5961	930	76.06	76.06	76.96	82.42	5.17	4.15	19.80	0.00
2003	5455.32	5861	912	65.30	65.30	68.28	66.91	4.15	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

Key Factors in Last 20 Years [%]

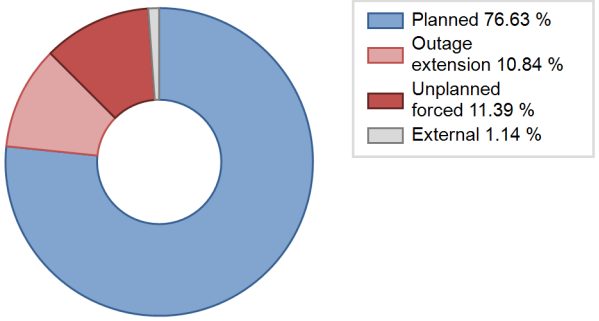


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2002 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		195			460	
C. Inspection, maintenance or repair combined with refuelling	1411			1384		
D. Inspection, maintenance or repair without refuelling				57		
E. Testing of plant systems or components				34	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				131		
L. Human factor related					83	
M. Governmental requirements or court decisions					36	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				72		
Subtotal	1411	195		1678	580	
Total	**1606**			**2258**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2002 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		68
12. Reactor I&C Systems	80	17
15. Reactor Cooling Systems		77
16. Steam generation systems		12
31. Turbine and auxiliaries	55	190
32. Feedwater and Main Steam System		32
33. Circulating Water System		3
41. Main Generator Systems	60	56
42. Electrical Power Supply Systems		1
Total	**195**	**456**

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2020 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	:	18 years

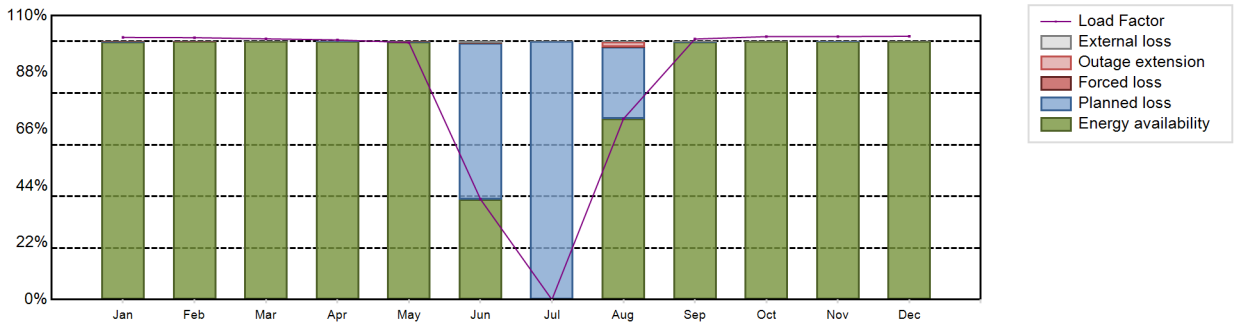
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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 (2020)

Net Energy Production	:	7660.96 GW(e).h	Forced Loss Rate (FLR)	:	0.02 %
Energy Availability Factor (EAF)	:	83.98 %	Unplanned Capability Loss Factor (UCL)	:	0.19 %
Unit Capability Factor (UCF)	:	84.03 %	Planned Unavailability Factor (PUF)	:	15.78 %
Load Factor (LF)	:	84.89 %	Externally cause unavailability (XUF)	:	0.05 %
Operating Factor (OF)	:	84.22 %	Total off-line time	:	1386 hours
Equivalent non-electrical energy generated (NEG)	:	0 GW(e).h			

Annual Summary



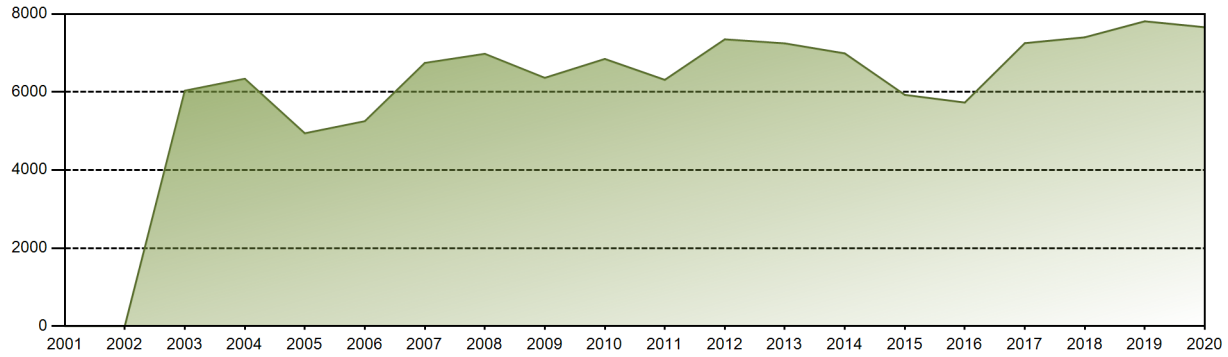
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	776.02	725.31	771.90	743.76	760.78	287.89	0.00	534.84	746.44	778.36	754.72	780.94	7660.96
EAF [%]	99.95	100.00	100.00	100.00	99.84	38.91	0.00	70.14	99.98	100.00	100.00	100.00	83.98
UCF [%]	99.95	100.00	100.00	100.00	99.84	39.46	0.00	70.18	99.99	100.00	100.00	100.00	84.03
LF [%]	101.56	101.47	101.02	100.58	99.57	38.93	0.00	70.00	100.95	101.87	101.87	102.01	84.89
OF [%]	100.00	100.00	100.00	100.00	100.00	39.58	0.00	72.18	100.00	100.00	100.00	100.00	84.22
FLR [%]	0.04	0.00	0.00	0.00	0.14	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.02
UCL [%]	0.04	0.00	0.00	0.00	0.14	0.00	0.00	2.03	0.00	0.00	0.00	0.00	0.19
PUF [%]	0.01	0.00	0.00	0.00	0.02	60.54	100.00	27.79	0.01	0.00	0.00	0.00	15.78
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.04	0.02	0.00	0.00	0.00	0.05

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Historical Summary

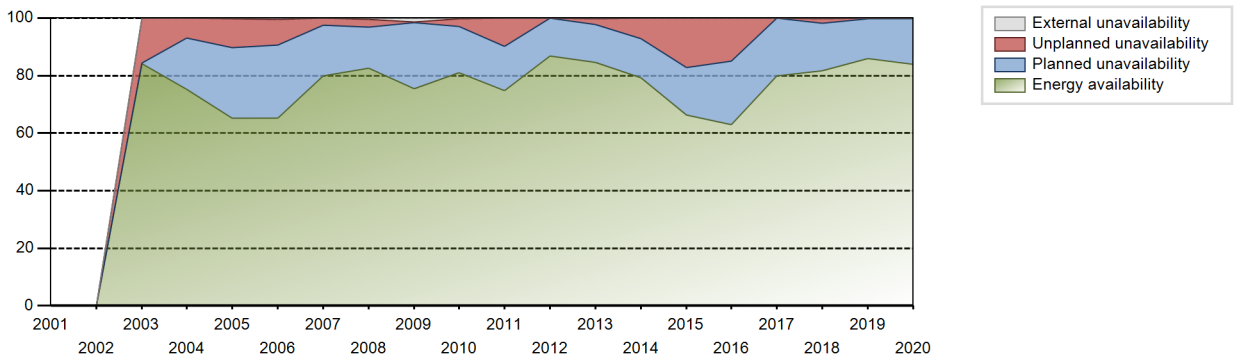
Lifetime energy generation	:	119174.96 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.94 %
Cumulative Energy Availability Factor (EAF)	:	77.46 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.45 %
Cumulative Unit Capability Factor (UCF)	:	77.68 %	Cumulative Planned Unavailability Factor (PUF)	:	16.87 %
Cumulative Load Factor (LF)	:	77.93 %	Cumulative Externally cause unavailability (XUF)	:	0.22 %
Cumulative Operating Factor (OF)	:	78.31 %			

Electricity Production (net) [GWh]



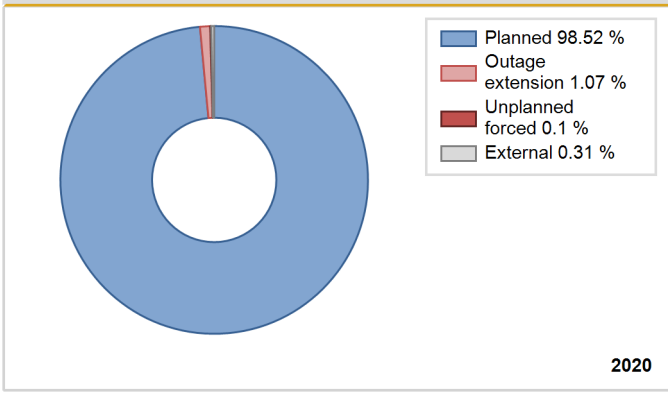
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2003	6033.03	6934	930	84.23	84.23	86.59	86.52	15.60	15.57	0.21	0.00
2004	6340.09	6678	950	75.22	75.22	75.98	76.02	8.49	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

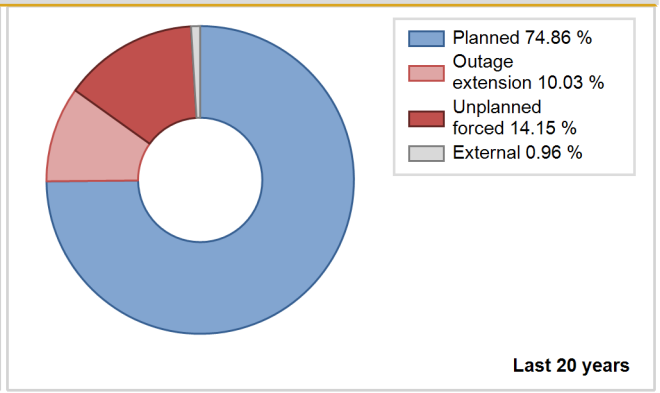
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2003 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		15			435	
C. Inspection, maintenance or repair combined with refuelling	1371			1290		
D. Inspection, maintenance or repair without refuelling				51		
E. Testing of plant systems or components				23	3	
F. Major backfitting, refurbishment or upgrading activities with refuelling				109		
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L. Human factor related					53	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
Subtotal	1371	15		1473	491	1
Total		**1386**			**1965**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2003 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		93
12. Reactor I&C Systems		11
13. Reactor Auxiliary Systems		16
15. Reactor Cooling Systems		20
16. Steam generation systems		77
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		110
32. Feedwater and Main Steam System	15	24
33. Circulating Water System		8
35. All other I&C Systems		33
41. Main Generator Systems		35
42. Electrical Power Supply Systems		27
Total	**15**	**456**

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2020 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	:	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]	:	15.6
Number of control rod assemblies	:	37
Number of external reactor coolant loops	:	6
Coolant type	:	H2O

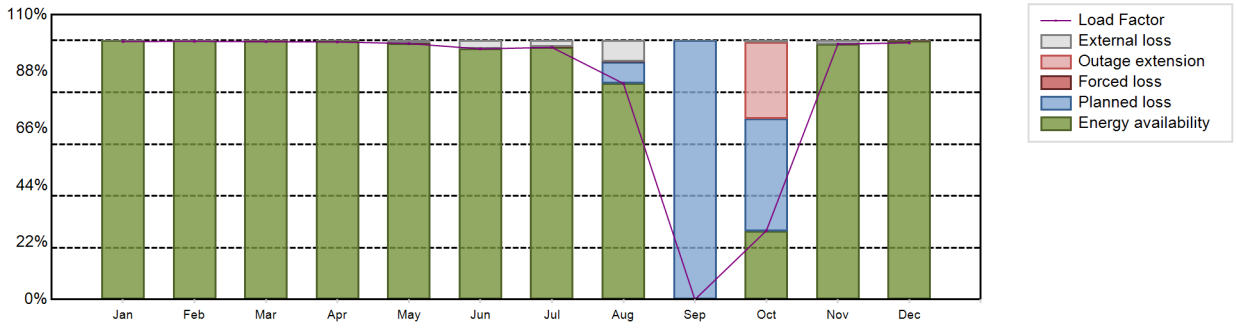
Operating coolant pressure [MPa]	:	12.25
Reactor outlet temperature [°C]	:	301
Number of SG	:	6
Containment type	:	Single
Containment design pressure [MPa]	:	0.07
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	3709.12 GW(e).h
Energy Availability Factor (EAF)	:	83.47 %
Unit Capability Factor (UCF)	:	84.86 %
Load Factor (LF)	:	83.29 %
Operating Factor (OF)	:	85.19 %

Forced Loss Rate (FLR)	:	0.08 %
Unplanned Capability Loss Factor (UCL)	:	2.57 %
Planned Unavailability Factor (PUF)	:	12.56 %
Externally cause unavailability (XUF)	:	1.39 %
Total off-line time	:	1301 hours

Annual Summary



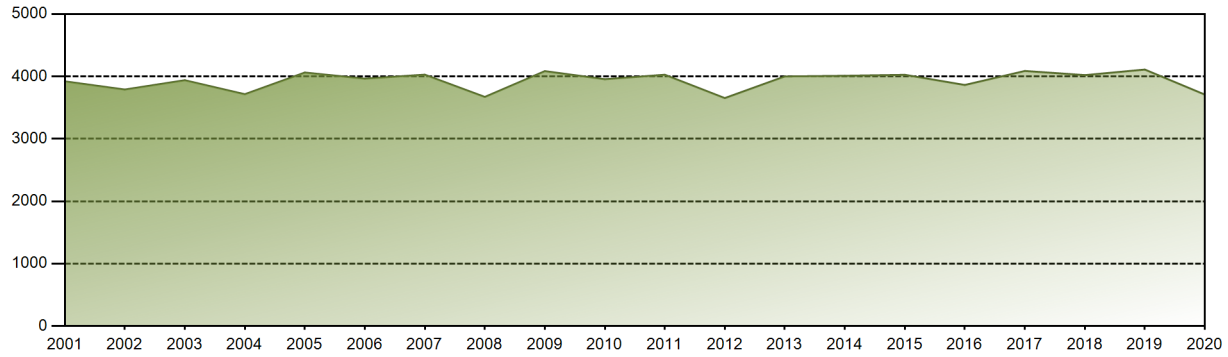
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	375.93	351.88	375.62	363.11	372.88	353.27	367.33	314.71	0.00	100.33	360.02	374.02	3709.12
EAF [%]	100.00	100.00	99.96	100.00	98.85	96.78	97.38	83.43	0.00	26.46	98.62	99.98	83.47
UCF [%]	100.00	100.00	99.96	100.00	99.70	100.00	99.85	91.43	0.00	27.14	100.00	99.98	84.86
LF [%]	99.66	99.72	99.58	99.47	98.85	96.78	97.38	83.43	0.00	26.60	98.62	99.16	83.29
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	92.07	0.00	29.97	100.00	100.00	85.19
FLR [%]	0.00	0.00	0.04	0.00	0.30	0.00	0.15	0.33	0.00	0.00	0.00	0.02	0.08
UCL [%]	0.00	0.00	0.04	0.00	0.30	0.00	0.15	0.31	0.00	29.57	0.00	0.02	2.57
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.26	100.00	43.29	0.00	0.00	12.56
XUF [%]	0.00	0.00	0.00	0.00	0.85	3.22	2.47	8.00	0.00	0.68	1.38	0.00	1.39

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Historical Summary

Lifetime energy generation	:	157499.83 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.51 %
Cumulative Energy Availability Factor (EAF)	:	87.88 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.7 %
Cumulative Unit Capability Factor (UCF)	:	88.46 %	Cumulative Planned Unavailability Factor (PUF)	:	8.84 %
Cumulative Load Factor (LF)	:	87.64 %	Cumulative Externally cause unavailability (XUF)	:	0.59 %
Cumulative Operating Factor (OF)	:	89.67 %			

Electricity Production (net) [GWh]

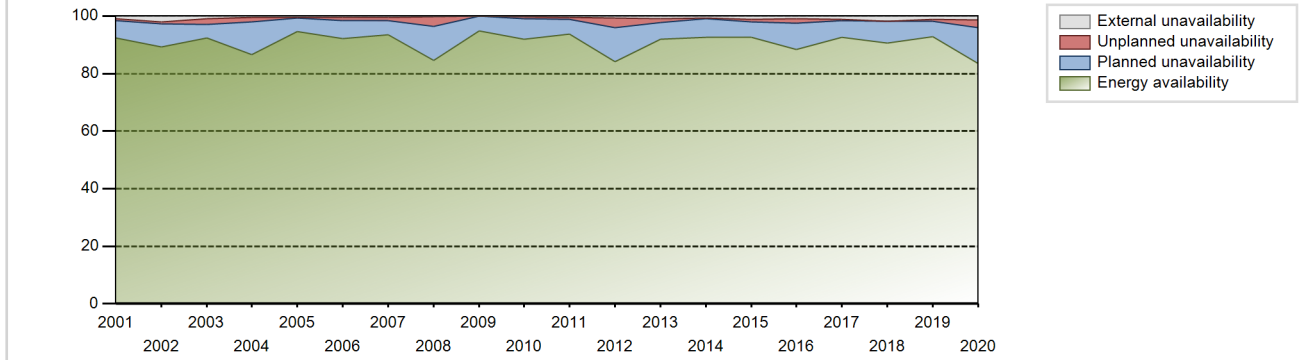


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	2505.50	7192	431	83.79	83.79	83.79	95.09	12.65	12.13	4.08	0.00
1978	2975.80	7531	430	78.93	78.93	79.00	85.97	9.27	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

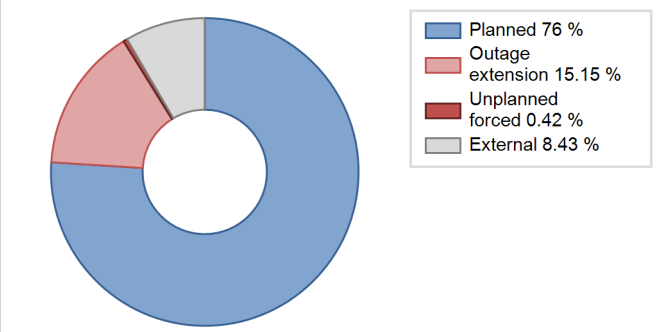
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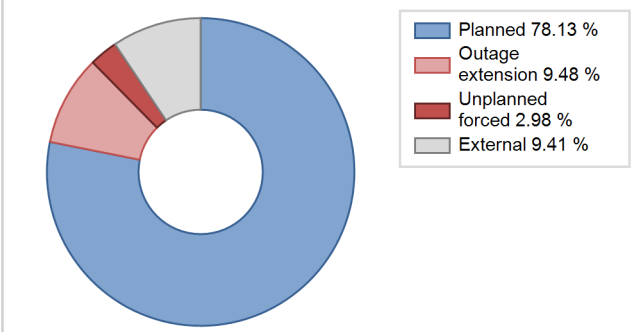
2014	4010.58	8262	496	92.60	93.38	92.30	94.32	0.06	0.06	6.57	0.78
2015	4025.96	8248	496	92.68	93.76	92.66	94.16	0.07	0.99	5.25	1.08
2016	3862.81	7873	502	88.45	89.43	88.48	89.63	0.07	1.58	8.99	0.98
2017	4087.37	8246	507	92.71	93.85	92.71	94.13	0.15	0.55	5.59	1.15
2018	4021.00	8124	507	90.64	92.47	90.54	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					174	
C.	Inspection, maintenance or repair combined with refuelling	1080			705	8	
D.	Inspection, maintenance or repair without refuelling				15		
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		220			13	
Subtotal		1080	220		722	196	4
Total			**1300**			**922**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		12
14. Safety Systems		3
15. Reactor Cooling Systems		126
16. Steam generation systems		5
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		3
31. Turbine and auxiliaries		13
32. Feedwater and Main Steam System		6
41. Main Generator Systems		2
42. Electrical Power Supply Systems		1
Total		**172**

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2020 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	:	40 years

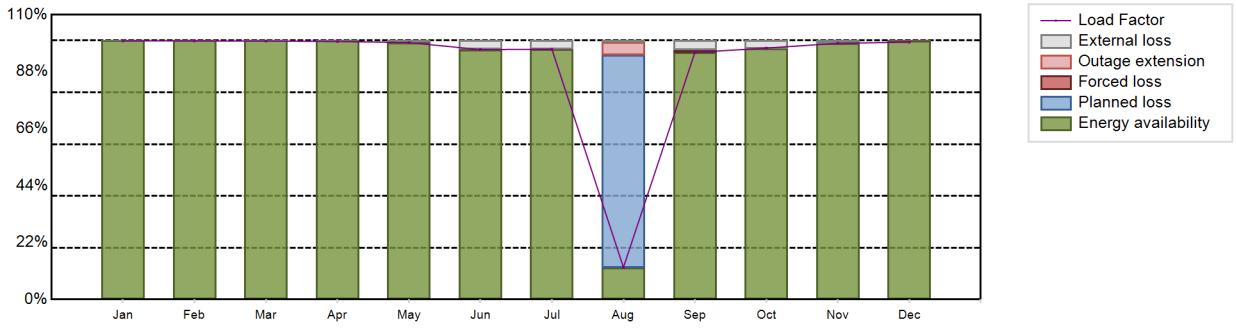
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	12.25
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	300
Fuel material	:	UO2	Number of SG	:	6
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.07
Average fuel enrichment [% of U235]	:	4.3	**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]	:	45000	Number of LP cylinders per turbine	:	2
Active core diameter [m]	:	2.73	HP cylinder inlet steam pressure [MPa]	:	4.4
Active core height/length [m]	:	2.42	Output voltage [kV]	:	15.75
Number of fissile fuel assemblies/bundles	:	313	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	15.7	Number of main condensate pumps	:	3
Number of control rod assemblies	:	37	Number of FW pumps for full power operation	:	4
Number of external reactor coolant loops	:	6	Number of on-site safety related diesel generators	:	4
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	4058.51 GW(e).h	Forced Loss Rate (FLR)	:	0.11 %
Energy Availability Factor (EAF)	:	91.22 %	Unplanned Capability Loss Factor (UCL)	:	0.52 %
Unit Capability Factor (UCF)	:	92.53 %	Planned Unavailability Factor (PUF)	:	6.96 %
Load Factor (LF)	:	91.13 %	Externally cause unavailability (XUF)	:	1.3 %
Operating Factor (OF)	:	93.02 %	Total off-line time	:	613 hours

Annual Summary



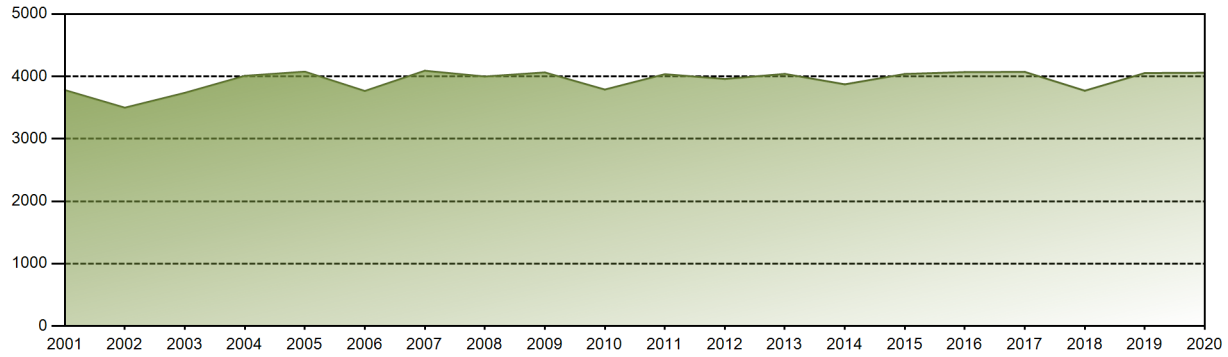
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	376.77	352.47	376.56	363.75	374.34	352.31	364.73	46.80	348.38	366.28	361.21	374.91	4058.51
EAF [%]	100.00	100.00	100.00	100.00	99.24	96.51	96.69	12.29	95.44	96.97	98.95	99.98	91.22
UCF [%]	100.00	100.00	100.00	100.00	99.92	99.75	99.96	13.01	99.09	100.00	100.00	99.98	92.53
LF [%]	99.88	99.89	99.83	99.65	99.24	96.51	96.69	12.41	95.44	97.10	98.95	99.39	91.13
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	17.74	100.00	100.00	100.00	100.00	93.02
FLR [%]	0.00	0.00	0.00	0.00	0.08	0.25	0.04	0.00	0.91	0.00	0.00	0.02	0.11
UCL [%]	0.00	0.00	0.00	0.00	0.08	0.25	0.04	4.84	0.91	0.00	0.00	0.02	0.52
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.15	0.00	0.00	0.00	0.00	6.96
XUF [%]	0.00	0.00	0.00	0.00	0.68	3.24	3.27	0.72	3.65	3.03	1.05	0.00	1.30

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Historical Summary

Lifetime energy generation	:	148215.35 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.41 %
Cumulative Energy Availability Factor (EAF)	:	89.44 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.52 %
Cumulative Unit Capability Factor (UCF)	:	90.23 %	Cumulative Planned Unavailability Factor (PUF)	:	8.25 %
Cumulative Load Factor (LF)	:	89.36 %	Cumulative Externally cause unavailability (XUF)	:	0.79 %
Cumulative Operating Factor (OF)	:	91.22 %			

Electricity Production (net) [GWh]

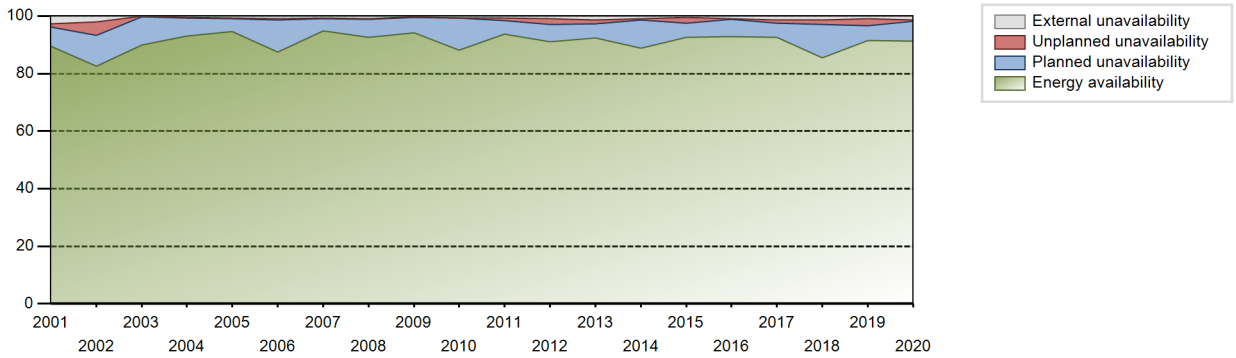


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	2714.20	7062	440	72.18	72.18	70.42	80.62	9.96	7.99	19.83	0.00
1982	2997.40	7046	440	78.00	78.00	77.77	80.43	0.30	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

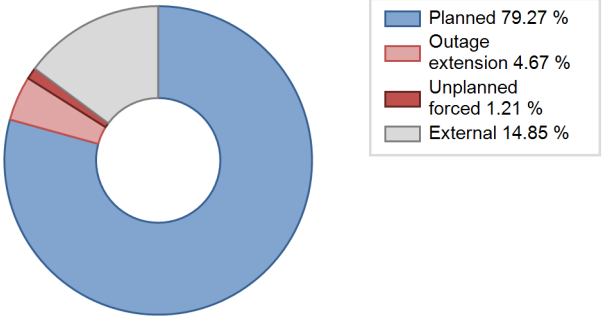
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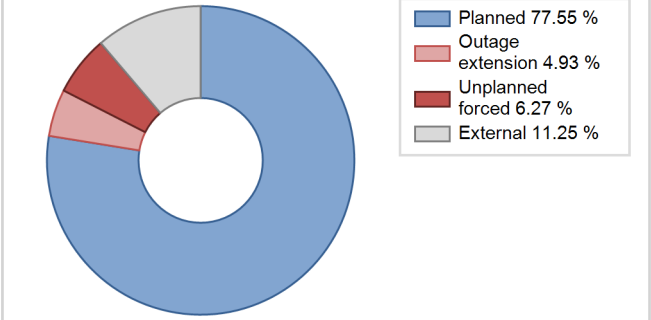
2018	3770.71	7639	507	85.52	86.92	85.60	87.20	0.26	1.44	11.64	1.41
2019	4053.97	8142	507	91.58	92.48	91.28	92.95	0.19	2.56	4.96	0.91
2020	4058.51	8171	507	91.22	92.53	91.13	93.02	0.11	0.52	6.96	1.30

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 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	576			650	2	
D. Inspection, maintenance or repair without refuelling				30		
Z. Other		36		1	6	
Subtotal	576	36		681	94	
Total	**612**			**775**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1981 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		10
12. Reactor I&C Systems		9
14. Safety Systems		4
15. Reactor Cooling Systems		44
16. Steam generation systems		2
31. Turbine and auxiliaries		1
32. Feedwater and Main Steam System		13
34. Miscellaneous Systems		2
41. Main Generator Systems		1
Total		**86**

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2020 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	:	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]	:	3.85
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

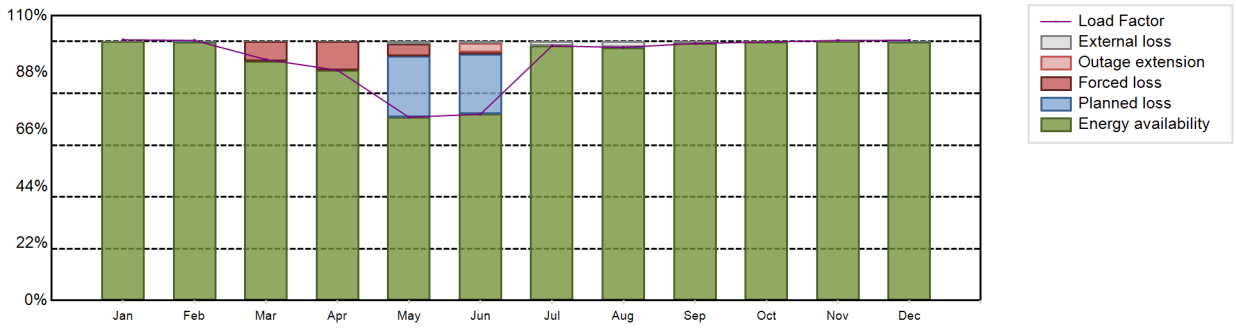
Operating coolant pressure [MPa]	:	7.12
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	4.8
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	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	:	4
Number of on-site safety related diesel generators	:	4
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	7310.06 GW(e).h
Energy Availability Factor (EAF)	:	93.25 %
Unit Capability Factor (UCF)	:	93.75 %
Load Factor (LF)	:	93.51 %
Operating Factor (OF)	:	95.53 %

Forced Loss Rate (FLR)	:	2.12 %
Unplanned Capability Loss Factor (UCL)	:	2.3 %
Planned Unavailability Factor (PUF)	:	3.94 %
Externally cause unavailability (XUF)	:	0.5 %
Total off-line time	:	393 hours

Annual Summary



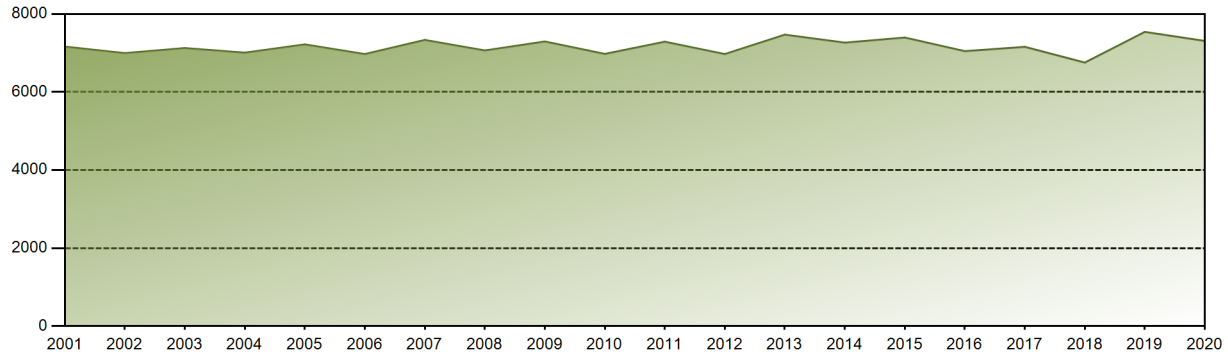
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	666.79	622.32	615.42	570.00	468.70	461.05	651.17	647.20	636.06	662.10	643.75	665.50	7310.06
EAF [%]	100.00	99.76	92.50	88.95	70.78	71.96	98.35	97.75	99.28	99.87	100.00	99.80	93.25
UCF [%]	100.00	99.76	92.50	88.95	71.55	72.61	100.00	99.93	99.99	99.87	100.00	99.80	93.75
LF [%]	100.70	100.46	93.07	88.95	70.78	71.95	98.34	97.74	99.26	99.86	100.46	100.51	93.51
OF [%]	100.00	100.00	97.17	97.08	76.61	75.42	100.00	100.00	100.00	100.00	100.00	100.00	95.53
FLR [%]	0.00	0.00	7.50	11.05	6.35	1.23	0.00	0.00	0.01	0.01	0.00	0.00	2.12
UCL [%]	0.00	0.00	7.50	11.05	4.85	4.29	0.00	0.00	0.01	0.01	0.00	0.00	2.30
PUF [%]	0.00	0.24	0.00	0.00	23.60	23.10	0.00	0.07	0.00	0.12	0.00	0.20	3.94
XUF [%]	0.00	0.00	0.00	0.00	0.77	0.66	1.65	2.17	0.72	0.00	0.00	0.00	0.50

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Historical Summary

Lifetime energy generation	:	267098.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.43 %
Cumulative Energy Availability Factor (EAF)	:	92.72 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.59 %
Cumulative Unit Capability Factor (UCF)	:	93.16 %	Cumulative Planned Unavailability Factor (PUF)	:	5.24 %
Cumulative Load Factor (LF)	:	92.55 %	Cumulative Externally cause unavailability (XUF)	:	0.45 %
Cumulative Operating Factor (OF)	:	93.75 %			

Electricity Production (net) [GWh]

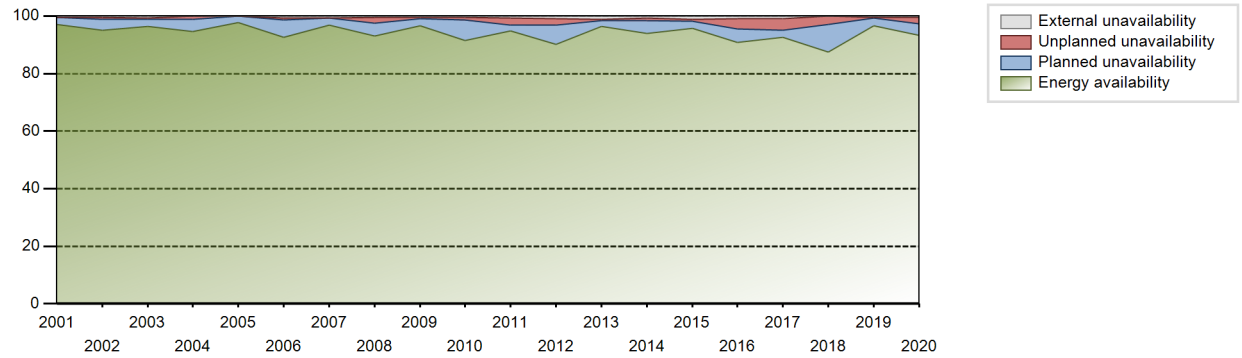


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1979	3465.00	5614	660	86.85	86.85	86.82	90.40	12.45	12.35	0.80	0.00
1980	4280.80	6849	658	76.31	76.31	74.06	77.97	3.12	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

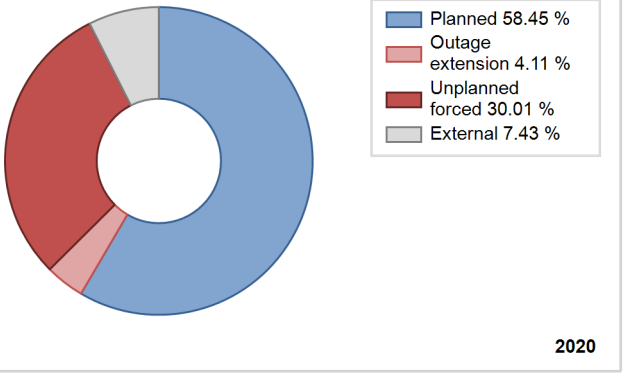
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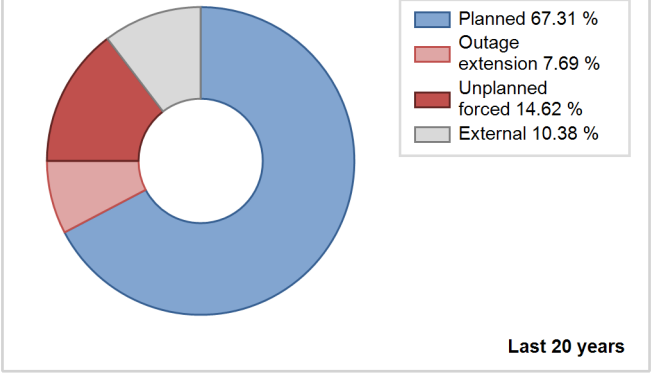
2016	7047.81	8146	880	90.90	91.84	91.18	92.74	2.29	3.46	4.70	0.93
2017	7158.27	8289	880	92.65	93.67	92.86	94.62	3.26	3.82	2.51	1.02
2018	6755.36	7731	880	87.55	87.67	87.63	88.25	0.65	2.73	9.60	0.12
2019	7542.04	8539	890	96.52	96.96	96.74	97.48	0.27	0.32	2.72	0.44
2020	7310.06	8391	890	93.25	93.75	93.51	95.53	2.12	2.30	3.94	0.50

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1979 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		43			99	
B.	Refuelling without maintenance				39		
C.	Inspection, maintenance or repair combined with refuelling	327	24		372	1	
D.	Inspection, maintenance or repair without refuelling				13		
E.	Testing of plant systems or components				0	5	
F.	Major backfitting, refurbishment or upgrading activities with refuelling				19		
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		3			1	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						0
Z.	Other					25	
Subtotal		327	70		443	131	12
Total		**397**			**586**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1979 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		15
12. Reactor I&C Systems		5
13. Reactor Auxiliary Systems		24
14. Safety Systems		4
15. Reactor Cooling Systems	1	15
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		0
31. Turbine and auxiliaries		17
32. Feedwater and Main Steam System	42	5
33. Circulating Water System		3
41. Main Generator Systems		37
42. Electrical Power Supply Systems		2
Total	**43**	**127**

Highlights (2020)

The plant units operated safely. OL1's net production was 7,310 (7,542) GWh and load factor 93.7 (96.9)%. OL2's net production was 7,277 (7,209) GWh and load factor 93.3 (92.7)%.
The 2020 annual outages of the Olkiluoto nuclear power plant were started with a refuelling outage at the OL2 plant unit on 10 May. The refueling outage was completed on 21 May.

The annual outage carried out at the OL1 plant unit was a maintenance outage, which started on 24 May and was completed on 8 June. The duration of the plant unit's annual outage was shortened in March from the planned 25 days to 14 days due to the COVID-19 pandemic. Numerous special procedures and arrangements were put in place during the annual outages to protect people's health in Olkiluoto and prevent the possible spread of the virus, as well as to ensure a safe and high-quality annual outage. Modernizations and repair work with safety and availability significance were completed during the annual outages. Other planned modernizations were transferred to be completed in upcoming outages. Preventive maintenance was carried out normally according to the preventive maintenance programme. A significant task was the modernization of the bushing modules of one containment, which was completed for the first time. Other significant tasks were the modernization of the valve actuator in the cooling system of the shut down reactor as well as the changing of two valves, the connection of the recirculation line to one subsystem in auxiliary feed water systems, as well as repair works, preventive maintenance, inspections, and testing.

The annual outages were carried out successfully despite special arrangements due to COVID-19.

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2020 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	:	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]	:	3.66
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

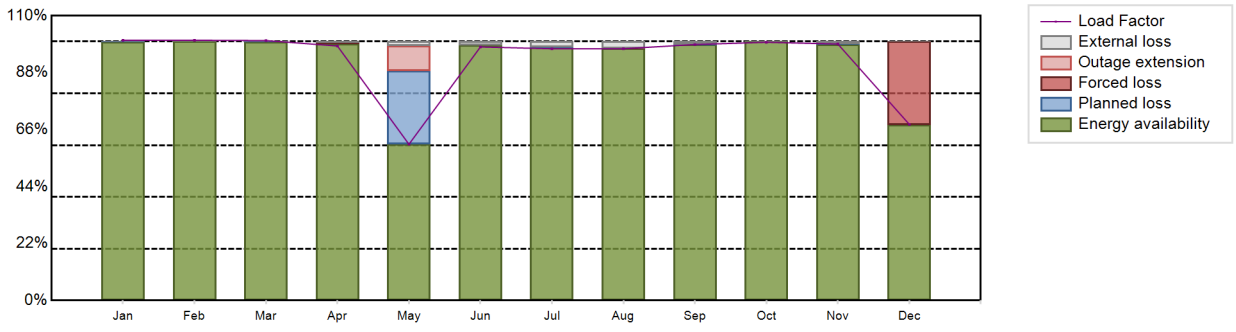
Operating coolant pressure [MPa]	:	7.12
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	4.8
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	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	:	none

Annual Production Results (2020)

Net Energy Production	:	7276.55 GW(e).h
Energy Availability Factor (EAF)	:	93.13 %
Unit Capability Factor (UCF)	:	93.97 %
Load Factor (LF)	:	93.08 %
Operating Factor (OF)	:	94.36 %

Forced Loss Rate (FLR)	:	2.87 %
Unplanned Capability Loss Factor (UCL)	:	3.58 %
Planned Unavailability Factor (PUF)	:	2.45 %
Externally cause unavailability (XUF)	:	0.84 %
Total off-line time	:	495 hours

Annual Summary



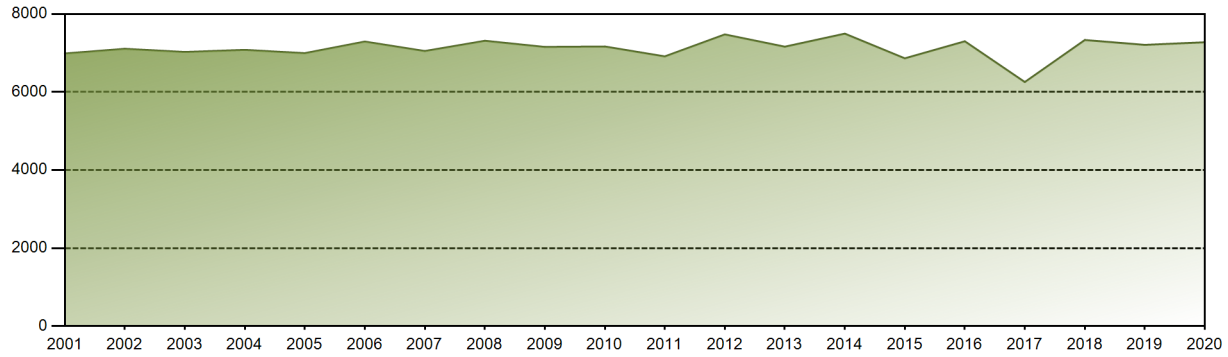
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	665.46	622.68	663.91	629.78	399.57	627.54	643.86	643.98	633.46	661.26	634.78	450.26	7276.55
EAF [%]	99.92	100.00	99.90	99.16	60.43	98.55	97.92	97.27	98.87	100.00	98.94	67.78	93.13
UCF [%]	99.92	100.00	99.90	99.49	62.10	100.00	99.93	99.94	99.93	100.00	99.79	67.78	93.97
LF [%]	100.50	100.52	100.40	98.28	60.34	97.93	97.24	97.25	98.85	99.73	99.06	68.00	93.08
OF [%]	100.00	100.00	100.00	100.00	63.98	100.00	100.00	100.00	100.00	100.00	100.00	69.49	94.36
FLR [%]	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.06	0.00	0.00	0.00	32.22	2.87
UCL [%]	0.00	0.00	0.00	0.51	9.54	0.00	0.00	0.06	0.00	0.00	0.00	32.22	3.58
PUF [%]	0.08	0.00	0.10	0.00	28.36	0.00	0.07	0.00	0.07	0.00	0.21	0.00	2.45
XUF [%]	0.00	0.00	0.00	0.34	1.66	1.45	2.01	2.67	1.06	0.00	0.85	0.00	0.84

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Historical Summary

Lifetime energy generation	:	257523.89 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.24 %
Cumulative Energy Availability Factor (EAF)	:	93.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.56 %
Cumulative Unit Capability Factor (UCF)	:	93.66 %	Cumulative Planned Unavailability Factor (PUF)	:	4.78 %
Cumulative Load Factor (LF)	:	93 %	Cumulative Externally cause unavailability (XUF)	:	0.54 %
Cumulative Operating Factor (OF)	:	94.2 %			

Electricity Production (net) [GWh]

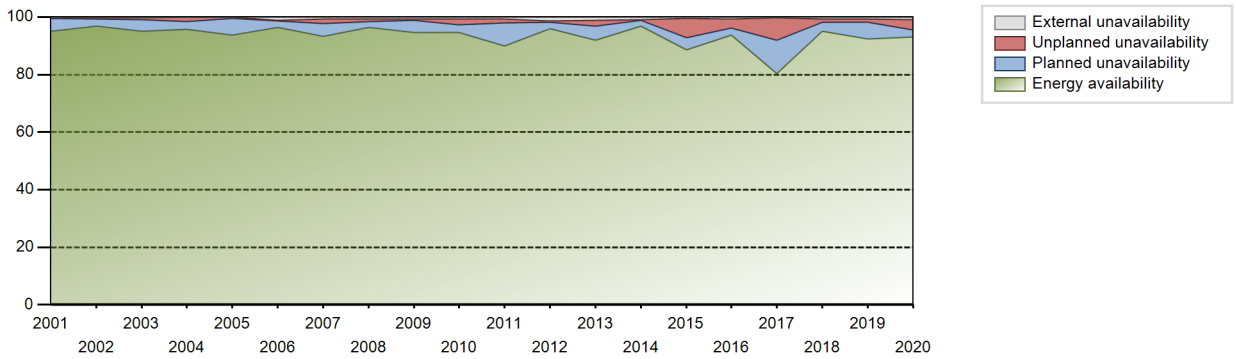


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1982	4587.10	7269	658	77.65	77.65	77.64	79.53	2.38	1.89	20.45	0.00
1983	5087.20	8221	657	86.75	86.75	88.39	93.85	5.00	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

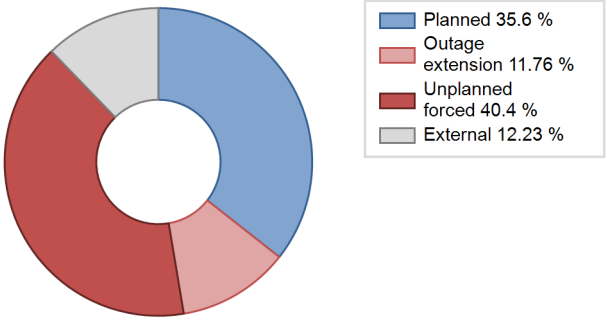
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2019	7209.08	8162	890	92.33	92.95	92.47	93.17	1.16	1.16	5.88	0.63
2020	7276.55	8289	890	93.13	93.97	93.08	94.36	2.87	3.58	2.45	0.84

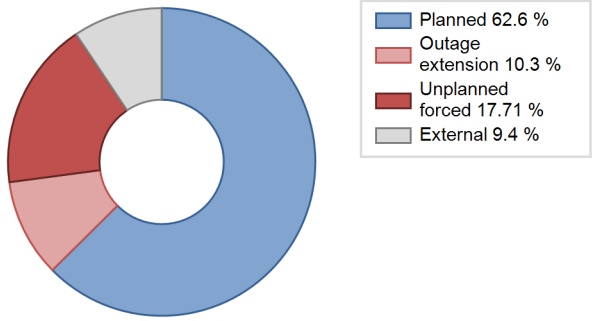
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1982 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		299			312	
B. Refuelling without maintenance				35		
C. Inspection, maintenance or repair combined with refuelling	197			355		
D. Inspection, maintenance or repair without refuelling				8		
E. Testing of plant systems or components				18	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				26		
J. Grid limitation, failure or grid unavailability						4
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						12
L. Human factor related					8	
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	197	299		442	322	16
Total		**496**			**780**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1982 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		22
12. Reactor I&C Systems		1
13. Reactor Auxiliary Systems		0
14. Safety Systems		4
15. Reactor Cooling Systems	228	21
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		7
32. Feedwater and Main Steam System	71	10
33. Circulating Water System		1
34. Miscellaneous Systems		0
35. All other I&C Systems		1
41. Main Generator Systems		224
42. Electrical Power Supply Systems		3
Total	**299**	**296**

Highlights (2020)

The plant units operated safely. OL1's net production was 7,310 (7,542) GWh and load factor 93.7 (96.9)%. OL2's net production was 7,277 (7,209) GWh and load factor 93.3 (92.7)%.

There was a disturbance at the OL2 plant unit in December, when the plant unit was suddenly disconnected from the grid, and a site area emergency was declared at the unit. The disturbance soon proved to be less serious than a site area emergency, and the plant unit was driven into a cold shutdown state. The situation was caused due to hot water moving into the filters of the reactor water clean-up system. The plant's safety systems operated as planned, and the disturbance did not cause harm to people or the environment.

The 2020 annual outages of the Olkiluoto nuclear power plant were started with a refuelling outage at the OL2 plant unit on 10 May. The refueling outage was completed on 21 May.

The annual outage carried out at the OL1 plant unit was a maintenance outage, which started on 24 May and was completed on 8 June. The duration of the plant unit's annual outage was shortened in March from the planned 25 days to 14 days due to the COVID-19 pandemic. Numerous special procedures and arrangements were put in place during the annual outages to protect people's health in Olkiluoto and prevent the possible spread of the virus, as well as to ensure a safe and high-quality annual outage. Modernizations and repair work with safety and availability significance were completed during the annual outages. Other planned modernizations were transferred to be completed in upcoming outages. Preventive maintenance was carried out normally according to the preventive maintenance programme. A significant task was the modernization of the bushing modules of one containment, which was completed for the first time. Other significant tasks were the modernization of the valve actuator in the cooling system of the shut down reactor as well as the changing of two valves, the connection of the recirculation line to one subsystem in auxiliary feed water systems, as well as repair works, preventive maintenance, inspections, and testing.

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2020 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	:	33 years

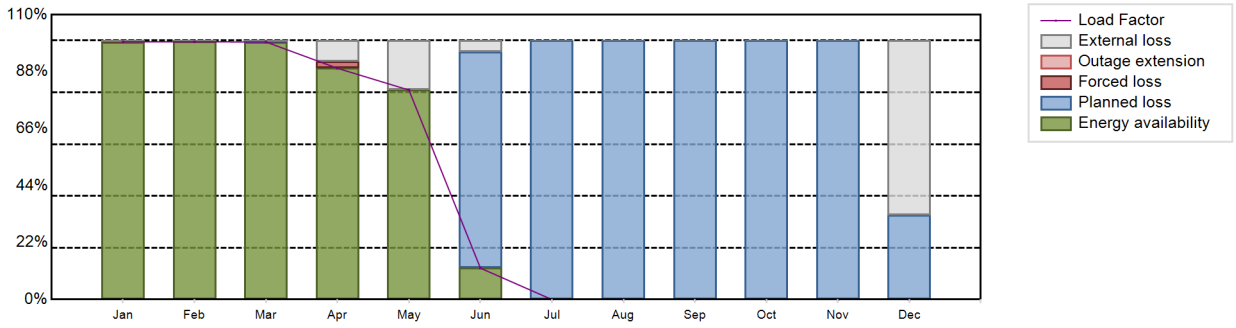
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	328.7
Fuel material	:	UO2/MOX	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 [%]	:	33.3	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]	:	4.25	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	Cooling towers
Fuel linear heat generation rate [kW/m]	:	17.5	Number of main condensate pumps	:	-
Number of control rod assemblies	:	51	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 (2020)

Net Energy Production	:	4590.82 GW(e).h	Forced Loss Rate (FLR)	:	0.46 %
Energy Availability Factor (EAF)	:	39.9 %	Unplanned Capability Loss Factor (UCL)	:	0.22 %
Unit Capability Factor (UCF)	:	48.36 %	Planned Unavailability Factor (PUF)	:	51.42 %
Load Factor (LF)	:	39.9 %	Externally cause unavailability (XUF)	:	8.46 %
Operating Factor (OF)	:	42.88 %	Total off-line time	:	5017 hours

Annual Summary



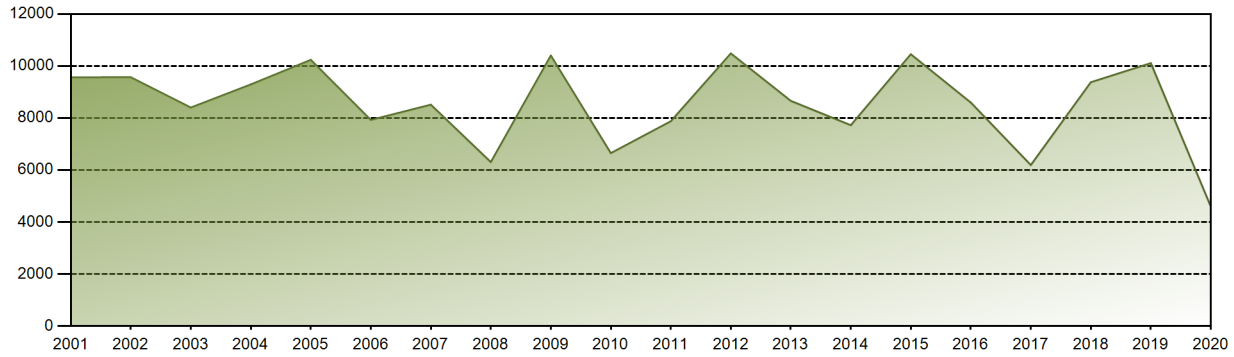
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	969.94	907.48	968.19	842.37	788.51	114.34	0.00	0.00	0.00	0.00	0.00	0.00	4590.82
EAF [%]	99.48	99.51	99.45	89.34	80.92	12.14	0.01	0.00	0.00	0.00	0.00	0.01	39.90
UCF [%]	99.89	100.00	99.91	97.45	100.00	16.42	0.01	0.00	0.00	0.00	0.00	67.48	48.36
LF [%]	99.52	99.53	99.47	89.31	80.90	12.12	0.00	0.00	0.00	0.00	0.00	0.00	39.90
OF [%]	100.00	100.00	100.00	100.00	100.00	16.67	0.00	0.00	0.00	0.00	0.00	0.00	42.88
FLR [%]	0.09	0.00	0.08	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
UCL [%]	0.09	0.00	0.08	2.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
PUF [%]	0.02	0.00	0.00	0.00	0.00	83.58	99.99	100.00	100.00	100.00	100.00	32.52	51.42
XUF [%]	0.41	0.49	0.46	8.11	19.08	4.28	0.00	0.00	0.00	0.00	0.00	67.47	8.46

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Historical Summary

Lifetime energy generation	:	267598.41 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.42 %
Cumulative Energy Availability Factor (EAF)	:	75.48 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.45 %
Cumulative Unit Capability Factor (UCF)	:	77.04 %	Cumulative Planned Unavailability Factor (PUF)	:	14.51 %
Cumulative Load Factor (LF)	:	70.66 %	Cumulative Externally cause unavailability (XUF)	:	1.56 %
Cumulative Operating Factor (OF)	:	77.59 %			

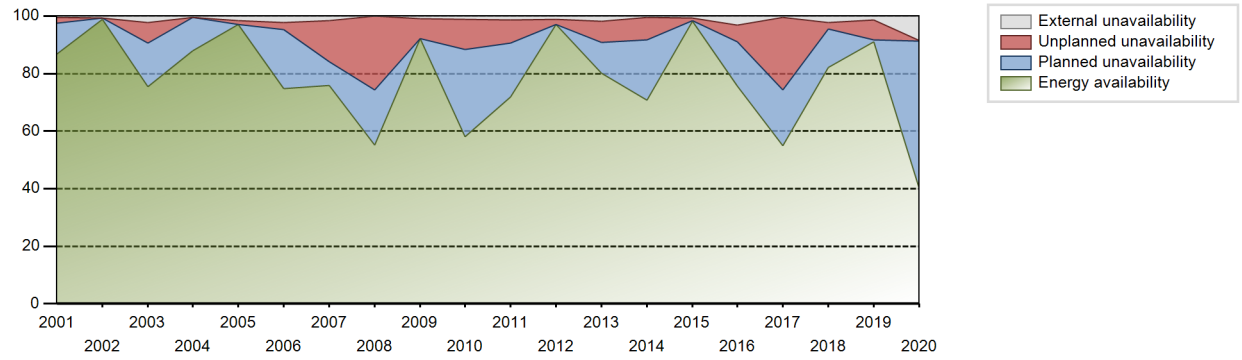
Electricity Production (net) [GWh]



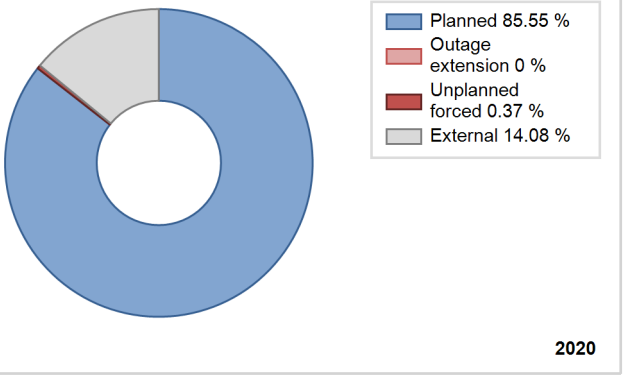
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	6283.00	6478	1310	85.78	86.06	64.40	86.06	13.94	13.94	0.00	0.28
1989	5152.56	4244	1310	45.97	46.53	44.90	48.45	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	39.90	48.36	39.90	42.88	0.46	0.22	51.42	8.46

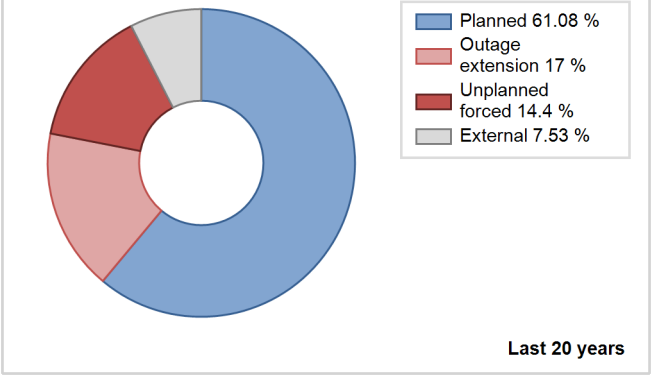
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					552	
B. Refuelling without maintenance				101		
C. Inspection, maintenance or repair combined with refuelling	4513			1118	7	
D. Inspection, maintenance or repair without refuelling				6		
E. Testing of plant systems or components				39	2	1
H. Nuclear regulatory requirements					72	
L. Human factor related					16	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)			481			16
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.)			21		2	46
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						1
Z. Other					18	
Subtotal	4513		502	1264	669	64
Total	**5015**			**1997**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1988 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		21
12. Reactor I&C Systems		55
13. Reactor Auxiliary Systems		41
14. Safety Systems		28
15. Reactor Cooling Systems		29
16. Steam generation systems		42
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		7
31. Turbine and auxiliaries		57
32. Feedwater and Main Steam System		62
33. Circulating Water System		1
34. Miscellaneous Systems		143
35. All other I&C Systems		10
41. Main Generator Systems		33
42. Electrical Power Supply Systems		15
Total		**544**

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2020 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	:	32 years

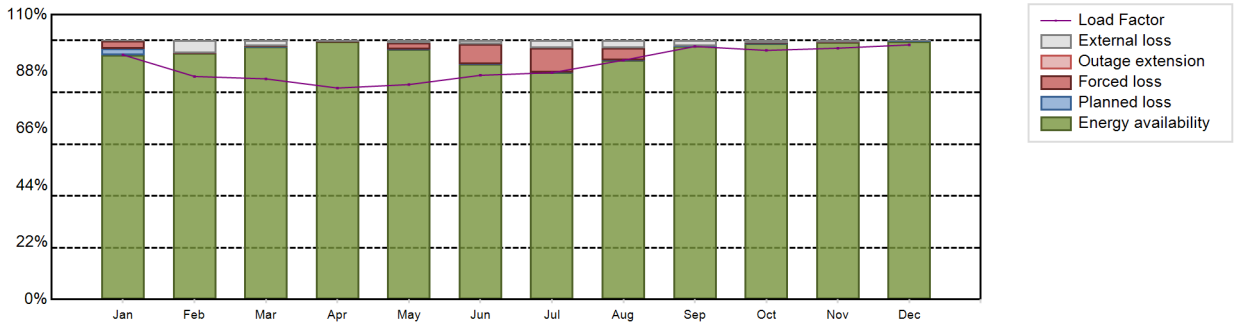
Design Characteristics

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 [%]	:	33.3	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]	:	4.25	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	Cooling towers
Fuel linear heat generation rate [kW/m]	:	17.5	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 (2020)

Net Energy Production	:	10421.33 GW(e).h	Forced Loss Rate (FLR)	:	2.34 %
Energy Availability Factor (EAF)	:	95.84 %	Unplanned Capability Loss Factor (UCL)	:	2.33 %
Unit Capability Factor (UCF)	:	97.41 %	Planned Unavailability Factor (PUF)	:	0.26 %
Load Factor (LF)	:	90.56 %	Externally cause unavailability (XUF)	:	1.57 %
Operating Factor (OF)	:	97.96 %	Total off-line time	:	179 hours

Annual Summary



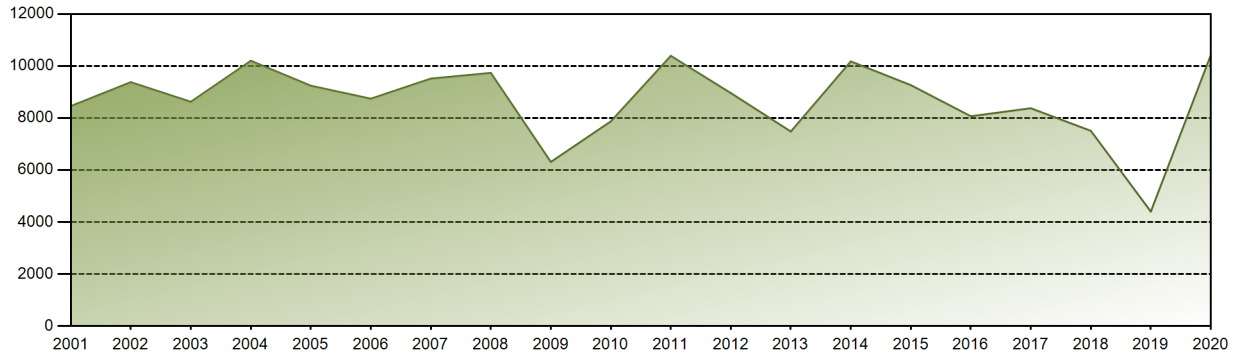
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	920.96	785.44	829.39	770.37	809.06	816.76	853.82	900.71	921.78	939.00	915.52	958.53	10421.33
EAF [%]	94.50	95.14	97.67	99.62	96.67	90.87	87.62	92.44	97.82	98.81	99.35	99.73	95.84
UCF [%]	94.65	99.89	99.68	99.97	97.50	92.34	90.51	95.19	99.91	99.74	99.88	99.93	97.41
LF [%]	94.49	86.15	85.21	81.68	83.01	86.59	87.60	92.41	97.73	96.21	97.07	98.35	90.56
OF [%]	100.00	100.00	99.87	100.00	96.91	92.50	90.73	95.83	100.00	99.87	100.00	100.00	97.96
FLR [%]	3.00	0.02	0.26	0.03	2.44	7.64	9.39	4.77	0.00	0.23	0.08	0.00	2.34
UCL [%]	2.93	0.02	0.26	0.03	2.43	7.64	9.38	4.77	0.00	0.23	0.08	0.00	2.33
PUF [%]	2.42	0.08	0.06	0.01	0.07	0.02	0.11	0.05	0.09	0.02	0.04	0.07	0.26
XUF [%]	0.16	4.75	2.01	0.35	0.83	1.47	2.90	2.75	2.09	0.93	0.53	0.20	1.57

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Historical Summary

Lifetime energy generation	:	266620.39 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.05 %
Cumulative Energy Availability Factor (EAF)	:	77.1 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.85 %
Cumulative Unit Capability Factor (UCF)	:	78.94 %	Cumulative Planned Unavailability Factor (PUF)	:	13.21 %
Cumulative Load Factor (LF)	:	72.05 %	Cumulative Externally cause unavailability (XUF)	:	1.84 %
Cumulative Operating Factor (OF)	:	79.26 %			

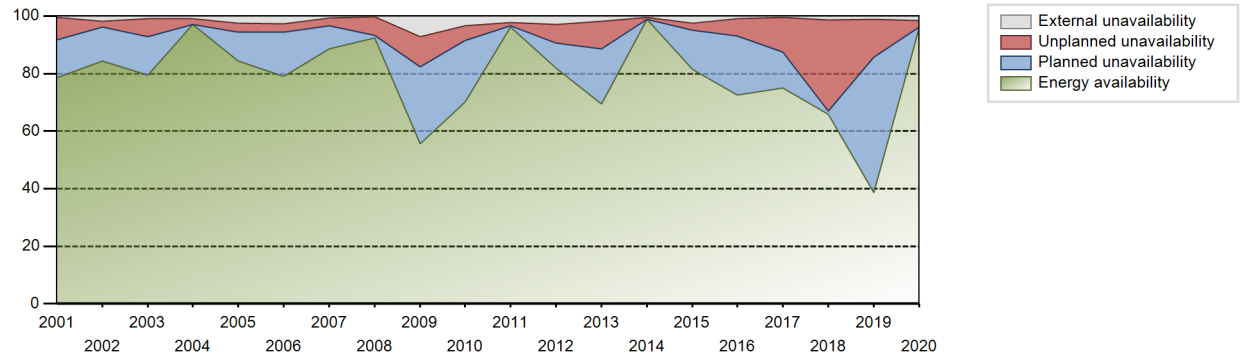
Electricity Production (net) [GWh]



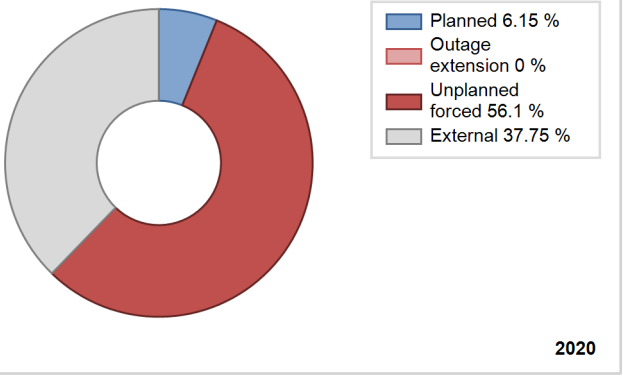
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	8505.66	7419	1310	86.64	86.97	74.12	84.69	12.32	12.23	0.80	0.33
1990	6323.98	5350	1310	56.88	58.44	55.11	61.07	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	8605	1310	95.84	97.41	90.56	97.96	2.34	2.33	0.26	1.57

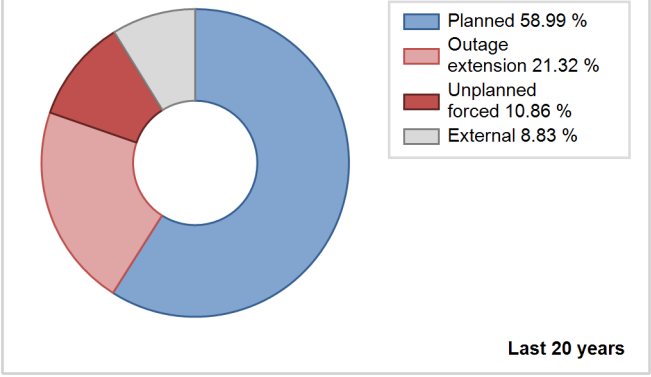
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					466	
B. Refuelling without maintenance				68		
C. Inspection, maintenance or repair combined with refuelling				1012		
E. Testing of plant systems or components				32		
H. Nuclear regulatory requirements					97	
L. Human factor related					17	
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	33
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						3
Z. Other					38	1
Subtotal				1112	620	38
Total		**0**			**1770**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		29
12. Reactor I&C Systems		45
13. Reactor Auxiliary Systems		10
14. Safety Systems		22
15. Reactor Cooling Systems		33
16. Steam generation systems		28
17. Safety I&C Systems (excluding reactor I&C)		7
21. Fuel Handling and Storage Facilities		11
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System		9
33. Circulating Water System		2
34. Miscellaneous Systems		203
35. All other I&C Systems		7
41. Main Generator Systems		4
42. Electrical Power Supply Systems		12
Total		**457**

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2020 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

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	:	1981-06-12
Commercial Date	:	1981-12-01
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]	:	24
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	:	28
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

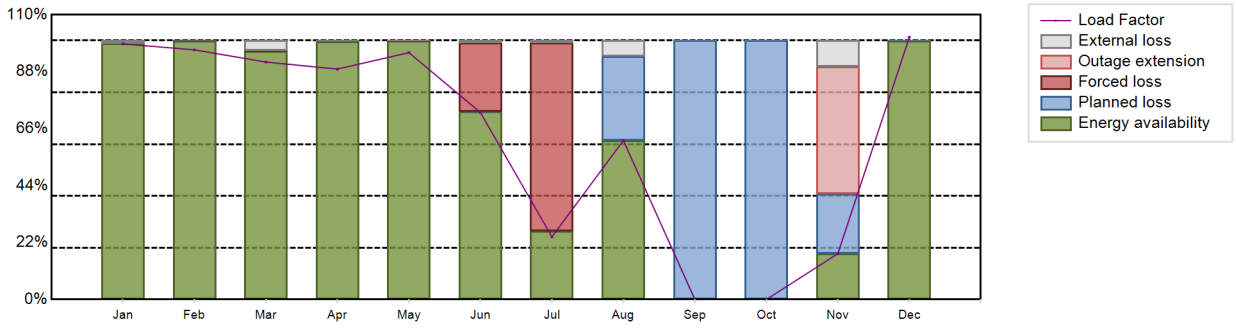
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	323
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4983.14 GW(e).h
Energy Availability Factor (EAF)	:	64.34 %
Unit Capability Factor (UCF)	:	66.26 %
Load Factor (LF)	:	62.34 %
Operating Factor (OF)	:	65.87 %

Forced Loss Rate (FLR)	:	11.21 %
Unplanned Capability Loss Factor (UCL)	:	12.39 %
Planned Unavailability Factor (PUF)	:	21.35 %
Externally cause unavailability (XUF)	:	1.92 %
Total off-line time	:	2998 hours

Annual Summary



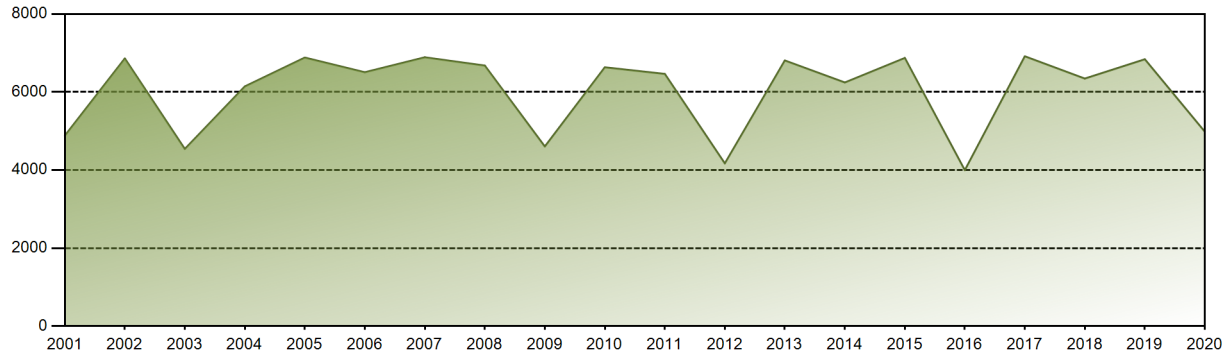
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	668.33	610.71	620.08	583.13	645.50	473.23	163.85	416.02	0.00	0.00	116.19	686.10	4983.14
EAF [%]	98.81	99.94	95.97	99.63	99.84	72.62	26.36	61.46	0.00	0.00	17.73	99.93	64.34
UCF [%]	100.00	99.94	99.90	99.64	99.91	73.40	27.33	67.56	0.00	0.00	27.72	99.93	66.26
LF [%]	98.71	96.42	91.71	89.00	95.34	72.23	24.20	61.45	0.00	0.00	17.73	101.34	62.34
OF [%]	100.00	100.00	96.37	100.00	100.00	73.47	25.54	67.88	0.00	0.00	27.50	100.00	65.87
FLR [%]	0.00	0.02	0.10	0.20	0.06	26.60	72.67	0.00	0.00	0.00	0.00	0.00	11.21
UCL [%]	0.00	0.02	0.10	0.20	0.06	26.59	72.67	0.00	0.00	0.00	49.10	0.00	12.39
PUF [%]	0.00	0.05	0.00	0.16	0.02	0.00	0.00	32.44	100.00	100.00	23.18	0.07	21.35
XUF [%]	1.19	0.00	3.93	0.01	0.07	0.78	0.97	6.10	0.00	0.00	9.99	0.00	1.92

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Historical Summary

Lifetime energy generation	:	227797.83 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.55 %
Cumulative Energy Availability Factor (EAF)	:	76.55 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7 %
Cumulative Unit Capability Factor (UCF)	:	79.39 %	Cumulative Planned Unavailability Factor (PUF)	:	13.61 %
Cumulative Load Factor (LF)	:	72.73 %	Cumulative Externally cause unavailability (XUF)	:	2.85 %
Cumulative Operating Factor (OF)	:	77.86 %			

Electricity Production (net) [GWh]

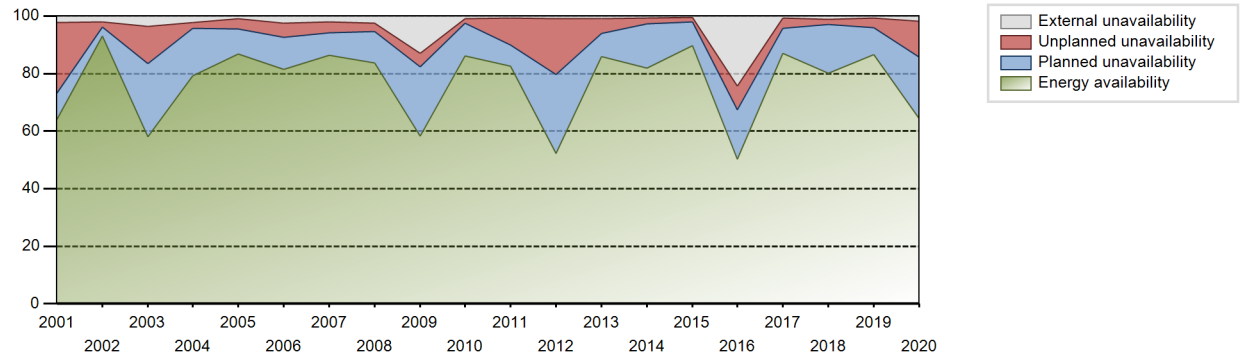


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	1636.20	2584	915	65.60	65.60	65.60	70.16	7.37	5.22	29.18	0.00
1982	6129.80	7588	910	81.46	81.46	76.90	86.62	18.54	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

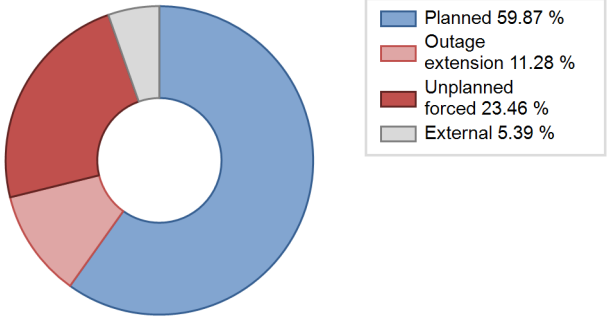
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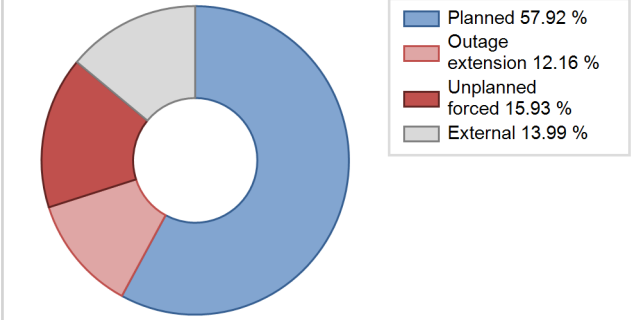
2018	6345.55	7164	910	80.08	81.21	79.60	81.78	0.73	1.73	17.07	1.13
2019	6840.40	7698	910	86.68	87.34	85.81	87.88	1.01	3.51	9.16	0.66
2020	4983.14	5786	910	64.34	66.26	62.34	65.87	11.21	12.39	21.35	1.92

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					404	0
B. Refuelling without maintenance				172		
C. Inspection, maintenance or repair combined with refuelling				893	4	
D. Inspection, maintenance or repair without refuelling				31		
E. Testing of plant systems or components				1	1	
H. Nuclear regulatory requirements					55	
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	1
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						45
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.)					17	78
Z. Other					16	
Subtotal				1097	508	126
Total		**0**			**1731**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		23
12. Reactor I&C Systems		56
13. Reactor Auxiliary Systems		6
14. Safety Systems		23
15. Reactor Cooling Systems		55
16. Steam generation systems		61
17. Safety I&C Systems (excluding reactor I&C)		4
21. Fuel Handling and Storage Facilities		38
31. Turbine and auxiliaries		28
32. Feedwater and Main Steam System		35
33. Circulating Water System		1
34. Miscellaneous Systems		57
35. All other I&C Systems		0
41. Main Generator Systems		65
42. Electrical Power Supply Systems		8
Total		**460**

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2020 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	:	38 years

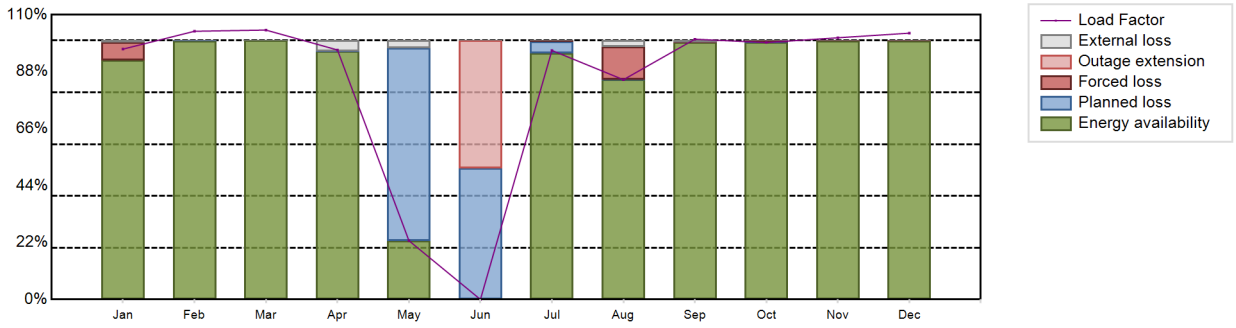
Design Characteristics

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]	:	3.44	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 (2020)

Net Energy Production	:	6716.68 GW(e).h	Forced Loss Rate (FLR)	:	2.07 %
Energy Availability Factor (EAF)	:	82.49 %	Unplanned Capability Loss Factor (UCL)	:	5.81 %
Unit Capability Factor (UCF)	:	83.37 %	Planned Unavailability Factor (PUF)	:	10.82 %
Load Factor (LF)	:	84.03 %	Externally cause unavailability (XUF)	:	0.88 %
Operating Factor (OF)	:	85.02 %	Total off-line time	:	1316 hours

Annual Summary



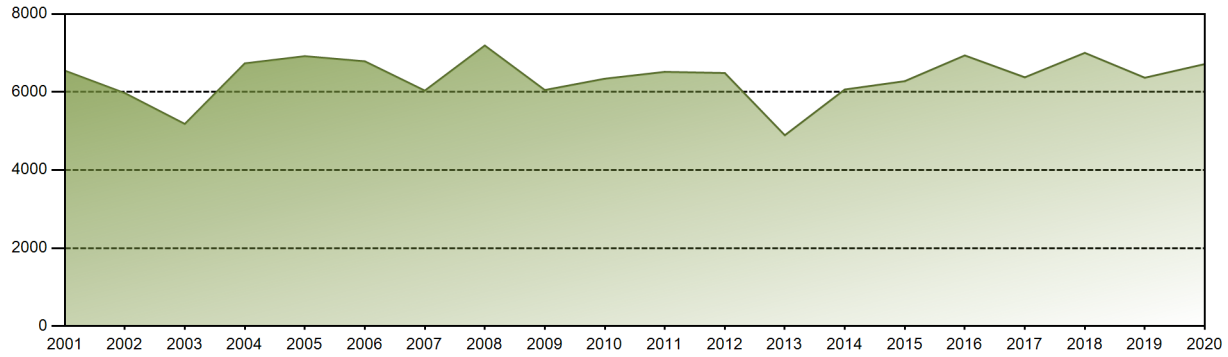
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	654.77	656.18	703.63	631.53	153.83	0.22	651.29	574.83	658.76	672.83	662.33	696.48	6716.68
EAF [%]	92.41	99.94	100.00	96.00	22.73	0.04	95.25	84.95	99.29	99.38	99.93	99.96	82.49
UCF [%]	93.07	99.94	100.00	100.00	25.65	0.04	95.25	87.34	99.90	99.38	99.93	99.96	83.37
LF [%]	96.71	103.60	104.07	96.39	22.72	0.03	96.20	84.90	100.54	99.24	101.09	102.87	84.03
OF [%]	93.55	100.00	100.00	100.00	25.94	0.56	100.00	100.00	100.00	99.87	100.00	100.00	85.02
FLR [%]	6.93	0.00	0.00	0.00	0.00	0.00	0.51	12.65	0.05	0.60	0.07	0.04	2.07
UCL [%]	6.93	0.00	0.00	0.00	0.00	49.31	0.49	12.65	0.05	0.60	0.07	0.04	5.81
PUF [%]	0.00	0.06	0.00	0.00	74.35	50.64	4.26	0.01	0.04	0.02	0.00	0.00	10.82
XUF [%]	0.65	0.00	0.00	4.00	2.93	0.00	0.00	2.40	0.62	0.00	0.00	0.00	0.88

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Historical Summary

Lifetime energy generation	:	236094.02 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.76 %
Cumulative Energy Availability Factor (EAF)	:	80.42 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.57 %
Cumulative Unit Capability Factor (UCF)	:	82.47 %	Cumulative Planned Unavailability Factor (PUF)	:	13.96 %
Cumulative Load Factor (LF)	:	77.35 %	Cumulative Externally cause unavailability (XUF)	:	2.05 %
Cumulative Operating Factor (OF)	:	80.98 %			

Electricity Production (net) [GWh]

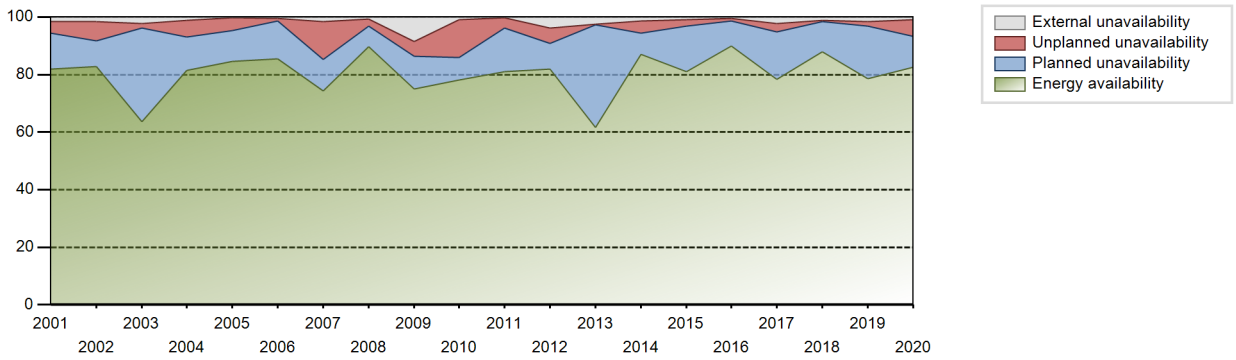


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	5094.00	5817	910	62.33	62.33	61.55	63.87	9.70	6.69	30.98	0.00
1984	6645.00	7716	910	85.54	85.54	83.13	87.84	4.07	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

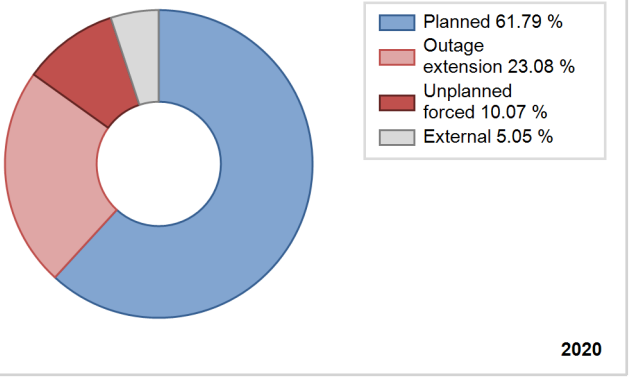
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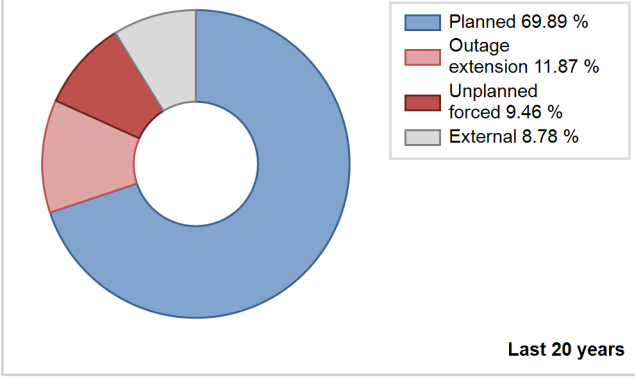
2020	6716.68	7468	910	82.49	83.37	84.03	85.02	2.07	5.81	10.82	0.88

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1983 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					217	
B. Refuelling without maintenance				124		
C. Inspection, maintenance or repair combined with refuelling				1026	2	
D. Inspection, maintenance or repair without refuelling				18		
E. Testing of plant systems or components				54	0	
H. Nuclear regulatory requirements					13	
J. Grid limitation, failure or grid unavailability						3
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						22
L. Human factor related					6	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						48
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.)						16
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						7
Z. Other					20	
Subtotal				1222	258	96
Total		**0**			**1576**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		18
12. Reactor I&C Systems		5
13. Reactor Auxiliary Systems		6
14. Safety Systems		11
15. Reactor Cooling Systems		22
16. Steam generation systems		30
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		28
32. Feedwater and Main Steam System		39
33. Circulating Water System		4
34. Miscellaneous Systems		29
35. All other I&C Systems		1
41. Main Generator Systems		7
42. Electrical Power Supply Systems		16
Total		**218**

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2020 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

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	:	1983-08-17
Commercial Date	:	1983-11-14
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]	:	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

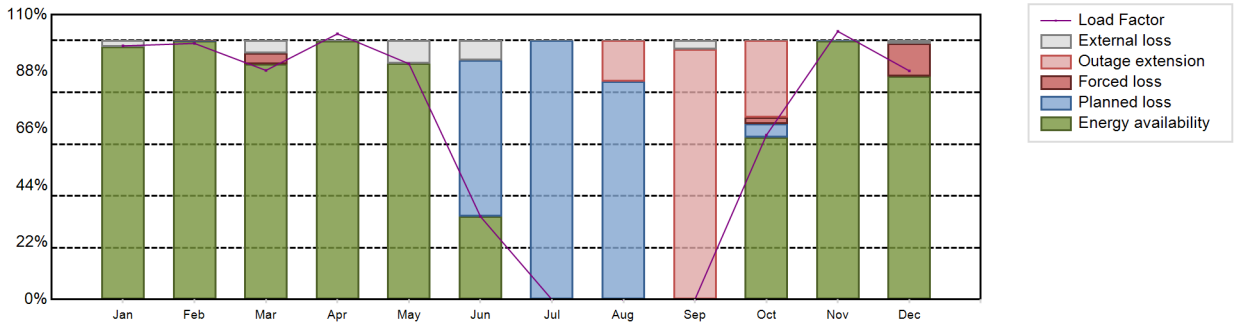
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	323
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5093.2 GW(e).h
Energy Availability Factor (EAF)	:	63.21 %
Unit Capability Factor (UCF)	:	65.58 %
Load Factor (LF)	:	63.72 %
Operating Factor (OF)	:	65.53 %

Forced Loss Rate (FLR)	:	2.49 %
Unplanned Capability Loss Factor (UCL)	:	13.45 %
Planned Unavailability Factor (PUF)	:	20.97 %
Externally cause unavailability (XUF)	:	2.37 %
Total off-line time	:	3028 hours

Annual Summary



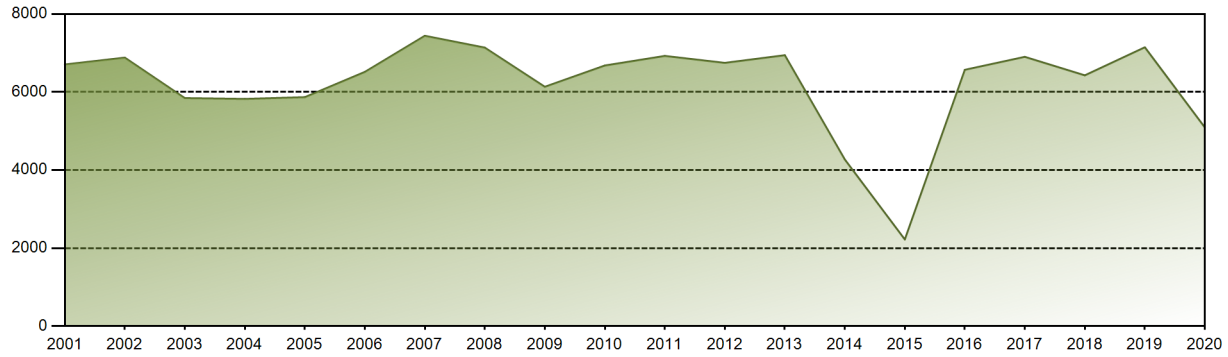
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	663.15	626.46	598.27	672.27	616.44	210.14	0.00	0.00	0.00	430.19	678.51	597.79	5093.20
EAF [%]	97.72	99.89	90.81	99.91	91.06	32.08	0.00	0.00	0.00	62.62	99.92	86.24	63.21
UCF [%]	100.00	99.89	95.65	100.00	100.00	39.79	0.00	0.00	3.34	62.62	99.92	87.36	65.58
LF [%]	97.95	98.91	88.48	102.60	91.05	32.07	0.00	0.00	0.00	63.45	103.56	88.30	63.72
OF [%]	100.00	100.00	91.66	100.00	100.00	40.00	0.00	0.00	0.00	68.32	100.00	87.90	65.53
FLR [%]	0.00	0.09	4.35	0.00	0.00	0.00	0.00	0.00	0.00	4.09	0.00	12.64	2.49
UCL [%]	0.00	0.09	4.35	0.00	0.00	0.00	0.00	15.86	96.66	32.27	0.00	12.64	13.45
PUF [%]	0.00	0.02	0.00	0.00	0.00	60.21	100.00	84.14	0.00	5.12	0.08	0.00	20.97
XUF [%]	2.28	0.00	4.83	0.09	8.94	7.70	0.00	0.00	3.33	0.00	0.00	1.12	2.37

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Historical Summary

Lifetime energy generation	:	227027.5 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.72 %
Cumulative Energy Availability Factor (EAF)	:	78.66 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.34 %
Cumulative Unit Capability Factor (UCF)	:	80.62 %	Cumulative Planned Unavailability Factor (PUF)	:	15.03 %
Cumulative Load Factor (LF)	:	76.36 %	Cumulative Externally cause unavailability (XUF)	:	1.96 %
Cumulative Operating Factor (OF)	:	79.43 %			

Electricity Production (net) [GWh]

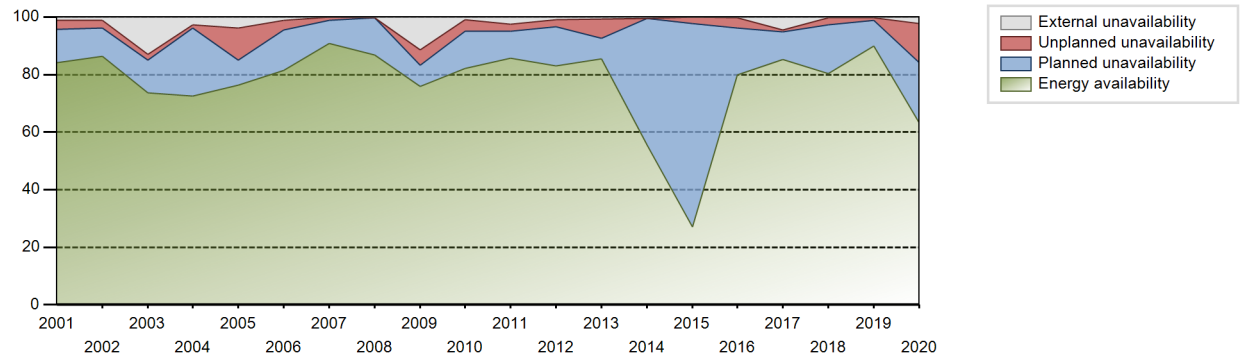


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	1912.00	2739	910	87.37	87.37	87.37	86.95	0.00	0.00	12.63	0.00
1984	5944.00	7055	910	80.35	80.35	74.36	80.32	4.20	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

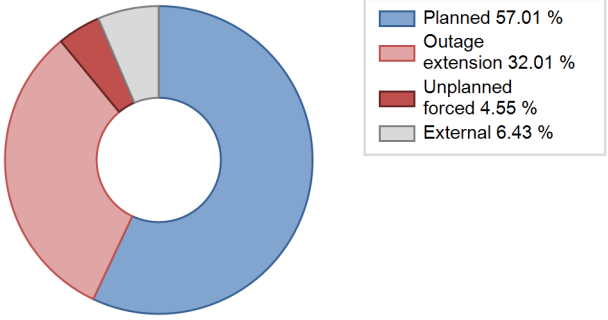
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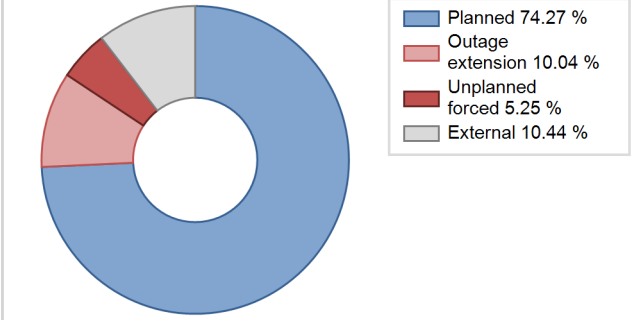
2020	5093.20	5756	910	63.21	65.58	63.72	65.53	2.49	13.45	20.97	2.37

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1983 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					248	
B. Refuelling without maintenance				96		
C. Inspection, maintenance or repair combined with refuelling				1104	5	
D. Inspection, maintenance or repair without refuelling				19	0	
E. Testing of plant systems or components				4	0	
H. Nuclear regulatory requirements					21	
J. Grid limitation, failure or grid unavailability						7
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
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
Z. Other					45	10
Subtotal				1223	322	66
Total		**0**			**1611**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		11
12. Reactor I&C Systems		19
13. Reactor Auxiliary Systems		26
14. Safety Systems		8
15. Reactor Cooling Systems		8
16. Steam generation systems		60
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		12
32. Feedwater and Main Steam System		8
33. Circulating Water System		1
34. Miscellaneous Systems		57
41. Main Generator Systems		32
42. Electrical Power Supply Systems		14
Total		**257**

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2020 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	:	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]	:	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

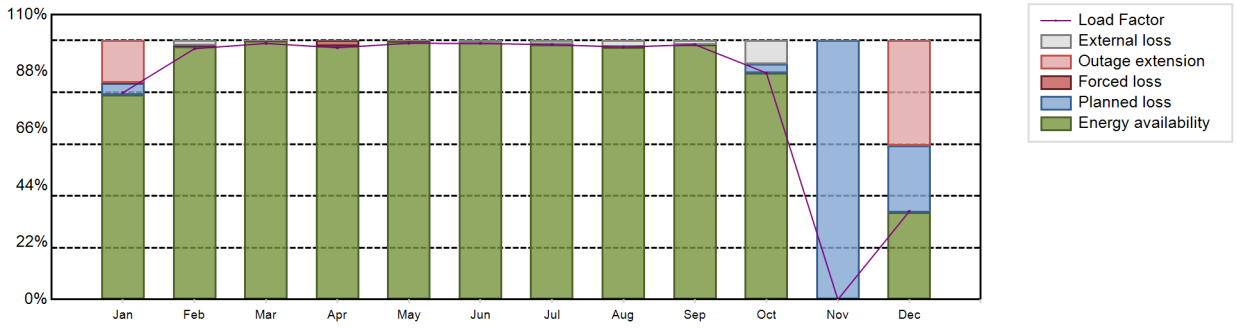
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	323
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	6573.47 GW(e).h
Energy Availability Factor (EAF)	:	82.4 %
Unit Capability Factor (UCF)	:	83.86 %
Load Factor (LF)	:	82.24 %
Operating Factor (OF)	:	85.05 %

Forced Loss Rate (FLR)	:	0.29 %
Unplanned Capability Loss Factor (UCL)	:	5.06 %
Planned Unavailability Factor (PUF)	:	11.08 %
Externally cause unavailability (XUF)	:	1.46 %
Total off-line time	:	1313 hours

Annual Summary



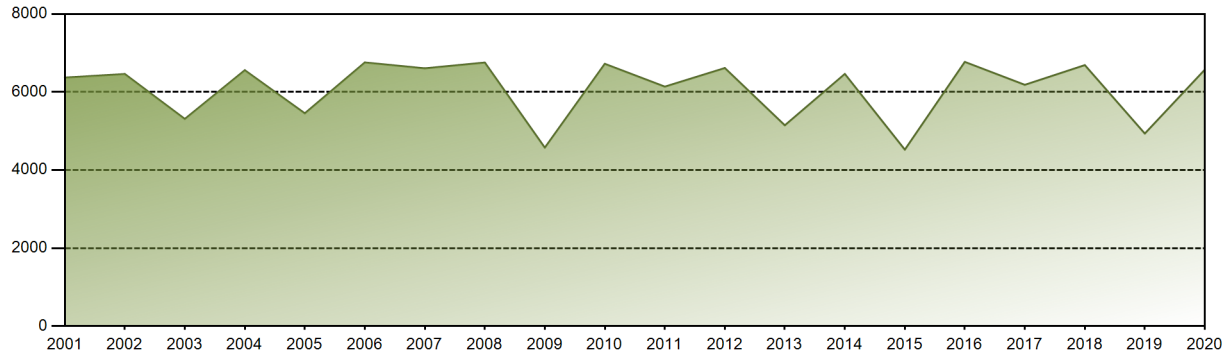
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	540.88	613.56	668.66	637.18	670.08	647.93	666.39	660.09	644.96	593.30	0.00	230.46	6573.47
EAF [%]	78.99	97.60	99.95	97.81	99.67	99.15	98.50	97.43	98.41	87.52	0.00	33.70	82.40
UCF [%]	78.99	99.56	99.99	97.81	99.69	99.95	99.94	99.84	99.98	96.65	0.00	33.70	83.86
LF [%]	79.89	96.87	98.89	97.25	98.97	98.89	98.43	97.50	98.44	87.51	0.00	34.04	82.24
OF [%]	83.74	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	96.78	0.00	39.78	85.05
FLR [%]	0.37	0.39	0.01	2.15	0.05	0.05	0.01	0.04	0.02	0.00	0.00	0.00	0.29
UCL [%]	16.51	0.39	0.01	2.15	0.05	0.05	0.01	0.04	0.02	0.00	0.00	40.59	5.06
PUF [%]	4.51	0.05	0.00	0.04	0.26	0.00	0.05	0.12	0.00	3.35	100.00	25.71	11.08
XUF [%]	0.00	1.96	0.05	0.00	0.03	0.80	1.44	2.41	1.57	9.13	0.00	0.00	1.46

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Historical Summary

Lifetime energy generation	:	224721.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.51 %
Cumulative Energy Availability Factor (EAF)	:	78.78 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.61 %
Cumulative Unit Capability Factor (UCF)	:	81.22 %	Cumulative Planned Unavailability Factor (PUF)	:	13.17 %
Cumulative Load Factor (LF)	:	75.18 %	Cumulative Externally cause unavailability (XUF)	:	2.44 %
Cumulative Operating Factor (OF)	:	80.59 %			

Electricity Production (net) [GWh]

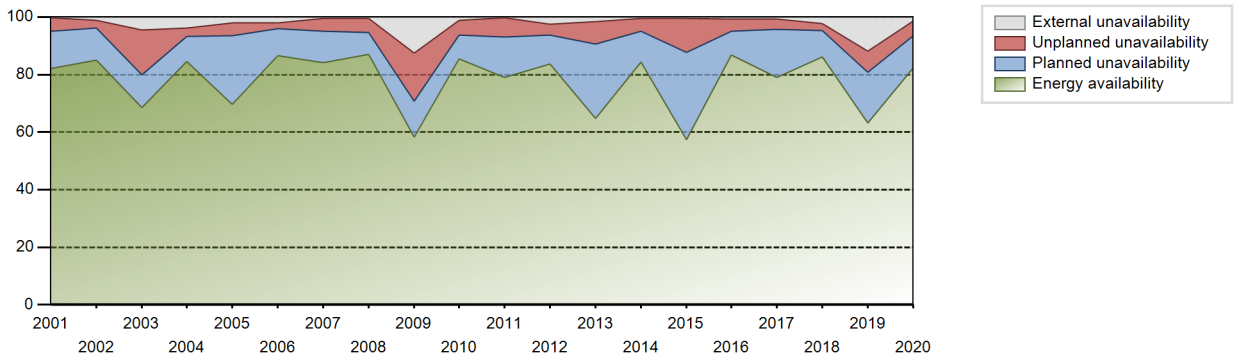


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	3356.00	4418	910	93.49	93.49	94.46	94.75	6.51	6.51	0.00	0.00
1984	6012.00	6780	910	76.00	76.00	75.21	77.19	3.36	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

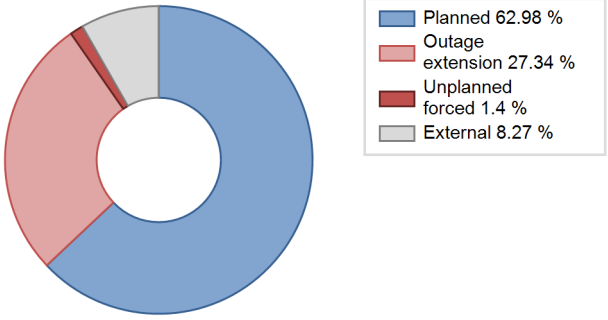
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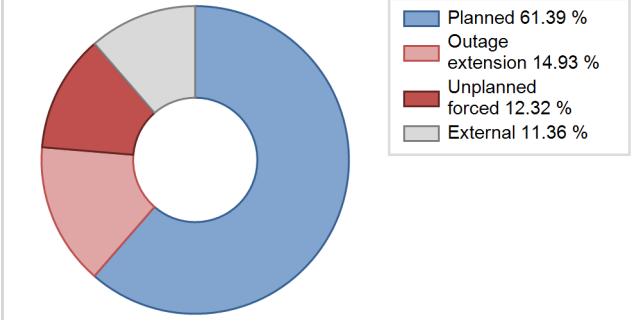
2020	6573.47	7471	910	82.40	83.86	82.24	85.05	0.29	5.06	11.08	1.46

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1983 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					339	
B. Refuelling without maintenance				121		
C. Inspection, maintenance or repair combined with refuelling				957	24	
D. Inspection, maintenance or repair without refuelling				6	7	
E. Testing of plant systems or components				2	1	
H. Nuclear regulatory requirements					7	
L. Human factor related					13	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						21
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.)						49
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						2
Z. Other					26	5
Subtotal				1086	417	80
Total	**0**			**1583**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		7
12. Reactor I&C Systems		44
13. Reactor Auxiliary Systems		12
14. Safety Systems		34
15. Reactor Cooling Systems		6
16. Steam generation systems		34
21. Fuel Handling and Storage Facilities		18
31. Turbine and auxiliaries		42
32. Feedwater and Main Steam System		5
33. Circulating Water System		8
34. Miscellaneous Systems		73
41. Main Generator Systems		43
42. Electrical Power Supply Systems		19
Total		**345**

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2020 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	:	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	:	48
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

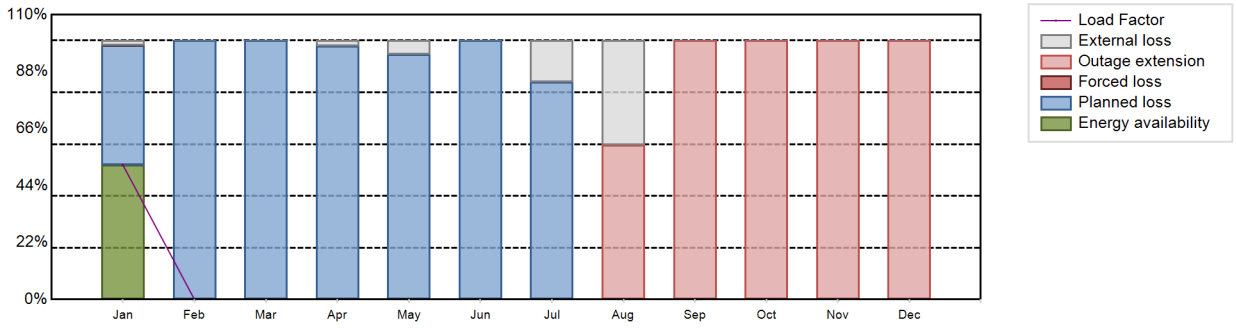
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	351.5 GW(e).h
Energy Availability Factor (EAF)	:	4.4 %
Unit Capability Factor (UCF)	:	9.96 %
Load Factor (LF)	:	4.4 %
Operating Factor (OF)	:	4.69 %

Forced Loss Rate (FLR)	:	0.13 %
Unplanned Capability Loss Factor (UCL)	:	38.41 %
Planned Unavailability Factor (PUF)	:	51.63 %
Externally cause unavailability (XUF)	:	5.55 %
Total off-line time	:	8372 hours

Annual Summary



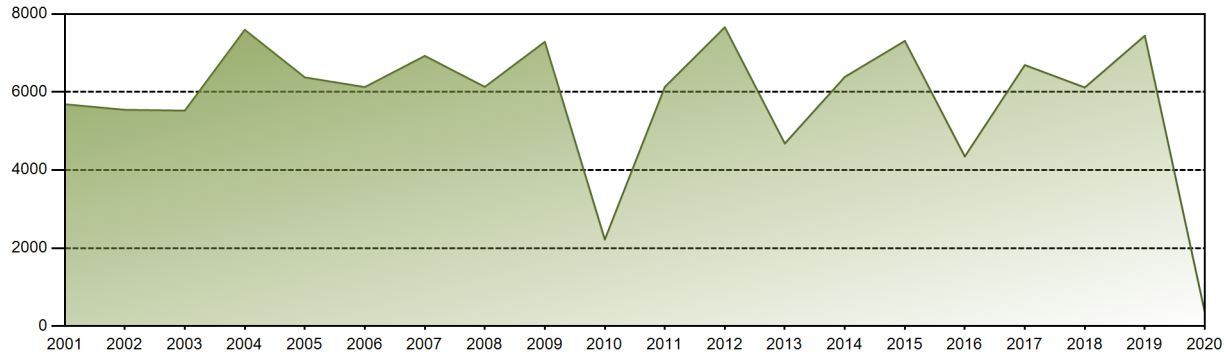
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	351.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	351.50
EAF [%]	51.96	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40
UCF [%]	53.77	0.00	0.00	2.08	5.32	0.00	16.12	40.32	0.00	0.00	0.00	0.00	9.96
LF [%]	51.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40
OF [%]	55.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.69
FLR [%]	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.13
UCL [%]	0.15	0.00	0.00	0.00	0.00	0.00	0.00	59.68	100.00	100.00	100.00	100.00	38.41
PUF [%]	46.08	100.00	100.00	97.92	94.68	100.00	83.88	0.00	0.00	0.00	0.00	0.00	51.63
XUF [%]	1.81	0.00	0.00	2.08	5.30	0.00	16.12	40.32	0.00	0.00	0.00	0.00	5.55

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Historical Summary

Lifetime energy generation	:	229099.48 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	8.4 %
Cumulative Energy Availability Factor (EAF)	:	71.94 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.18 %
Cumulative Unit Capability Factor (UCF)	:	74.18 %	Cumulative Planned Unavailability Factor (PUF)	:	16.64 %
Cumulative Load Factor (LF)	:	68.01 %	Cumulative Externally cause unavailability (XUF)	:	2.24 %
Cumulative Operating Factor (OF)	:	73.65 %			

Electricity Production (net) [GWh]

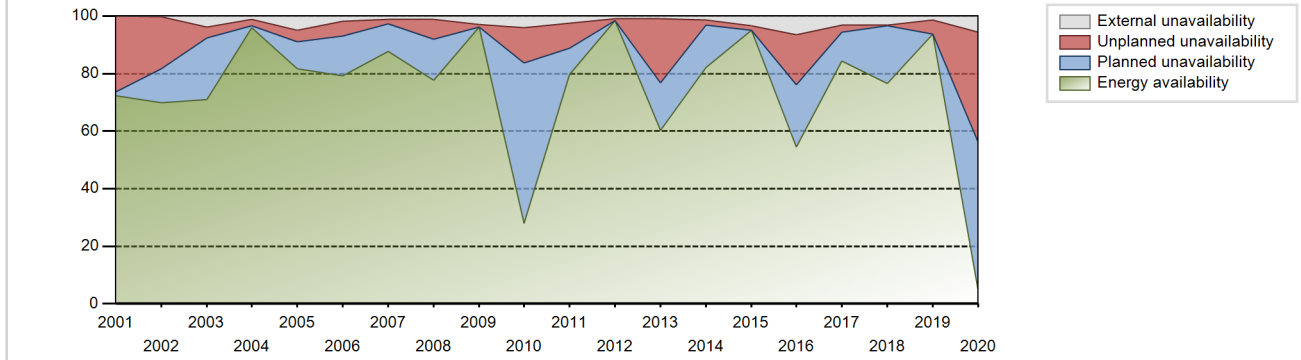


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1979	4379.00	5588	925	53.15	53.15	52.04	60.48	3.85	2.13	44.72	0.00
1980	4460.00	5271	920	55.71	55.71	55.19	60.01	21.66	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

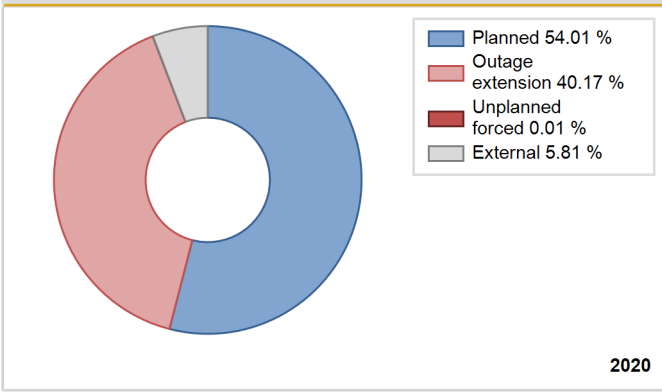
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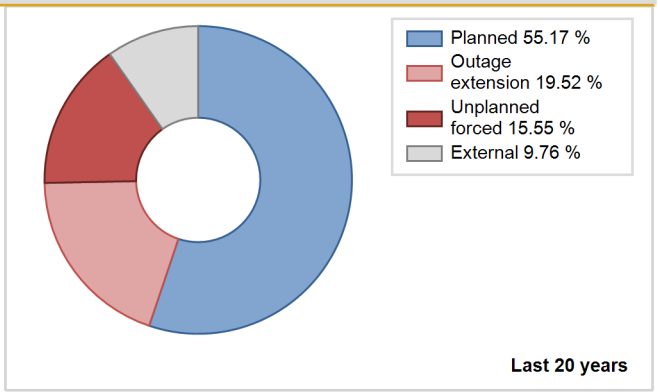
2016	4345.61	5400	910	54.40	60.80	54.36	61.48	3.78	17.55	21.65	6.39
2017	6690.06	7569	910	84.40	87.66	83.92	86.40	2.60	2.34	10.00	3.25
2018	6115.35	6916	910	76.59	79.71	76.71	78.95	0.09	0.19	20.10	3.12
2019	7443.41	8383	910	93.64	95.04	93.37	95.70	4.95	4.95	0.01	1.39
2020	351.50	412	910	4.40	9.96	4.40	4.69	0.13	38.41	51.63	5.55

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1979 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					515	
C. Inspection, maintenance or repair combined with refuelling				1177	32	
D. Inspection, maintenance or repair without refuelling				90		
E. Testing of plant systems or components				9	0	
H. Nuclear regulatory requirements					32	
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	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						5
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.)						31
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						1
Z. Other				2	72	
Subtotal				1278	662	38
Total	**0**			**1978**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1979 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		176
12. Reactor I&C Systems		20
13. Reactor Auxiliary Systems		11
14. Safety Systems		50
15. Reactor Cooling Systems		26
16. Steam generation systems		26
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries		36
32. Feedwater and Main Steam System		23
33. Circulating Water System		1
34. Miscellaneous Systems		92
35. All other I&C Systems		3
41. Main Generator Systems		53
42. Electrical Power Supply Systems		5
Total		**526**

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2020 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	:	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	:	48
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

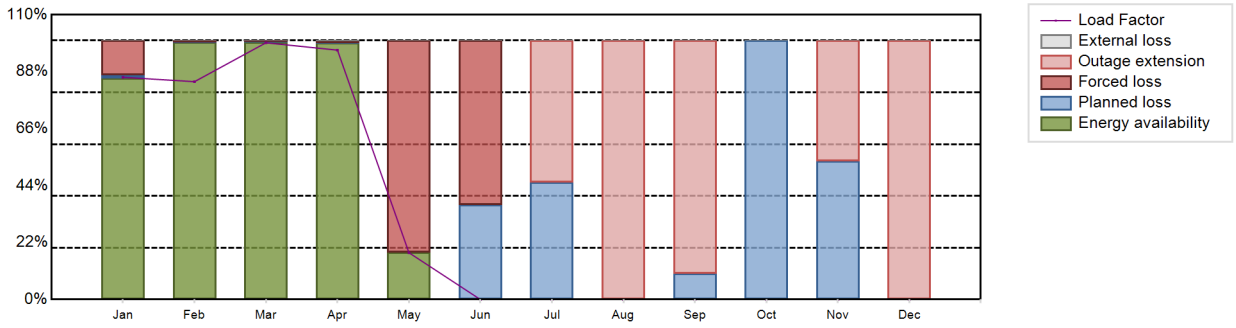
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	2537.87 GW(e).h
Energy Availability Factor (EAF)	:	33.18 %
Unit Capability Factor (UCF)	:	33.18 %
Load Factor (LF)	:	31.75 %
Operating Factor (OF)	:	33.72 %

Forced Loss Rate (FLR)	:	28.8 %
Unplanned Capability Loss Factor (UCL)	:	46.21 %
Planned Unavailability Factor (PUF)	:	20.61 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	5822 hours

Annual Summary



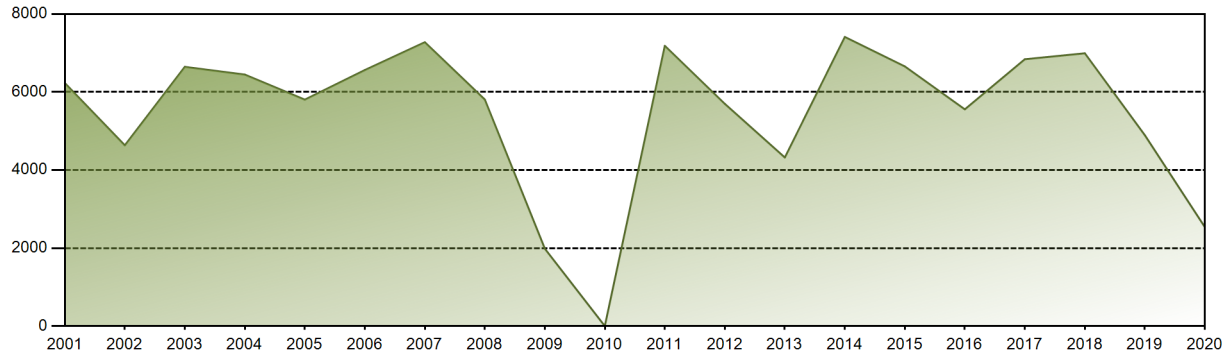
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	581.07	532.88	670.44	631.05	122.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2537.87
EAF [%]	85.51	99.30	99.45	99.12	18.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.18
UCF [%]	85.51	99.30	99.45	99.12	18.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.18
LF [%]	85.82	84.13	99.16	96.31	18.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.75
OF [%]	86.42	100.00	100.00	100.00	21.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.72
FLR [%]	13.42	0.69	0.51	0.87	81.90	100.00	0.00	0.00	0.00	0.00	0.00	0.00	28.80
UCL [%]	13.26	0.69	0.51	0.87	81.90	63.33	54.84	100.00	90.00	0.00	46.67	100.00	46.21
PUF [%]	1.23	0.01	0.04	0.01	0.00	36.67	45.16	0.00	10.00	100.00	53.33	0.00	20.61
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

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Historical Summary

Lifetime energy generation	:	222466.34 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.79 %
Cumulative Energy Availability Factor (EAF)	:	70.65 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.98 %
Cumulative Unit Capability Factor (UCF)	:	73.18 %	Cumulative Planned Unavailability Factor (PUF)	:	14.84 %
Cumulative Load Factor (LF)	:	66.24 %	Cumulative Externally cause unavailability (XUF)	:	2.53 %
Cumulative Operating Factor (OF)	:	71.86 %			

Electricity Production (net) [GWh]

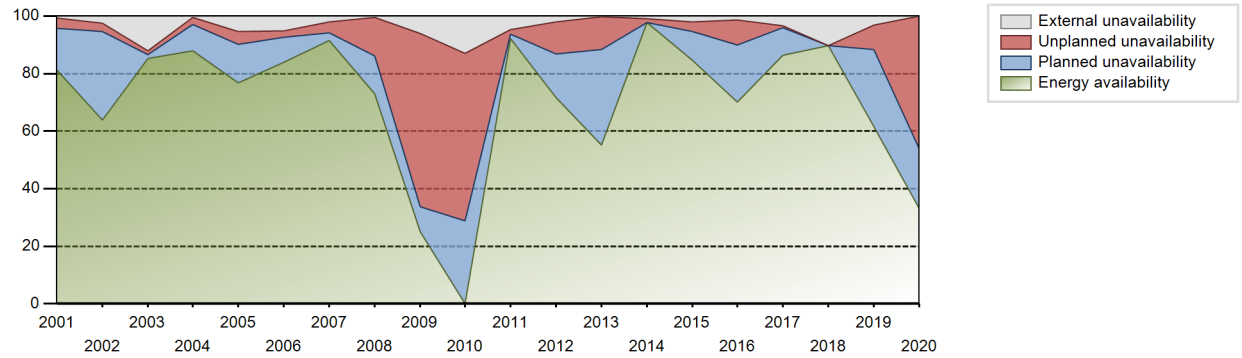


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1979	3504.00	4389	925	39.87	39.87	40.39	45.04	0.00	0.00	60.13	0.00
1980	5960.00	6951	920	74.66	74.66	73.75	79.13	12.90	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

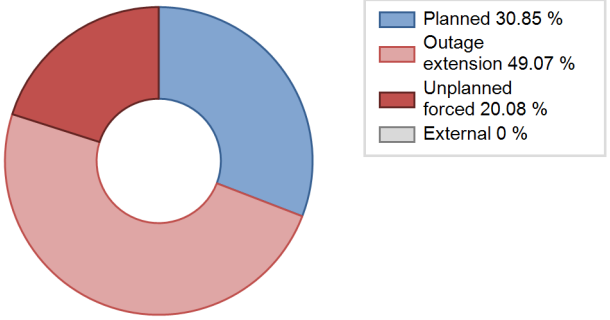
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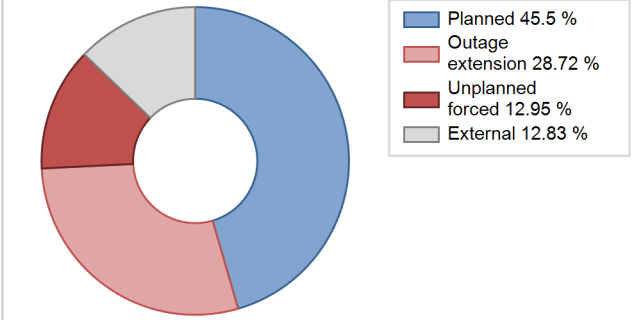
2016	5556.90	6516	910	70.15	71.51	69.52	74.18	6.77	8.61	19.88	1.36
2017	6840.57	7744	910	86.28	89.66	85.81	88.40	0.80	0.72	9.62	3.38
2018	6993.15	8196	910	89.68	99.94	87.73	93.56	0.05	0.05	0.01	10.26
2019	4893.90	5806	910	61.73	64.80	61.39	66.28	10.14	8.55	26.64	3.07
2020	2537.87	2962	910	33.18	33.18	31.75	33.72	28.80	46.21	20.61	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1979 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					705	
C. Inspection, maintenance or repair combined with refuelling				1055	31	
D. Inspection, maintenance or repair without refuelling				55		
E. Testing of plant systems or components				35	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)						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.)						29
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.)					19	99
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						1
Z. Other					12	
Subtotal				1147	781	141
Total		**0**			**2069**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1979 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		158
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		13
14. Safety Systems		16
15. Reactor Cooling Systems		32
16. Steam generation systems		257
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		44
32. Feedwater and Main Steam System		20
33. Circulating Water System		1
34. Miscellaneous Systems		53
35. All other I&C Systems		0
41. Main Generator Systems		85
42. Electrical Power Supply Systems		13
Total		**704**

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2020 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

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	:	1974-06-01
Grid Date	:	1979-03-08
Commercial Date	:	1979-07-01
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	:	48
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

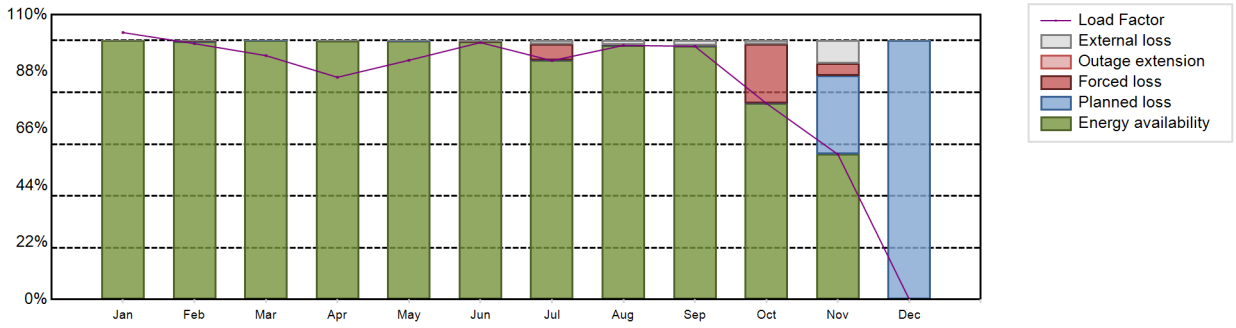
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6391.78 GW(e).h
Energy Availability Factor (EAF)	:	84.8 %
Unit Capability Factor (UCF)	:	86.1 %
Load Factor (LF)	:	82.69 %
Operating Factor (OF)	:	86.45 %

Forced Loss Rate (FLR)	:	3.3 %
Unplanned Capability Loss Factor (UCL)	:	2.94 %
Planned Unavailability Factor (PUF)	:	10.96 %
Externally cause unavailability (XUF)	:	1.3 %
Total off-line time	:	1190 hours

Annual Summary



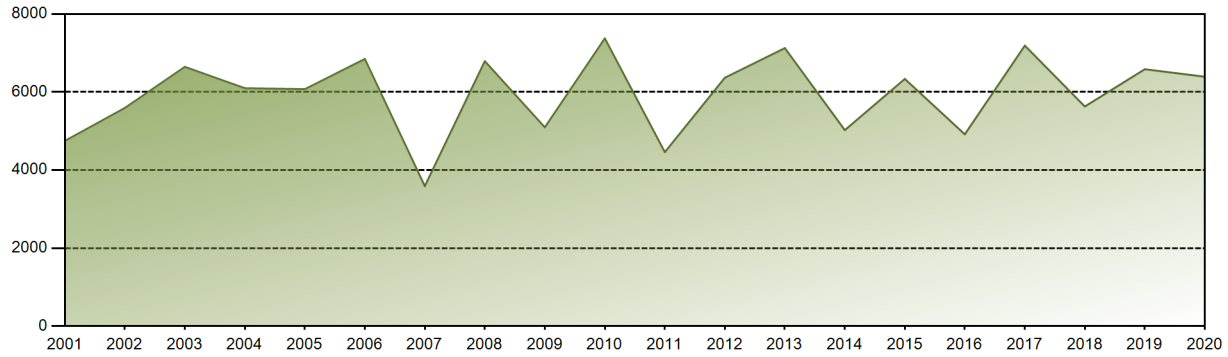
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	675.04	605.30	615.89	543.76	604.98	628.79	604.00	642.51	619.59	496.70	355.22	0.00	6391.78
EAF [%]	100.00	99.58	100.00	99.78	99.89	99.49	92.32	98.20	97.91	75.80	56.12	0.00	84.80
UCF [%]	100.00	99.77	100.00	99.78	99.99	99.91	93.58	99.70	99.88	77.18	64.99	0.00	86.10
LF [%]	103.10	98.83	94.20	85.82	92.40	99.24	92.25	98.13	97.79	75.76	56.06	0.00	82.69
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	94.09	100.00	100.00	77.85	67.08	0.00	86.45
FLR [%]	0.00	0.20	0.00	0.22	0.00	0.08	6.41	0.29	0.11	22.81	6.79	0.00	3.30
UCL [%]	0.00	0.20	0.00	0.22	0.00	0.08	6.40	0.29	0.11	22.81	4.74	0.00	2.94
PUF [%]	0.00	0.03	0.00	0.00	0.01	0.01	0.02	0.01	0.01	0.01	30.27	100.00	10.96
XUF [%]	0.00	0.18	0.00	0.01	0.10	0.42	1.26	1.51	1.97	1.38	8.86	0.00	1.30

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Historical Summary

Lifetime energy generation	:	228177.72 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	8.01 %
Cumulative Energy Availability Factor (EAF)	:	74.89 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.13 %
Cumulative Unit Capability Factor (UCF)	:	76.93 %	Cumulative Planned Unavailability Factor (PUF)	:	14.94 %
Cumulative Load Factor (LF)	:	70.55 %	Cumulative Externally cause unavailability (XUF)	:	2.04 %
Cumulative Operating Factor (OF)	:	76.33 %			

Electricity Production (net) [GWh]

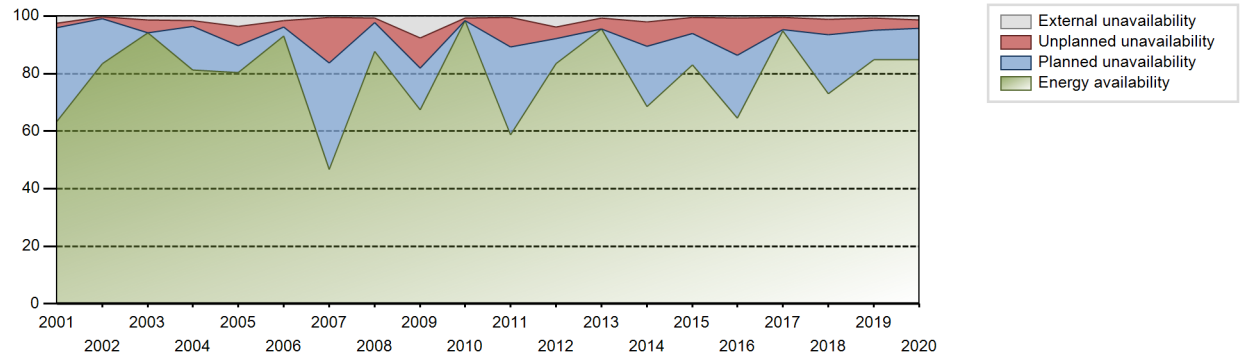


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1979	3528.00	5030	900	64.64	64.64	58.45	64.63	7.03	4.89	30.47	0.00
1980	5063.00	5983	900	65.84	65.84	64.04	68.11	7.76	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

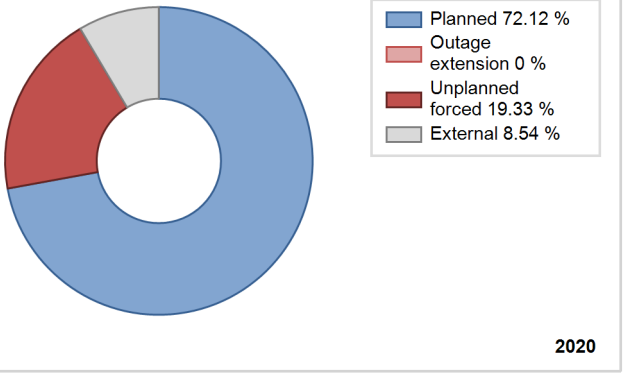
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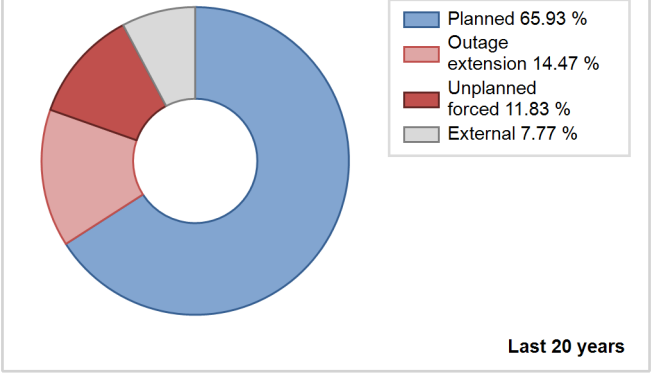
2016	4915.52	5739	880	64.52	65.19	63.59	65.33	0.11	12.89	21.92	0.67
2017	7189.64	8420	880	94.74	95.20	93.27	96.12	0.49	4.19	0.61	0.46
2018	5628.66	6625	880	73.06	74.24	73.02	75.63	5.71	5.27	20.48	1.19
2019	6584.52	7618	880	84.80	85.47	85.42	86.96	3.25	4.26	10.27	0.67
2020	6391.78	7594	880	84.80	86.10	82.69	86.45	3.30	2.94	10.96	1.30

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1979 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					546	
C. Inspection, maintenance or repair combined with refuelling				1116	16	
D. Inspection, maintenance or repair without refuelling				76		
E. Testing of plant systems or components				10	0	
H. Nuclear regulatory requirements					27	
L. Human factor related					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.)						42
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						6
Z. Other					15	
Subtotal				1202	614	48
Total		**0**			**1864**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1979 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		198
12. Reactor I&C Systems		23
13. Reactor Auxiliary Systems		3
14. Safety Systems		19
15. Reactor Cooling Systems		18
16. Steam generation systems		70
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		44
32. Feedwater and Main Steam System		14
33. Circulating Water System		3
34. Miscellaneous Systems		42
35. All other I&C Systems		4
41. Main Generator Systems		29
42. Electrical Power Supply Systems		99
Total		**567**

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2020 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	:	41 years

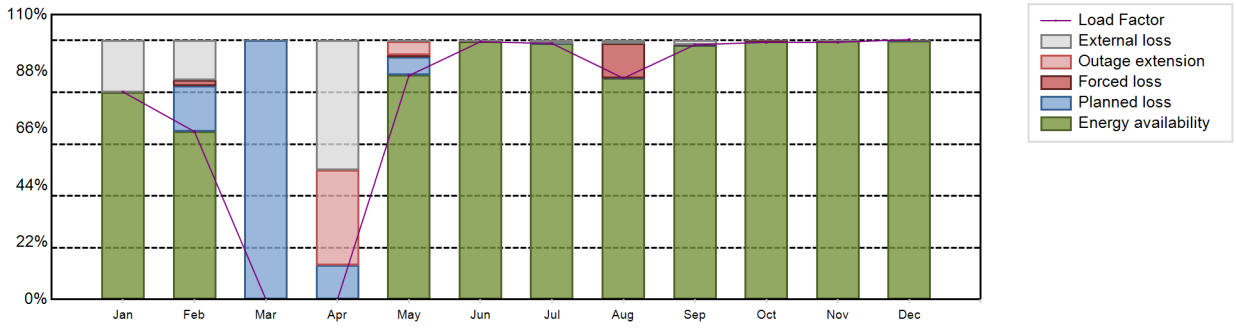
Design Characteristics

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	:	48	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 (2020)

Net Energy Production	:	5887.45 GW(e).h	Forced Loss Rate (FLR)	:	1.68 %
Energy Availability Factor (EAF)	:	76.2 %	Unplanned Capability Loss Factor (UCL)	:	4.88 %
Unit Capability Factor (UCF)	:	83.59 %	Planned Unavailability Factor (PUF)	:	11.53 %
Load Factor (LF)	:	76.16 %	Externally cause unavailability (XUF)	:	7.39 %
Operating Factor (OF)	:	78.56 %	Total off-line time	:	1883 hours

Annual Summary



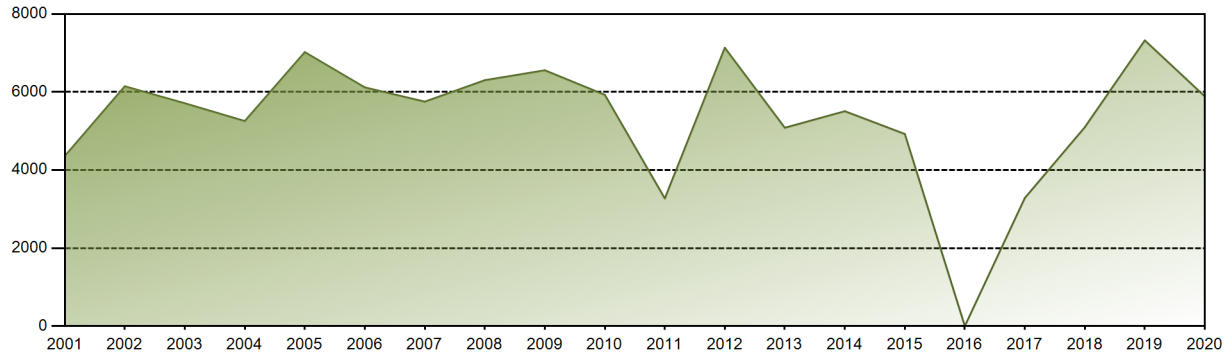
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	524.86	397.18	0.00	0.00	566.11	630.80	647.28	559.57	623.41	651.32	629.55	657.36	5887.45
EAF [%]	80.02	64.91	0.01	0.01	86.76	99.53	98.86	85.49	98.23	99.74	99.77	99.97	76.20
UCF [%]	100.00	80.24	0.01	50.01	87.06	99.96	99.99	86.66	99.79	99.74	99.80	99.97	83.59
LF [%]	80.17	64.85	0.00	0.00	86.47	99.56	98.86	85.47	98.39	99.35	99.36	100.40	76.16
OF [%]	81.59	78.88	0.00	0.00	94.76	100.00	100.00	87.10	100.00	99.87	100.00	100.00	78.56
FLR [%]	0.00	2.72	0.00	0.00	0.93	0.02	0.00	13.34	0.19	0.26	0.18	0.03	1.68
UCL [%]	0.00	2.24	0.00	36.66	6.03	0.02	0.00	13.34	0.19	0.26	0.18	0.03	4.88
PUF [%]	0.00	17.52	99.99	13.34	6.91	0.02	0.01	0.00	0.01	0.00	0.02	0.00	11.53
XUF [%]	19.98	15.32	0.00	50.00	0.29	0.43	1.13	1.17	1.56	0.00	0.04	0.00	7.39

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Historical Summary

Lifetime energy generation	:	218279.85 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.39 %
Cumulative Energy Availability Factor (EAF)	:	72.87 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	10.16 %
Cumulative Unit Capability Factor (UCF)	:	75.21 %	Cumulative Planned Unavailability Factor (PUF)	:	14.63 %
Cumulative Load Factor (LF)	:	68.31 %	Cumulative Externally cause unavailability (XUF)	:	2.34 %
Cumulative Operating Factor (OF)	:	74.49 %			

Electricity Production (net) [GWh]

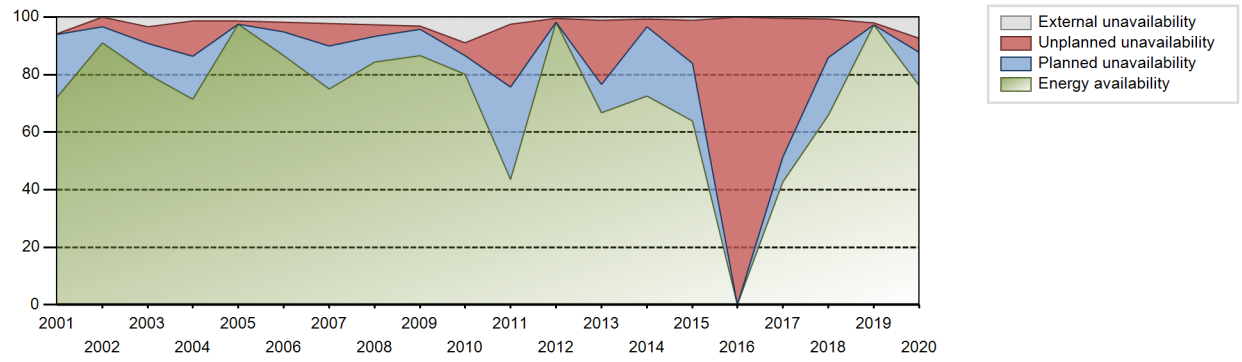


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	6589.00	8050	900	84.50	84.50	83.35	91.64	5.14	4.58	10.92	0.00
1981	4869.30	6061	900	62.75	62.75	61.76	69.19	15.79	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

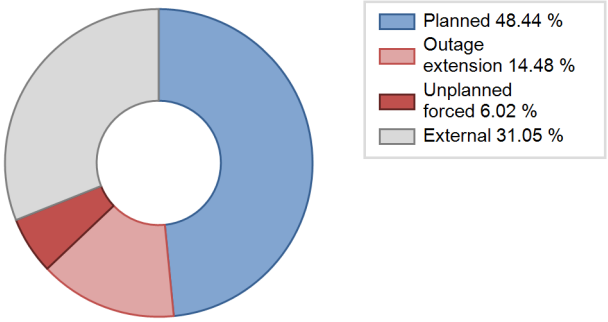
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2017	3282.27	3887	880	42.74	43.19	42.58	44.37	0.44	48.14	8.67	0.45
2018	5098.42	5902	880	65.87	66.62	66.14	67.37	9.11	13.37	20.02	0.75
2019	7323.23	8655	880	97.31	99.34	95.00	98.80	0.63	0.63	0.04	2.03
2020	5887.45	6901	880	76.20	83.59	76.16	78.56	1.68	4.88	11.53	7.39

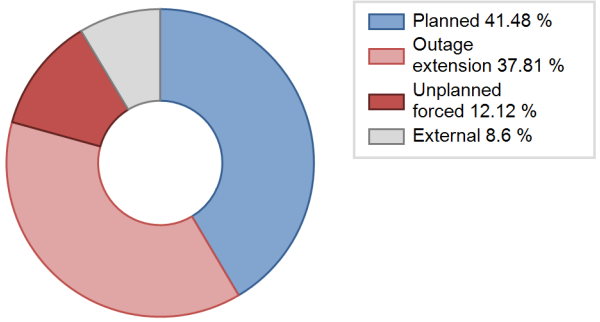
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					390	
C. Inspection, maintenance or repair combined with refuelling				1169	9	
D. Inspection, maintenance or repair without refuelling				22		
E. Testing of plant systems or components				8	2	
H. Nuclear regulatory requirements					339	
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					14	0
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						6
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.)					8	18
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						6
Z. Other					41	10
Subtotal				1199	803	53
Total		**0**			**2055**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		18
12. Reactor I&C Systems		46
13. Reactor Auxiliary Systems		11
14. Safety Systems		8
15. Reactor Cooling Systems		21
16. Steam generation systems		443
17. Safety I&C Systems (excluding reactor I&C)		2
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		78
32. Feedwater and Main Steam System		6
33. Circulating Water System		2
34. Miscellaneous Systems		45
41. Main Generator Systems		47
42. Electrical Power Supply Systems		7
Total		**735**

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2020 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	:	34 years

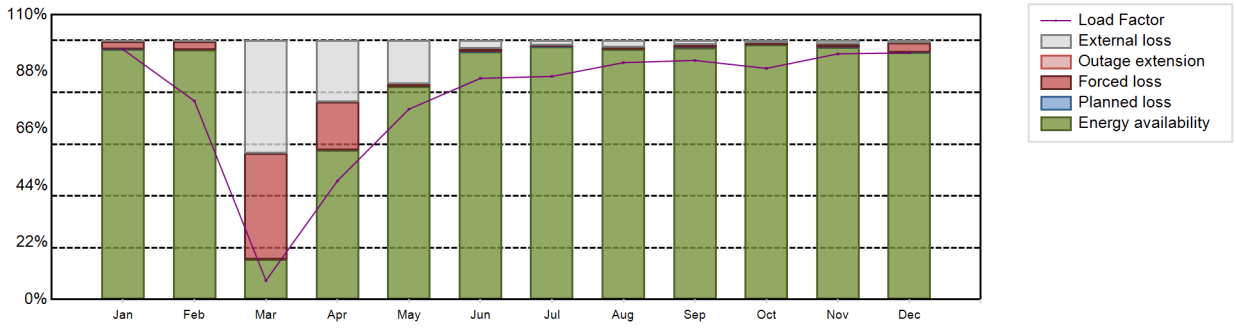
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	8894.78 GW(e).h
Energy Availability Factor (EAF)	:	85.48 %
Unit Capability Factor (UCF)	:	93.64 %
Load Factor (LF)	:	77.89 %
Operating Factor (OF)	:	89.05 %
Forced Loss Rate (FLR)	:	6.33 %
Unplanned Capability Loss Factor (UCL)	:	6.33 %
Planned Unavailability Factor (PUF)	:	0.03 %
Externally cause unavailability (XUF)	:	8.16 %
Total off-line time	:	962 hours

Annual Summary



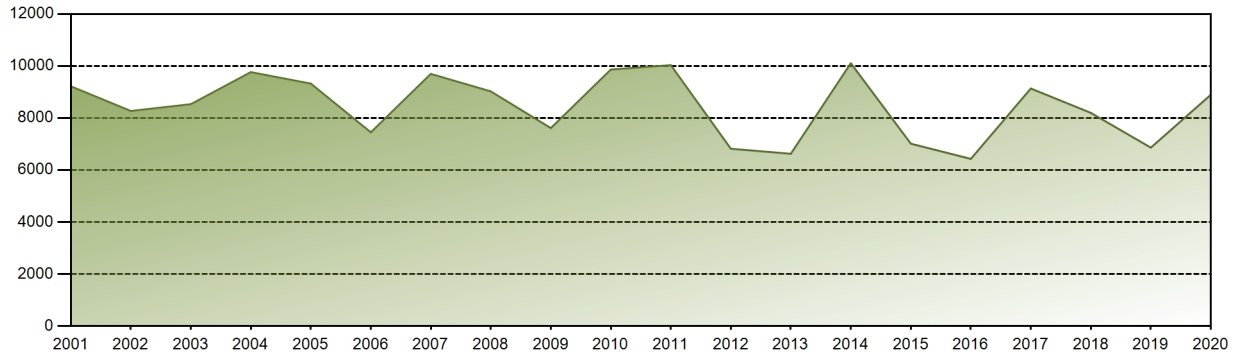
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	934.28	693.72	70.63	428.85	711.04	799.64	833.41	884.85	864.30	864.47	888.09	921.50	8894.78
EAF [%]	96.66	96.40	15.40	57.72	82.25	95.70	97.51	96.62	97.18	98.45	97.35	95.32	85.48
UCF [%]	97.02	96.74	59.05	81.39	99.07	98.88	99.34	99.23	98.87	99.24	98.77	96.32	93.64
LF [%]	96.60	76.67	7.31	45.82	73.52	85.43	86.17	91.49	92.34	89.26	94.88	95.27	77.89
OF [%]	99.73	100.00	15.48	71.25	86.83	100.00	96.51	100.00	100.00	99.87	100.00	100.00	89.05
FLR [%]	2.96	3.26	40.95	18.61	0.93	1.09	0.60	0.77	0.97	0.76	1.20	3.63	6.33
UCL [%]	2.96	3.26	40.95	18.61	0.93	1.09	0.60	0.77	0.97	0.76	1.20	3.63	6.33
PUF [%]	0.02	0.00	0.00	0.00	0.00	0.03	0.05	0.00	0.16	0.00	0.03	0.05	0.03
XUF [%]	0.36	0.34	43.65	23.66	16.83	3.19	1.83	2.61	1.69	0.79	1.43	1.00	8.16

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Historical Summary

Lifetime energy generation	:	269615.3 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	11.99 %
Cumulative Energy Availability Factor (EAF)	:	73.32 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.88 %
Cumulative Unit Capability Factor (UCF)	:	75.09 %	Cumulative Planned Unavailability Factor (PUF)	:	13.03 %
Cumulative Load Factor (LF)	:	69.7 %	Cumulative Externally cause unavailability (XUF)	:	1.78 %
Cumulative Operating Factor (OF)	:	76.41 %			

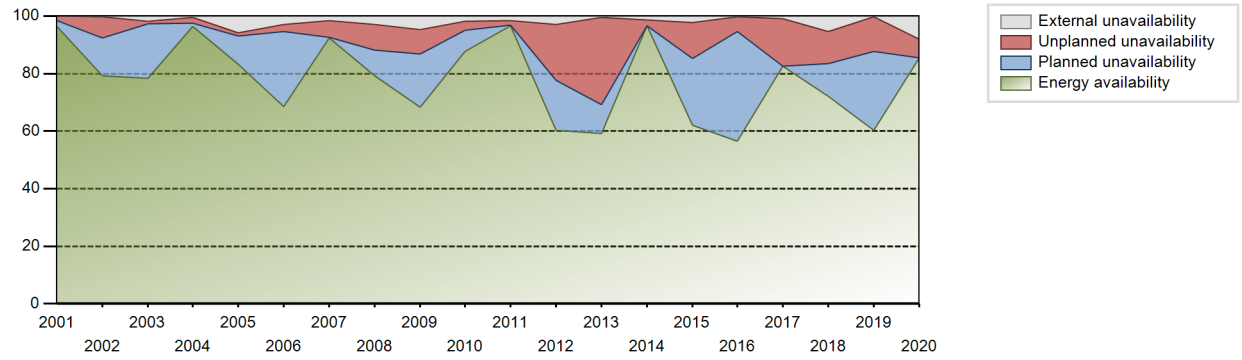
Electricity Production (net) [GWh]



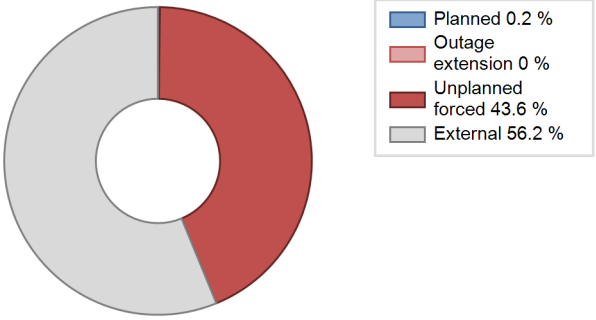
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	7429.80	6393	1265	68.80	69.47	65.53	68.38	30.53	30.53	0.00	0.67
1988	5283.00	4369	1300	47.40	47.80	46.26	49.74	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	7822	1300	85.48	93.64	77.89	89.05	6.33	6.33	0.03	8.16

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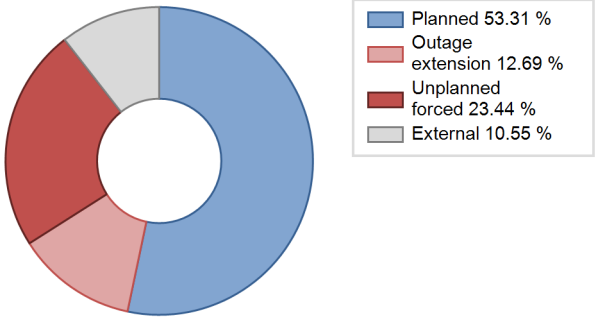
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					819	
B.	Refuelling without maintenance				85		
C.	Inspection, maintenance or repair combined with refuelling				929	10	
D.	Inspection, maintenance or repair without refuelling				36	6	
E.	Testing of plant systems or components				45		
H.	Nuclear regulatory requirements					6	
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					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.)					0	25
Z.	Other					46	
Subtotal					1095	897	31
Total		**0**			**2023**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		24
12. Reactor I&C Systems		57
13. Reactor Auxiliary Systems		33
14. Safety Systems		9
15. Reactor Cooling Systems		60
16. Steam generation systems		30
17. Safety I&C Systems (excluding reactor I&C)		7
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		59
32. Feedwater and Main Steam System		60
33. Circulating Water System		18
34. Miscellaneous Systems		92
35. All other I&C Systems		6
41. Main Generator Systems		253
42. Electrical Power Supply Systems		99
Total		**808**

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2020 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	:	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

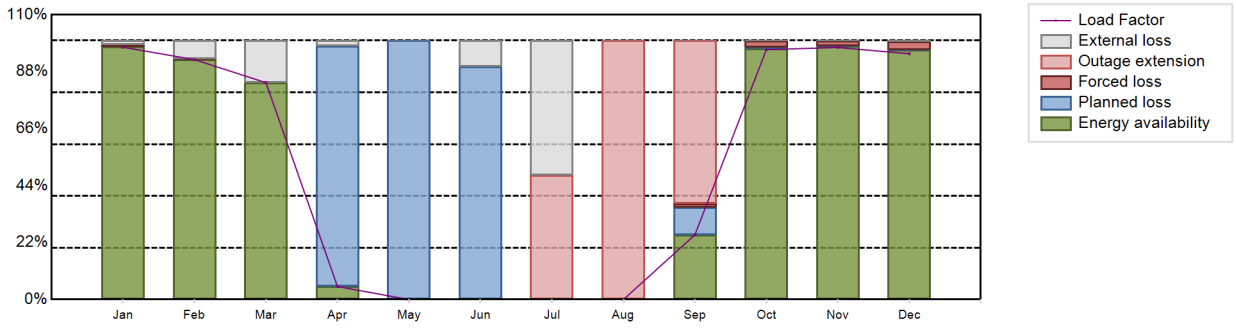
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	328.7
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.1
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.95
Output voltage [kV]	:	-
Primary means of condenser cooling	:	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 (2020)

Net Energy Production	:	5634.04 GW(e).h
Energy Availability Factor (EAF)	:	49.54 %
Unit Capability Factor (UCF)	:	57.06 %
Load Factor (LF)	:	49.34 %
Operating Factor (OF)	:	53.49 %

Forced Loss Rate (FLR)	:	1.48 %
Unplanned Capability Loss Factor (UCL)	:	18.56 %
Planned Unavailability Factor (PUF)	:	24.38 %
Externally cause unavailability (XUF)	:	7.51 %
Total off-line time	:	4085 hours

Annual Summary



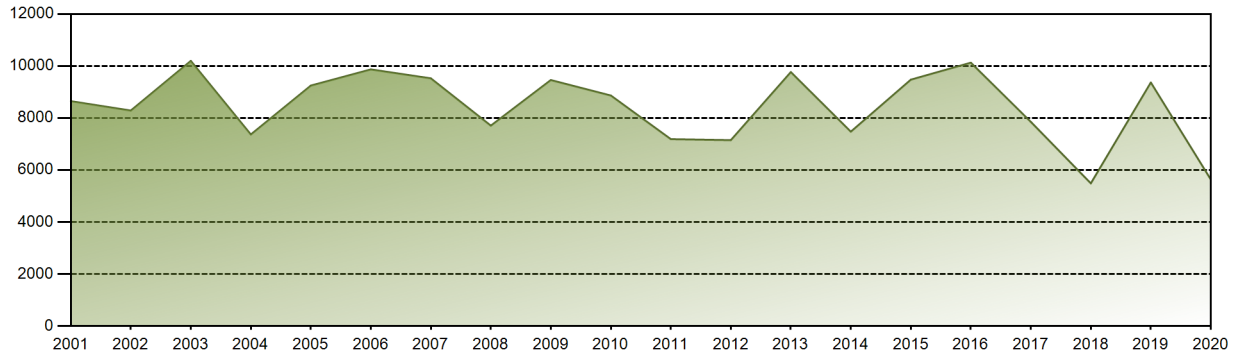
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	942.32	838.38	808.90	47.07	0.00	0.00	0.00	0.00	233.72	934.59	911.13	917.93	5634.04
EAF [%]	97.53	92.66	83.75	5.03	0.00	0.02	0.01	0.00	24.99	96.81	97.83	96.38	49.54
UCF [%]	99.03	99.73	100.00	7.13	0.00	10.00	51.89	0.00	24.99	97.04	97.95	96.82	57.06
LF [%]	97.43	92.66	83.75	5.03	0.00	0.00	0.00	0.00	24.97	96.50	97.34	94.91	49.34
OF [%]	100.00	100.00	100.00	7.22	0.00	0.00	0.00	0.00	35.56	99.87	100.00	100.00	53.49
FLR [%]	0.97	0.27	0.00	0.00	0.00	0.00	0.00	0.00	5.56	2.46	1.95	3.16	1.48
UCL [%]	0.97	0.27	0.00	0.00	0.00	0.00	48.11	100.00	64.38	2.45	1.94	3.16	18.56
PUF [%]	0.00	0.00	0.00	92.87	100.00	90.00	0.00	0.00	10.64	0.51	0.10	0.02	24.38
XUF [%]	1.50	7.07	16.25	2.10	0.00	9.99	51.88	0.00	0.00	0.23	0.13	0.44	7.51

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Historical Summary

Lifetime energy generation	:	272578.94 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.8 %
Cumulative Energy Availability Factor (EAF)	:	76.96 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.52 %
Cumulative Unit Capability Factor (UCF)	:	79.33 %	Cumulative Planned Unavailability Factor (PUF)	:	13.15 %
Cumulative Load Factor (LF)	:	72.19 %	Cumulative Externally cause unavailability (XUF)	:	2.37 %
Cumulative Operating Factor (OF)	:	78.93 %			

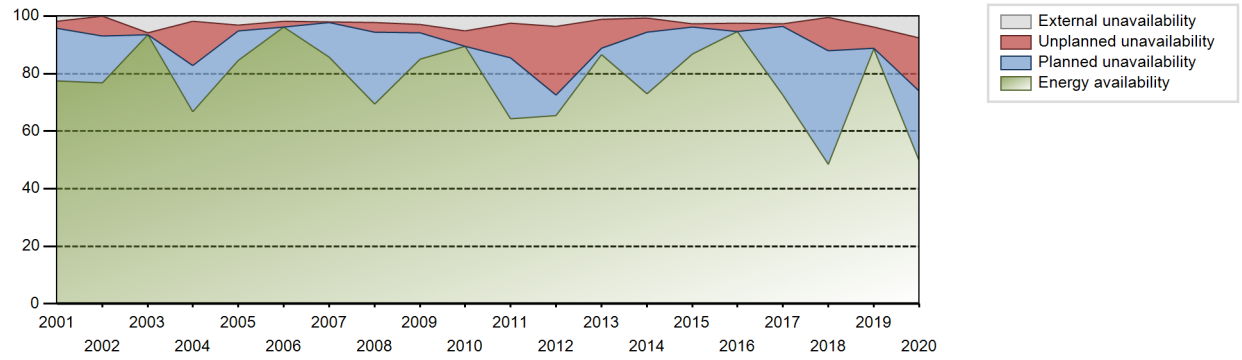
Electricity Production (net) [GWh]



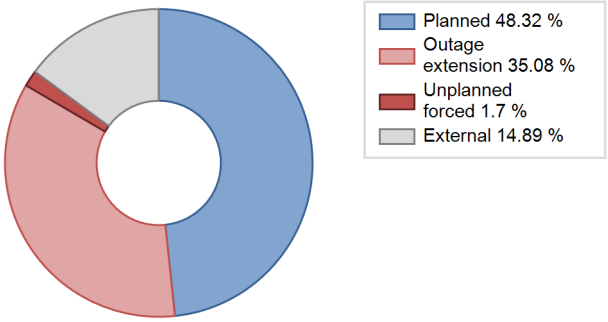
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	8138.00	7156	1300	90.80	91.04	71.35	81.94	5.24	5.03	3.93	0.24
1989	1765.48	1452	1300	15.48	16.51	15.50	16.58	77.27	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	49.54	57.06	49.34	53.49	1.48	18.56	24.38	7.51

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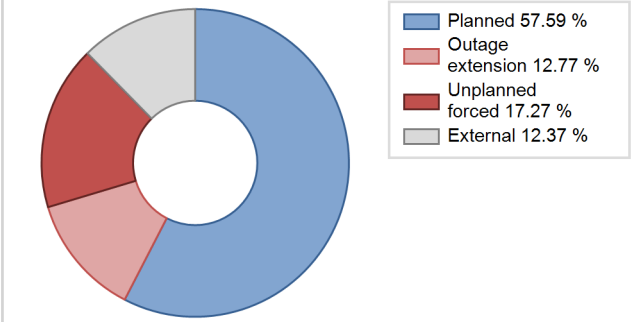
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					466	
B. Refuelling without maintenance				65		
C. Inspection, maintenance or repair combined with refuelling				929	5	
D. Inspection, maintenance or repair without refuelling				41	14	
E. Testing of plant systems or components				37	0	1
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						2
L. Human factor related					23	
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.)						14
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						20
Z. Other					26	20
Subtotal				1072	534	58
Total		**0**			**1664**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1988 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		8
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		4
14. Safety Systems		53
15. Reactor Cooling Systems		124
16. Steam generation systems		59
31. Turbine and auxiliaries		13
32. Feedwater and Main Steam System		13
33. Circulating Water System		1
34. Miscellaneous Systems		104
35. All other I&C Systems		2
41. Main Generator Systems		54
42. Electrical Power Supply Systems		20
Total		**463**

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2020 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

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	:	1982-06-15
Grid Date	:	1990-07-06
Commercial Date	:	1991-02-01
Age at end of year	:	30 years

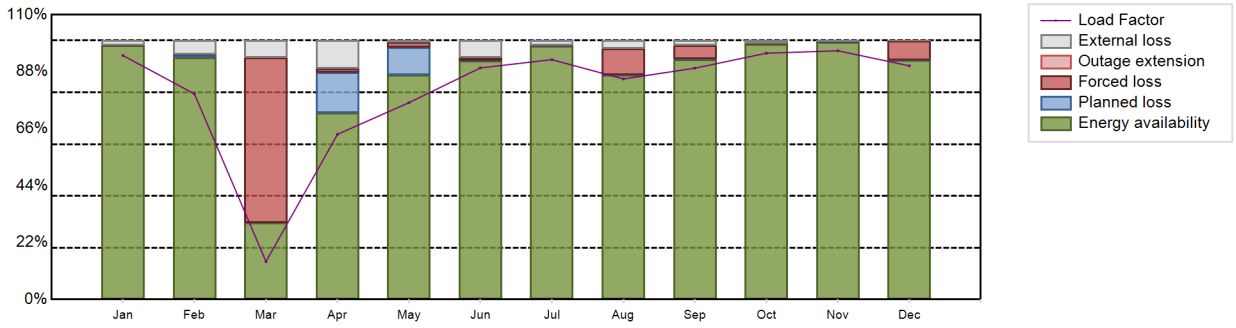
Design Characteristics

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 (2020)

Net Energy Production	:	9190.97 GW(e).h	Forced Loss Rate (FLR)	:	7.95 %
Energy Availability Factor (EAF)	:	86.57 %	Unplanned Capability Loss Factor (UCL)	:	7.76 %
Unit Capability Factor (UCF)	:	89.88 %	Planned Unavailability Factor (PUF)	:	2.35 %
Load Factor (LF)	:	80.49 %	Externally cause unavailability (XUF)	:	3.31 %
Operating Factor (OF)	:	87.8 %	Total off-line time	:	1072 hours

Annual Summary



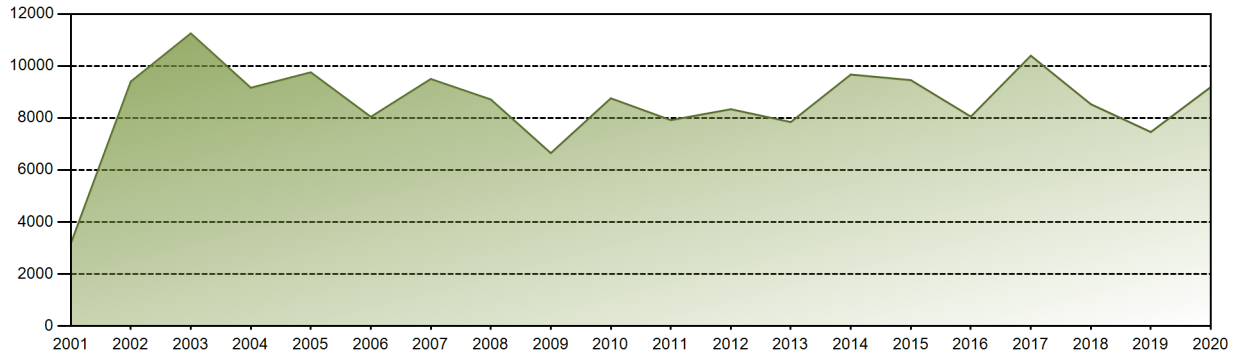
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	911.55	718.33	141.62	597.13	735.35	837.28	896.00	823.92	836.33	921.30	899.18	872.97	9190.97
EAF [%]	98.10	93.38	29.54	72.19	86.67	92.11	97.84	86.61	92.78	98.67	99.32	92.34	86.57
UCF [%]	99.96	98.63	36.02	83.11	87.35	98.59	99.68	89.68	94.59	99.72	99.71	92.58	89.88
LF [%]	94.25	79.39	14.66	63.80	76.03	89.45	92.64	85.19	89.35	95.13	96.07	90.26	80.49
OF [%]	100.00	99.43	16.82	74.17	89.38	96.11	100.00	90.32	95.00	99.87	100.00	93.55	87.80
FLR [%]	0.00	0.02	63.98	1.57	2.08	1.30	0.20	10.20	5.35	0.19	0.26	7.35	7.95
UCL [%]	0.00	0.02	63.98	1.33	1.85	1.30	0.20	10.19	5.35	0.19	0.26	7.34	7.76
PUF [%]	0.03	1.35	0.00	15.56	10.80	0.11	0.12	0.13	0.06	0.09	0.03	0.08	2.35
XUF [%]	1.87	5.25	6.47	10.93	0.67	6.48	1.84	3.07	1.81	1.04	0.39	0.23	3.31

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Historical Summary

Lifetime energy generation	:	257389.34 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.6 %
Cumulative Energy Availability Factor (EAF)	:	79.21 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.75 %
Cumulative Unit Capability Factor (UCF)	:	81.38 %	Cumulative Planned Unavailability Factor (PUF)	:	11.87 %
Cumulative Load Factor (LF)	:	74.9 %	Cumulative Externally cause unavailability (XUF)	:	2.17 %
Cumulative Operating Factor (OF)	:	81.21 %			

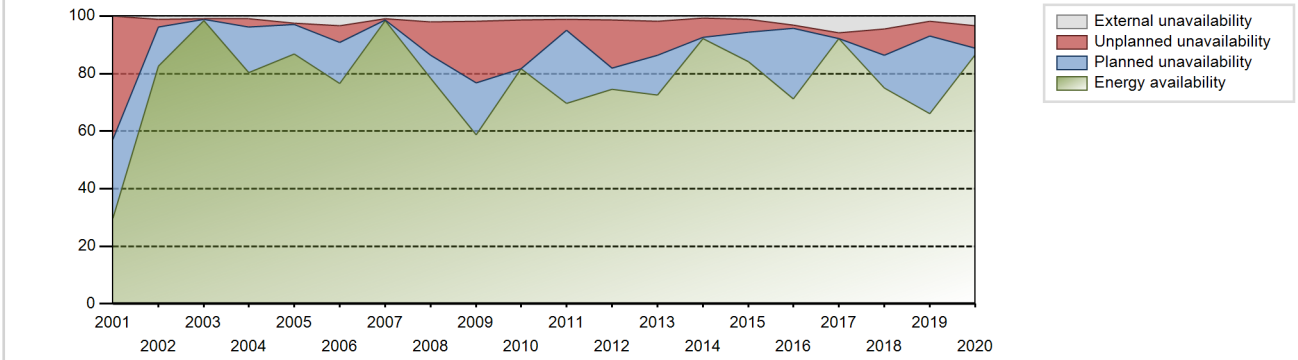
Electricity Production (net) [GWh]



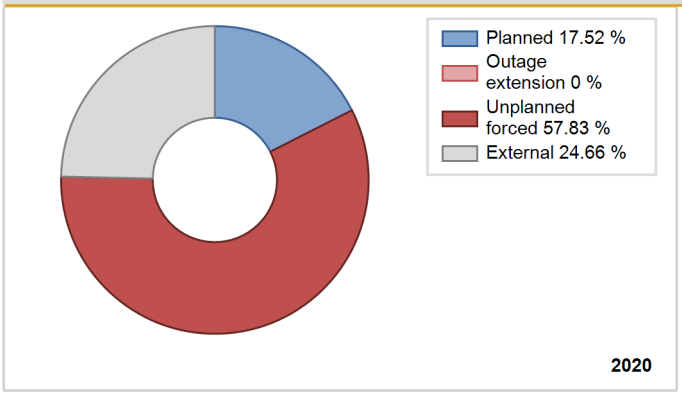
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1991	9683.15	7897	1300	88.20	89.61	85.70	90.51	10.29	10.27	0.12	1.41
1992	7145.04	5903	1300	65.61	67.00	62.57	67.20	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	7712	1300	86.57	89.88	80.49	87.80	7.95	7.76	2.35	3.31

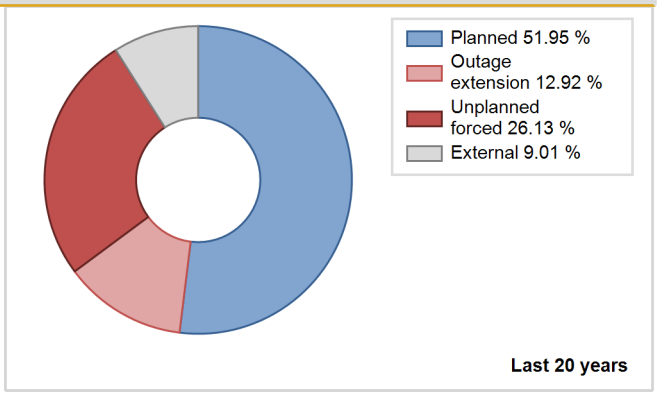
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1991 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					416	
B. Refuelling without maintenance				51		
C. Inspection, maintenance or repair combined with refuelling				905	13	
D. Inspection, maintenance or repair without refuelling				48		
E. Testing of plant systems or components				11		
H. Nuclear regulatory requirements					77	
J. Grid limitation, failure or grid unavailability						13
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						15
L. Human factor related					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.)					1	12
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						8
Z. Other					26	
Subtotal				1015	539	48
Total		**0**			**1602**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1991 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		76
12. Reactor I&C Systems		29
13. Reactor Auxiliary Systems		37
14. Safety Systems		27
15. Reactor Cooling Systems		8
16. Steam generation systems		26
21. Fuel Handling and Storage Facilities		8
31. Turbine and auxiliaries		22
32. Feedwater and Main Steam System		11
34. Miscellaneous Systems		76
41. Main Generator Systems		80
42. Electrical Power Supply Systems		10
Total		**410**

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2020 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	:	29 years

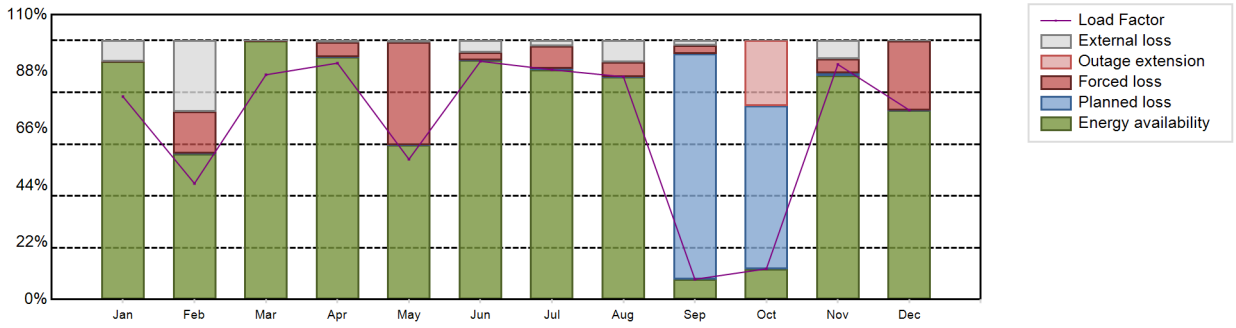
Design Characteristics

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 (2020)

Net Energy Production	:	7676.68 GW(e).h	Forced Loss Rate (FLR)	:	11.22 %
Energy Availability Factor (EAF)	:	70.71 %	Unplanned Capability Loss Factor (UCL)	:	11.7 %
Unit Capability Factor (UCF)	:	75.67 %	Planned Unavailability Factor (PUF)	:	12.63 %
Load Factor (LF)	:	67.23 %	Externally cause unavailability (XUF)	:	4.96 %
Operating Factor (OF)	:	76.2 %	Total off-line time	:	2091 hours

Annual Summary



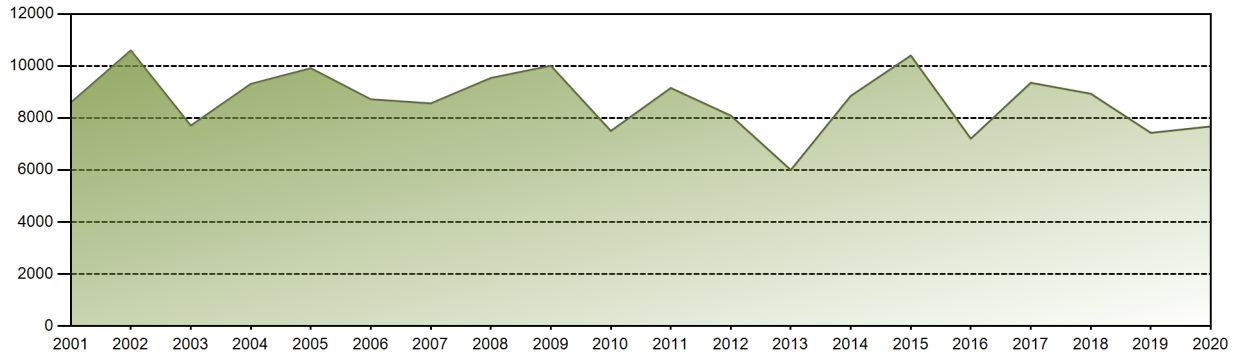
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	757.81	405.43	838.32	854.53	523.91	861.01	858.27	832.08	73.26	114.72	849.86	707.48	7676.68
EAF [%]	91.90	56.29	99.79	93.72	59.62	92.30	88.78	86.03	7.83	11.85	86.39	73.12	70.71
UCF [%]	99.88	83.76	99.83	94.42	60.18	96.92	90.90	94.33	9.66	11.85	93.54	73.21	75.67
LF [%]	78.35	44.81	86.79	91.30	54.17	91.99	88.74	86.03	7.83	11.84	90.80	73.15	67.23
OF [%]	100.00	54.60	100.00	100.00	66.26	94.72	94.49	100.00	13.19	20.00	94.44	75.27	76.20
FLR [%]	0.11	16.21	0.13	5.54	39.76	3.04	8.79	5.64	24.95	0.00	5.42	26.75	11.22
UCL [%]	0.11	16.20	0.13	5.54	39.72	3.04	8.76	5.64	3.21	25.24	5.36	26.73	11.70
PUF [%]	0.01	0.04	0.04	0.04	0.10	0.04	0.34	0.03	87.13	62.90	1.09	0.06	12.63
XUF [%]	7.98	27.47	0.03	0.69	0.56	4.62	2.12	8.30	1.82	0.00	7.16	0.08	4.96

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Historical Summary

Lifetime energy generation	:	254334.28 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.47 %
Cumulative Energy Availability Factor (EAF)	:	81.31 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.28 %
Cumulative Unit Capability Factor (UCF)	:	83.81 %	Cumulative Planned Unavailability Factor (PUF)	:	11.91 %
Cumulative Load Factor (LF)	:	76.33 %	Cumulative Externally cause unavailability (XUF)	:	2.5 %
Cumulative Operating Factor (OF)	:	83.37 %			

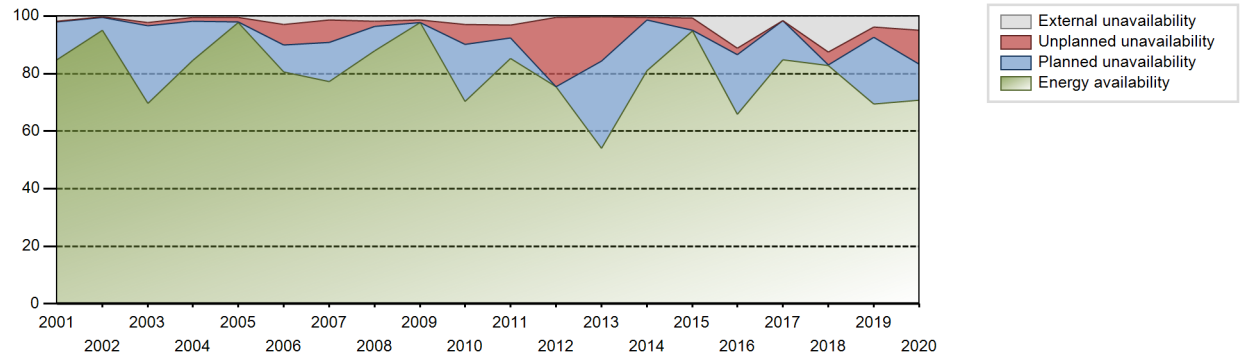
Electricity Production (net) [GWh]



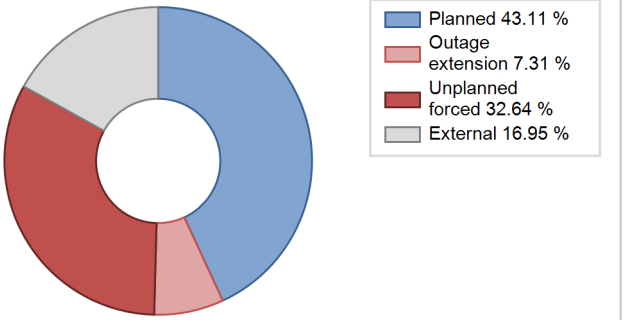
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1992	9355.95	7649	1300	85.83	88.01	81.93	87.08	0.88	0.78	11.21	2.18
1993	7736.44	6251	1300	77.98	79.09	67.94	71.36	6.27	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	6693	1300	70.71	75.67	67.23	76.20	11.22	11.70	12.63	4.96

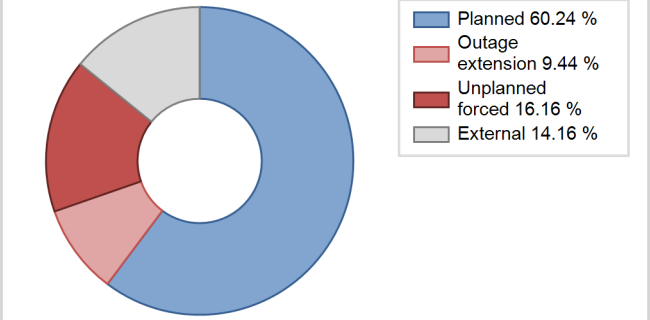
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1992 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					276	1
B.	Refuelling without maintenance				85		
C.	Inspection, maintenance or repair combined with refuelling				836	23	
D.	Inspection, maintenance or repair without refuelling				44		
E.	Testing of plant systems or components				44		
I.	Grid capacity limitation						0
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						23
L.	Human factor related					15	9
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	37
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						36
Z.	Other					7	
Subtotal					1009	323	107
Total			**0**			**1439**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1992 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		10
13. Reactor Auxiliary Systems		9
14. Safety Systems		26
15. Reactor Cooling Systems		10
16. Steam generation systems		37
17. Safety I&C Systems (excluding reactor I&C)		2
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System		13
33. Circulating Water System		2
34. Miscellaneous Systems		32
35. All other I&C Systems		4
41. Main Generator Systems		95
42. Electrical Power Supply Systems		16
Total		**303**

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2020 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	:	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]	:	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

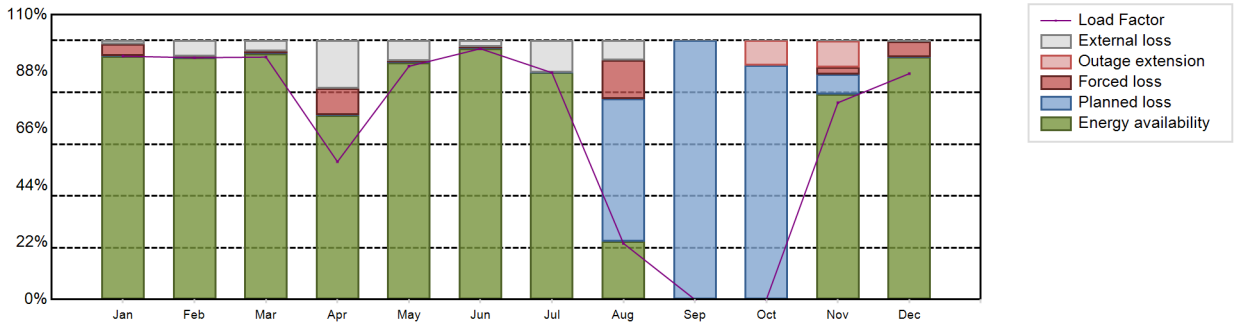
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5253.27 GW(e).h
Energy Availability Factor (EAF)	:	68.67 %
Unit Capability Factor (UCF)	:	73.73 %
Load Factor (LF)	:	66.08 %
Operating Factor (OF)	:	72.04 %

Forced Loss Rate (FLR)	:	4.39 %
Unplanned Capability Loss Factor (UCL)	:	5.02 %
Planned Unavailability Factor (PUF)	:	21.25 %
Externally cause unavailability (XUF)	:	5.06 %
Total off-line time	:	2456 hours

Annual Summary



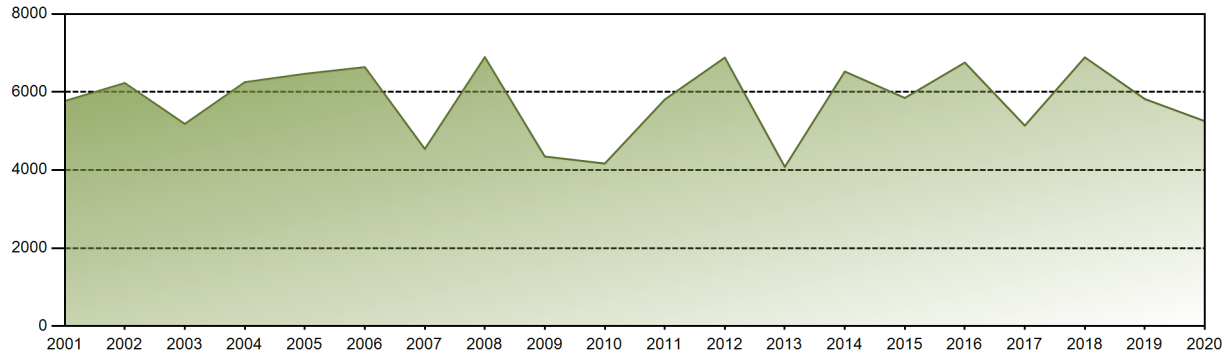
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	632.77	588.23	629.49	346.73	606.40	631.17	589.82	146.01	0.00	0.00	495.23	587.42	5253.27
EAF [%]	93.98	93.45	94.83	71.10	91.49	96.99	87.61	22.51	0.03	0.03	79.37	93.55	68.67
UCF [%]	95.46	99.46	98.94	89.71	99.29	99.47	99.80	30.04	0.03	0.03	79.60	93.86	73.73
LF [%]	93.98	93.39	93.62	53.21	90.06	96.86	87.60	21.69	0.00	0.00	76.00	87.24	66.08
OF [%]	100.00	100.00	96.64	61.39	93.41	100.00	100.00	29.84	0.00	0.00	89.17	94.76	72.04
FLR [%]	4.48	0.49	0.63	10.20	0.61	0.28	0.00	33.26	0.00	0.00	3.30	6.11	4.39
UCL [%]	4.48	0.49	0.62	10.19	0.61	0.28	0.00	14.97	0.00	9.53	12.82	6.10	5.02
PUF [%]	0.06	0.05	0.44	0.10	0.09	0.25	0.20	54.98	99.97	90.44	7.58	0.03	21.25
XUF [%]	1.48	6.01	4.11	18.61	7.81	2.49	12.19	7.54	0.00	0.00	0.23	0.31	5.06

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Historical Summary

Lifetime energy generation	:	216971.62 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.29 %
Cumulative Energy Availability Factor (EAF)	:	76.44 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.27 %
Cumulative Unit Capability Factor (UCF)	:	78.27 %	Cumulative Planned Unavailability Factor (PUF)	:	14.45 %
Cumulative Load Factor (LF)	:	73.12 %	Cumulative Externally cause unavailability (XUF)	:	1.83 %
Cumulative Operating Factor (OF)	:	78.27 %			

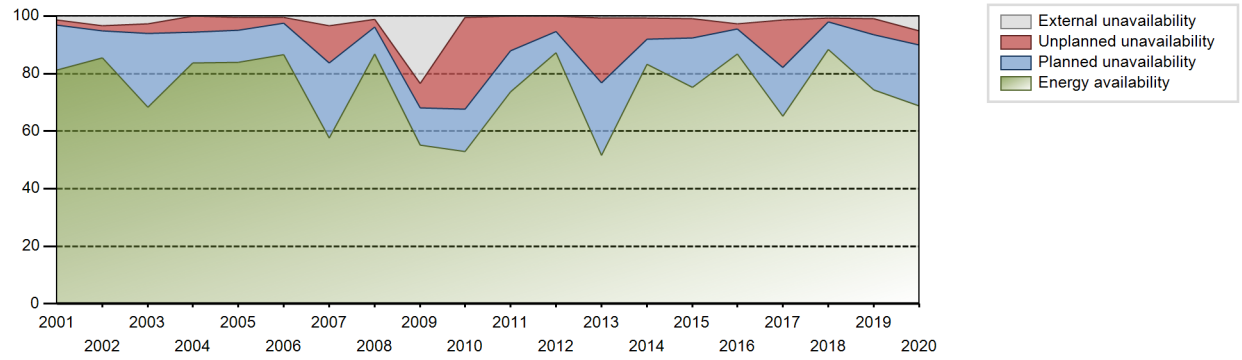
Electricity Production (net) [GWh]



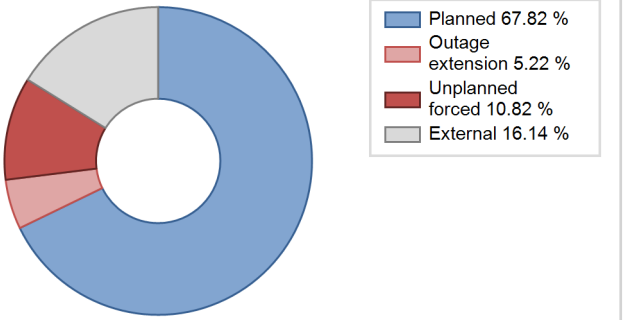
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	4568.00	5570	870	57.57	57.57	56.11	60.14	16.20	11.13	31.30	0.00
1985	5978.20	7402	870	82.12	84.46	78.44	84.50	2.46	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	6328	905	68.67	73.73	66.08	72.04	4.39	5.02	21.25	5.06

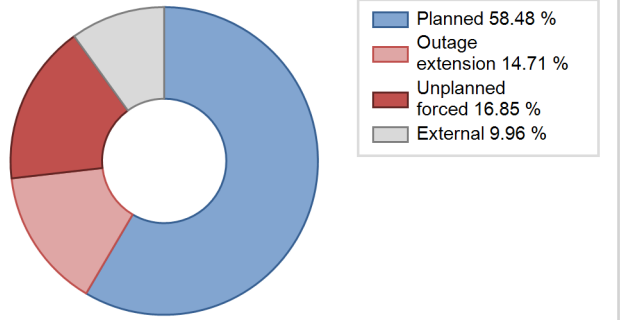
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					498	
B. Refuelling without maintenance				117		
C. Inspection, maintenance or repair combined with refuelling				1029	47	
E. Testing of plant systems or components				6	1	
H. Nuclear regulatory requirements					3	
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					12	
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.)					27	70
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					7	
Z. Other					21	
Subtotal				1152	616	77
Total		**0**			**1845**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		6
12. Reactor I&C Systems		9
13. Reactor Auxiliary Systems		27
14. Safety Systems		10
15. Reactor Cooling Systems		27
16. Steam generation systems		14
17. Safety I&C Systems (excluding reactor I&C)		2
21. Fuel Handling and Storage Facilities		13
31. Turbine and auxiliaries		125
32. Feedwater and Main Steam System		18
33. Circulating Water System		2
34. Miscellaneous Systems		96
35. All other I&C Systems		2
41. Main Generator Systems		108
42. Electrical Power Supply Systems		30
Total		**489**

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2020 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	:	37 years

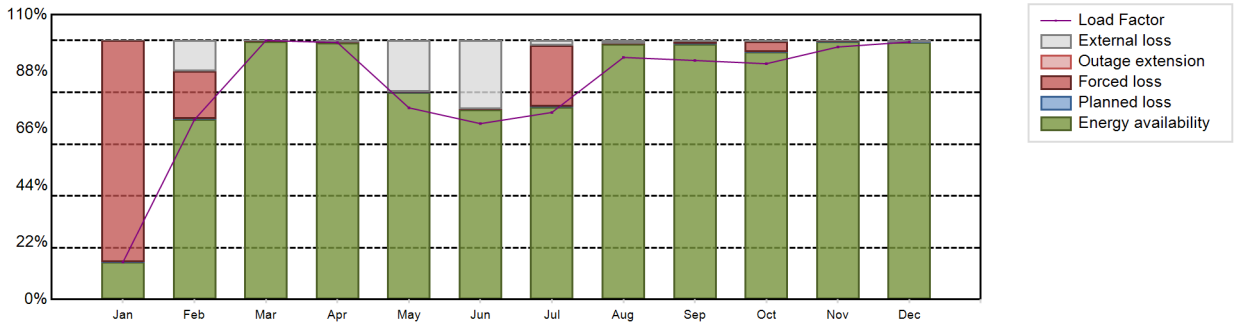
Design Characteristics

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 (2020)

Net Energy Production	:	6431.85 GW(e).h	Forced Loss Rate (FLR)	:	11.16 %
Energy Availability Factor (EAF)	:	83.51 %	Unplanned Capability Loss Factor (UCL)	:	11.15 %
Unit Capability Factor (UCF)	:	88.7 %	Planned Unavailability Factor (PUF)	:	0.15 %
Load Factor (LF)	:	80.91 %	Externally cause unavailability (XUF)	:	5.19 %
Operating Factor (OF)	:	84.84 %	Total off-line time	:	1332 hours

Annual Summary



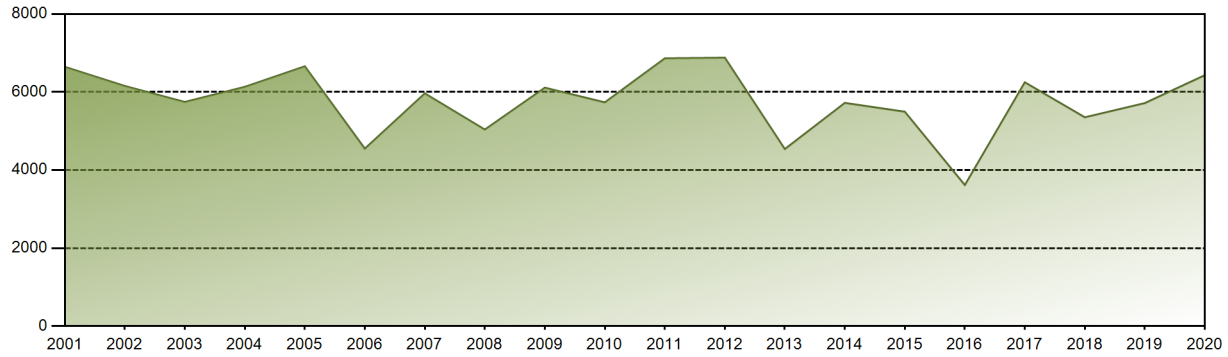
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	97.28	437.52	672.69	646.57	498.47	442.63	486.49	629.47	601.49	614.00	635.49	669.74	6431.85
EAF [%]	14.49	69.66	99.69	99.21	80.04	73.28	74.40	98.56	98.68	95.52	99.51	99.37	83.51
UCF [%]	14.49	81.35	99.75	99.79	99.72	99.70	76.32	99.57	99.09	95.88	99.77	99.92	88.70
LF [%]	14.45	69.46	100.04	99.23	74.03	67.93	72.25	93.49	92.31	91.07	97.53	99.47	80.91
OF [%]	16.80	70.40	100.00	100.00	80.11	74.86	81.99	100.00	100.00	94.09	100.00	100.00	84.84
FLR [%]	85.50	18.54	0.06	0.07	0.21	0.14	23.60	0.11	0.80	3.89	0.07	0.00	11.16
UCL [%]	85.40	18.52	0.06	0.07	0.21	0.14	23.58	0.11	0.80	3.89	0.07	0.00	11.15
PUF [%]	0.12	0.13	0.19	0.14	0.07	0.15	0.10	0.32	0.11	0.24	0.16	0.08	0.15
XUF [%]	0.00	11.69	0.06	0.58	19.67	26.42	1.92	1.01	0.41	0.35	0.26	0.55	5.19

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Historical Summary

Lifetime energy generation	:	211059.72 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.64 %
Cumulative Energy Availability Factor (EAF)	:	76.72 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.18 %
Cumulative Unit Capability Factor (UCF)	:	78.67 %	Cumulative Planned Unavailability Factor (PUF)	:	13.15 %
Cumulative Load Factor (LF)	:	72.8 %	Cumulative Externally cause unavailability (XUF)	:	1.95 %
Cumulative Operating Factor (OF)	:	77.93 %			

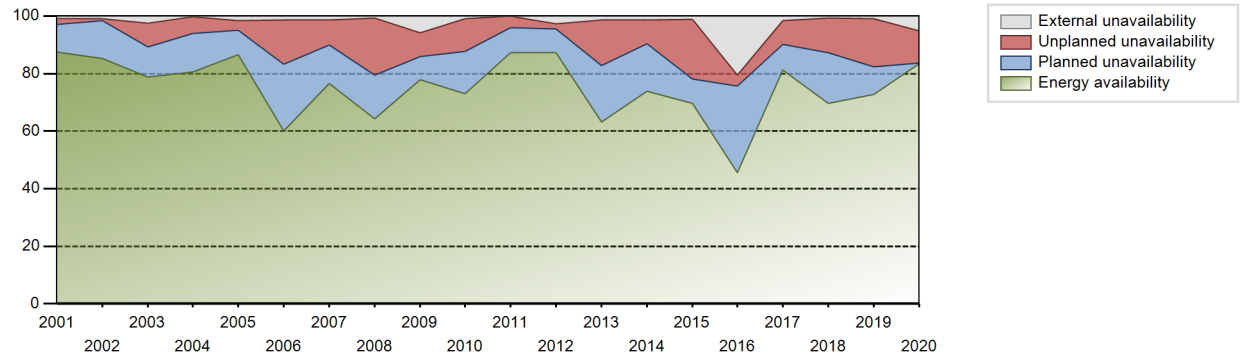
Electricity Production (net) [GWh]



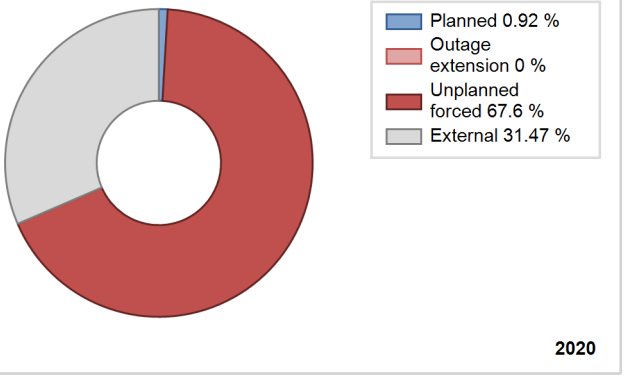
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	5394.00	7226	870	91.69	91.69	75.83	81.27	8.31	8.31	0.00	0.00
1985	5037.40	6201	870	67.88	69.30	66.10	70.79	4.44	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	88.70	80.91	84.84	11.16	11.15	0.15	5.19

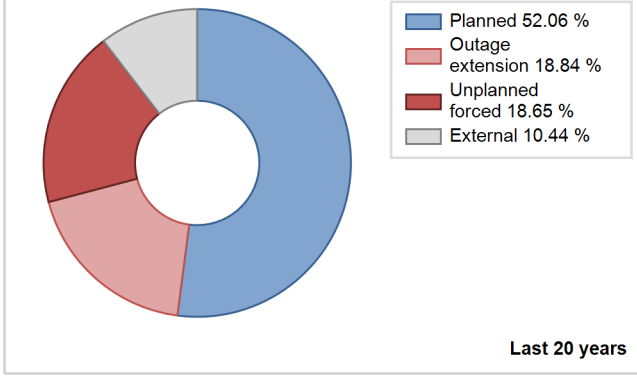
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					552	
B. Refuelling without maintenance				146		
C. Inspection, maintenance or repair combined with refuelling				939	7	
D. Inspection, maintenance or repair without refuelling				2		
E. Testing of plant systems or components				12	1	
H. Nuclear regulatory requirements					14	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						36
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.)					4	61
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					9	1
Z. Other					18	
Subtotal				1099	621	99
Total	**0**			**1819**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		14
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		32
14. Safety Systems		30
15. Reactor Cooling Systems		43
16. Steam generation systems		95
17. Safety I&C Systems (excluding reactor I&C)		5
21. Fuel Handling and Storage Facilities		20
31. Turbine and auxiliaries		57
32. Feedwater and Main Steam System		24
33. Circulating Water System		4
34. Miscellaneous Systems		112
35. All other I&C Systems		2
41. Main Generator Systems		93
42. Electrical Power Supply Systems		43
Total		**592**

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2020 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

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	:	1980-10-01
Grid Date	:	1986-10-20
Commercial Date	:	1987-03-04
Age at end of year	:	34 years

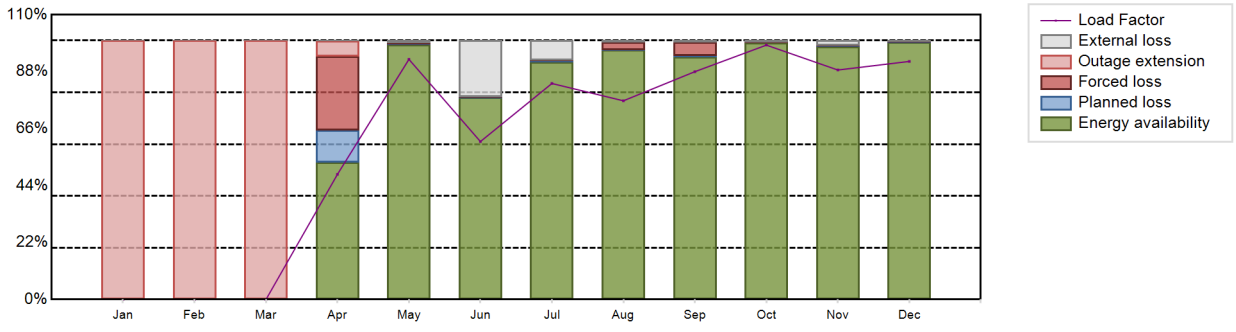
Design Characteristics

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 (2020)

Net Energy Production	:	4848.5 GW(e).h	Forced Loss Rate (FLR)	:	4.24 %
Energy Availability Factor (EAF)	:	67.51 %	Unplanned Capability Loss Factor (UCL)	:	28.45 %
Unit Capability Factor (UCF)	:	70.38 %	Planned Unavailability Factor (PUF)	:	1.17 %
Load Factor (LF)	:	60.99 %	Externally cause unavailability (XUF)	:	2.86 %
Operating Factor (OF)	:	68.84 %	Total off-line time	:	2737 hours

Annual Summary



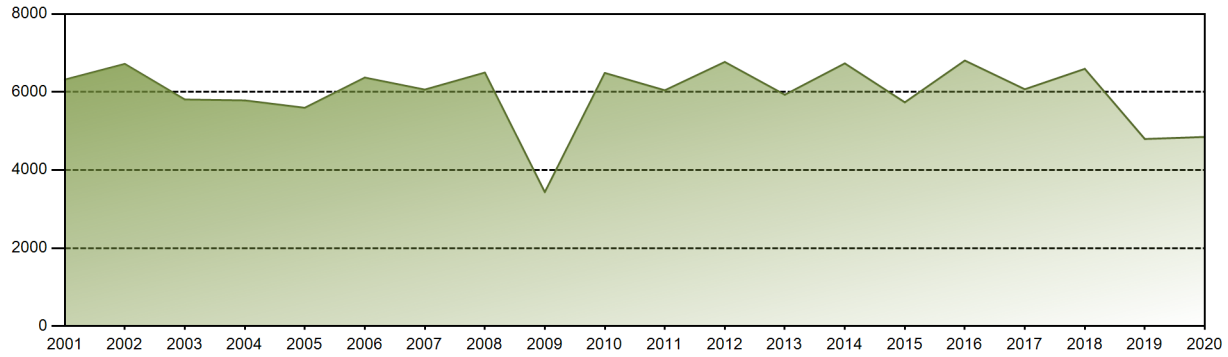
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	315.11	624.56	397.52	561.83	516.83	573.45	662.44	577.56	619.20	4848.50
EAF [%]	0.00	0.01	0.04	53.02	98.37	77.99	91.71	96.33	93.71	99.17	97.69	99.33	67.51
UCF [%]	0.00	0.01	0.04	53.13	99.21	99.79	99.28	96.90	94.39	99.78	99.64	99.80	70.38
LF [%]	0.00	0.00	0.00	48.36	92.76	61.01	83.44	76.76	88.01	98.25	88.64	91.96	60.99
OF [%]	0.00	0.00	0.00	65.28	100.00	83.33	93.41	85.89	95.97	99.87	100.00	100.00	68.84
FLR [%]	0.00	0.00	0.00	34.99	0.51	0.13	0.09	2.98	5.22	0.13	0.09	0.13	4.24
UCL [%]	100.00	99.99	99.96	34.60	0.51	0.13	0.09	2.97	5.20	0.13	0.09	0.13	28.45
PUF [%]	0.00	0.00	0.00	12.28	0.28	0.08	0.63	0.13	0.40	0.09	0.27	0.07	1.17
XUF [%]	0.00	0.00	0.00	0.11	0.85	21.80	7.58	0.56	0.68	0.61	1.95	0.47	2.86

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Historical Summary

Lifetime energy generation	:	198992.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.44 %
Cumulative Energy Availability Factor (EAF)	:	77.95 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.29 %
Cumulative Unit Capability Factor (UCF)	:	79.64 %	Cumulative Planned Unavailability Factor (PUF)	:	13.06 %
Cumulative Load Factor (LF)	:	73.73 %	Cumulative Externally cause unavailability (XUF)	:	1.7 %
Cumulative Operating Factor (OF)	:	79.72 %			

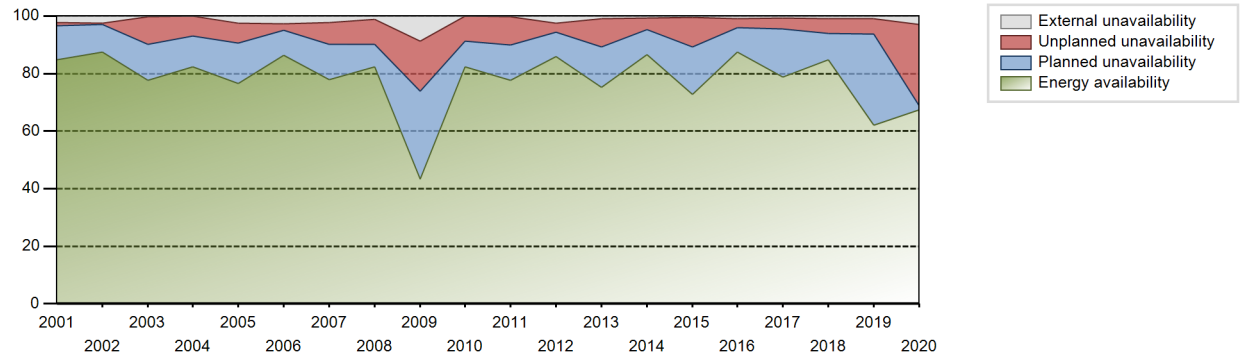
Electricity Production (net) [GWh]



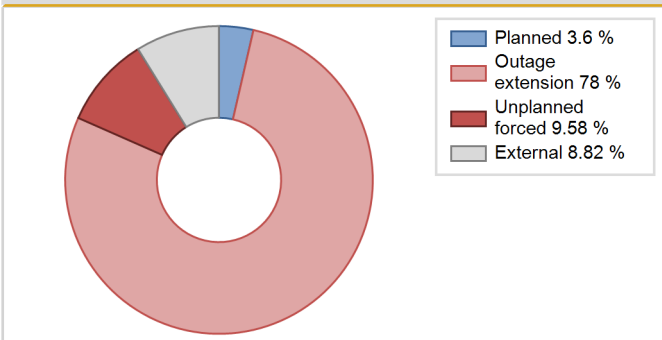
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	4120.60	5311	870	67.61	67.61	52.00	59.68	24.66	22.13	10.26	0.00
1988	4413.00	5354	905	58.90	61.48	55.51	60.95	21.77	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	6047	905	67.51	70.38	60.99	68.84	4.24	28.45	1.17	2.86

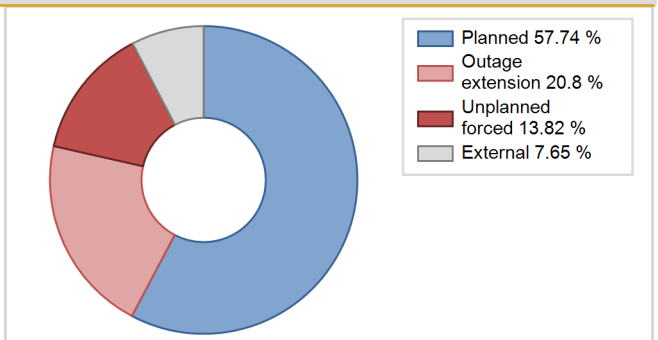
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					360	
B. Refuelling without maintenance				126		
C. Inspection, maintenance or repair combined with refuelling				928	23	
D. Inspection, maintenance or repair without refuelling				27		
E. Testing of plant systems or components				24	1	
H. Nuclear regulatory requirements					13	
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L. Human factor related					14	
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	30
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					8	
Z. Other					43	
Subtotal				1105	464	30
Total		**0**			**1599**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		25
12. Reactor I&C Systems		10
13. Reactor Auxiliary Systems		35
14. Safety Systems		6
15. Reactor Cooling Systems		24
16. Steam generation systems		20
21. Fuel Handling and Storage Facilities		21
31. Turbine and auxiliaries		64
32. Feedwater and Main Steam System		29
33. Circulating Water System		3
34. Miscellaneous Systems		87
35. All other I&C Systems		1
41. Main Generator Systems		30
42. Electrical Power Supply Systems		7
Total		**362**

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2020 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	:	33 years

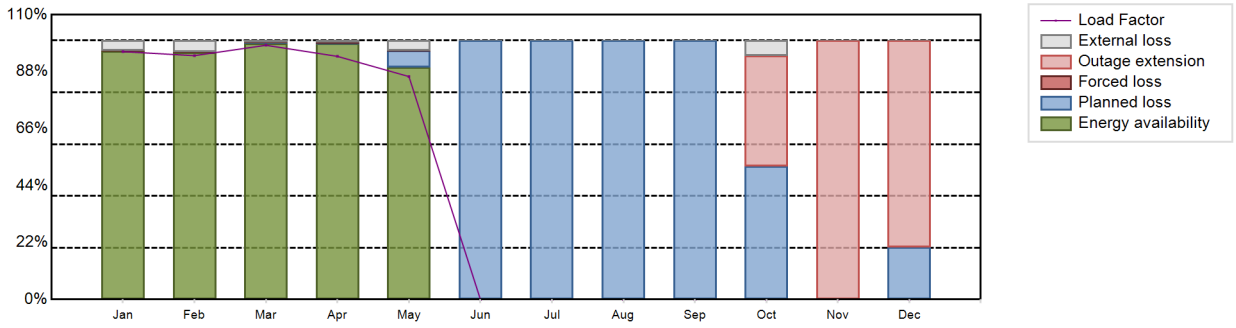
Design Characteristics

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]	:	16	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 (2020)

Net Energy Production	:	3089.77 GW(e).h	Forced Loss Rate (FLR)	:	0.21 %
Energy Availability Factor (EAF)	:	39.76 %	Unplanned Capability Loss Factor (UCL)	:	18.66 %
Unit Capability Factor (UCF)	:	41.33 %	Planned Unavailability Factor (PUF)	:	40.01 %
Load Factor (LF)	:	38.87 %	Externally cause unavailability (XUF)	:	1.57 %
Operating Factor (OF)	:	40.79 %	Total off-line time	:	5201 hours

Annual Summary



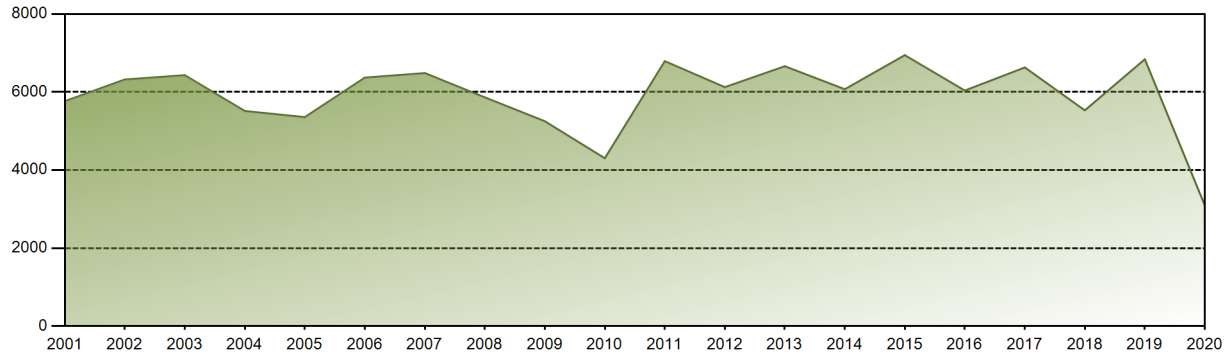
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	644.53	593.24	660.28	611.90	579.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3089.77
EAF [%]	96.01	95.52	98.80	98.90	89.59	0.03	0.00	0.00	0.00	0.01	0.04	0.04	39.76
UCF [%]	99.83	99.79	99.31	99.46	93.43	0.03	0.00	0.00	0.00	5.78	0.04	0.04	41.33
LF [%]	95.72	94.18	98.20	93.91	86.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.87
OF [%]	100.00	100.00	100.00	100.00	91.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.79
FLR [%]	0.10	0.11	0.34	0.47	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
UCL [%]	0.10	0.11	0.34	0.47	0.03	0.00	0.00	0.00	0.00	42.68	99.96	79.82	18.66
PUF [%]	0.07	0.10	0.35	0.07	6.54	99.97	100.00	100.00	100.00	51.54	0.00	20.13	40.01
XUF [%]	3.82	4.27	0.52	0.57	3.83	0.00	0.00	0.00	0.00	5.77	0.00	0.00	1.57

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Historical Summary

Lifetime energy generation	:	194246.41 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.67 %
Cumulative Energy Availability Factor (EAF)	:	78.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.29 %
Cumulative Unit Capability Factor (UCF)	:	80.22 %	Cumulative Planned Unavailability Factor (PUF)	:	13.5 %
Cumulative Load Factor (LF)	:	74.41 %	Cumulative Externally cause unavailability (XUF)	:	1.93 %
Cumulative Operating Factor (OF)	:	80.21 %			

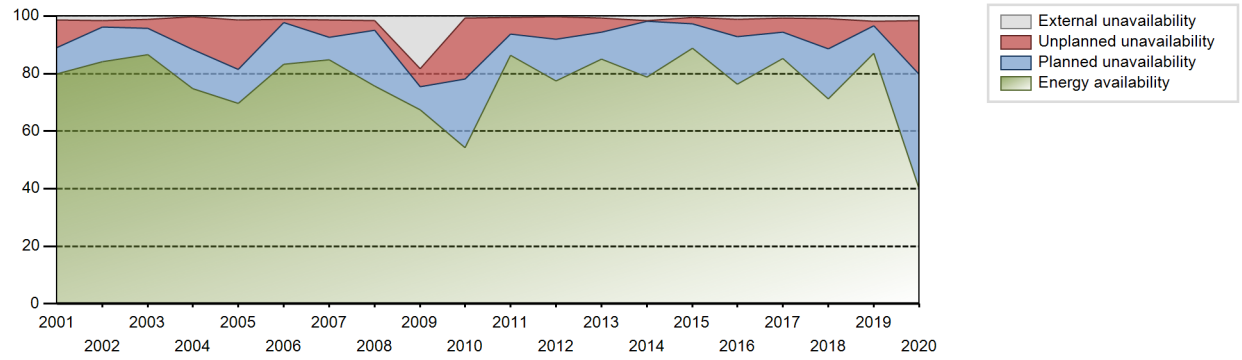
Electricity Production (net) [GWh]



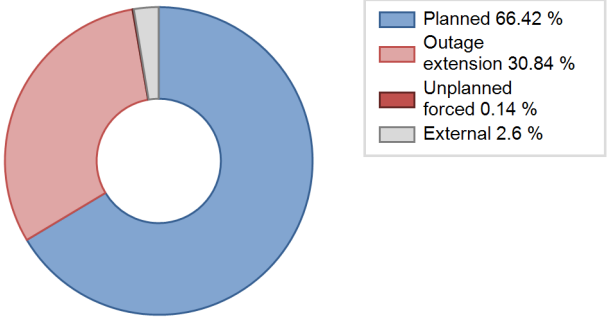
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	4410.00	5897	905	86.17	89.04	56.36	67.79	10.96	10.96	0.00	2.86
1989	4688.12	5664	905	60.39	63.58	59.14	64.66	13.81	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	39.76	41.33	38.87	40.79	0.21	18.66	40.01	1.57

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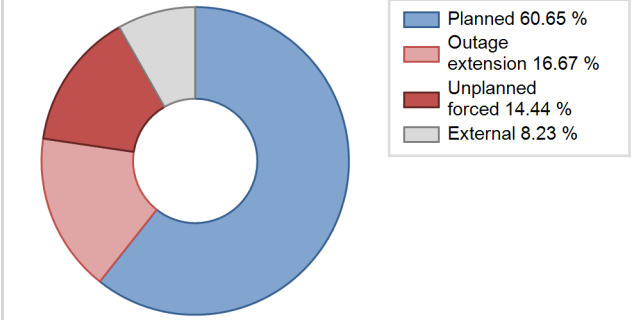
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					338	
B. Refuelling without maintenance				132		
C. Inspection, maintenance or repair combined with refuelling				872	12	
E. Testing of plant systems or components				20		
H. Nuclear regulatory requirements					1	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						4
L. Human factor related					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.)					6	50
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					8	1
Z. Other					36	15
Subtotal				1024	405	70
Total		**0**			**1499**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1988 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		48
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems		28
14. Safety Systems		9
15. Reactor Cooling Systems		40
16. Steam generation systems		10
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		15
31. Turbine and auxiliaries		40
32. Feedwater and Main Steam System		12
33. Circulating Water System		3
34. Miscellaneous Systems		60
35. All other I&C Systems		2
41. Main Generator Systems		28
42. Electrical Power Supply Systems		24
Total		**336**

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2020 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	:	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]	:	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

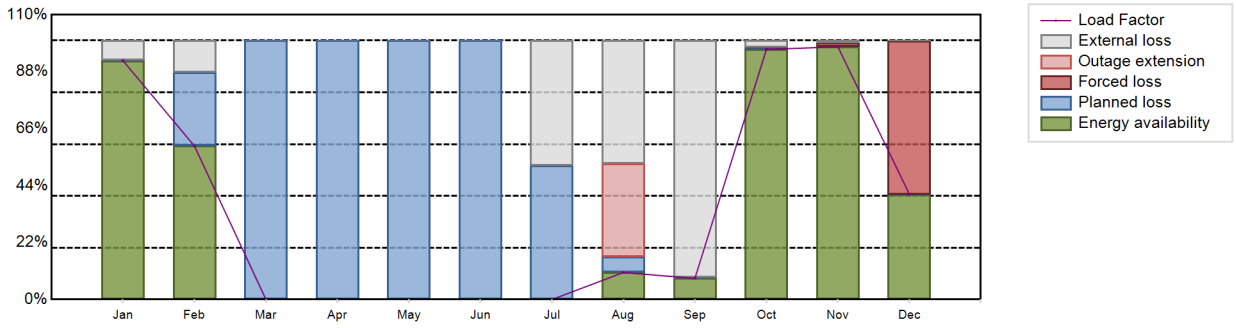
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	329.5
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.3
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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 (2020)

Net Energy Production	:	4440.81 GW(e).h
Energy Availability Factor (EAF)	:	33.73 %
Unit Capability Factor (UCF)	:	51.27 %
Load Factor (LF)	:	33.7 %
Operating Factor (OF)	:	36.48 %

Forced Loss Rate (FLR)	:	9.13 %
Unplanned Capability Loss Factor (UCL)	:	8.19 %
Planned Unavailability Factor (PUF)	:	40.54 %
Externally cause unavailability (XUF)	:	17.54 %
Total off-line time	:	5580 hours

Annual Summary



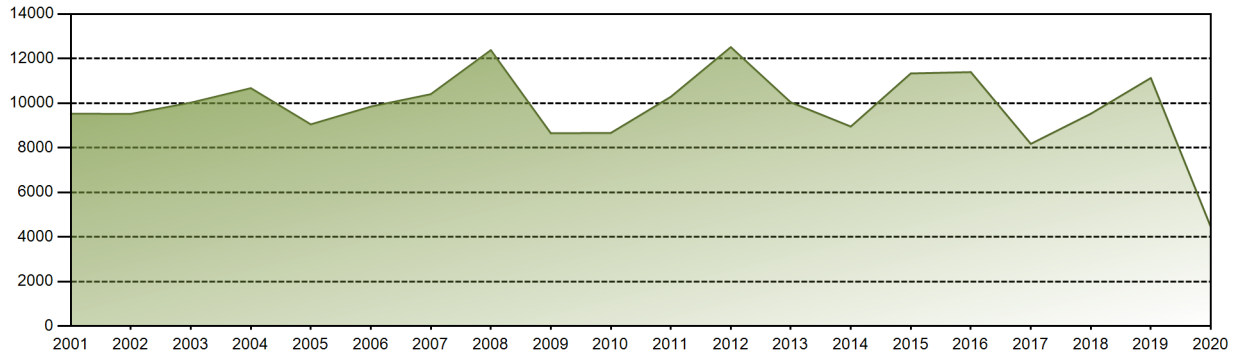
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	1029.55	618.70	0.00	0.00	0.00	0.00	0.00	116.55	88.21	1079.14	1054.11	454.55	4440.81
EAF [%]	92.27	59.30	0.07	0.04	0.05	0.07	0.04	10.48	8.25	96.56	97.57	40.64	33.73
UCF [%]	99.93	71.67	0.07	0.04	0.05	0.07	48.42	58.06	99.63	99.12	98.54	40.66	51.27
LF [%]	92.25	59.26	0.00	0.00	0.00	0.00	0.00	10.44	8.17	96.57	97.60	40.73	33.70
OF [%]	100.00	72.13	0.00	0.00	0.00	0.00	0.00	16.67	9.17	99.87	100.00	40.86	36.48
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19	1.35	59.33	9.13
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.85	0.00	0.19	1.35	59.33	8.19
PUF [%]	0.07	28.33	99.93	99.96	99.95	99.93	51.58	6.09	0.37	0.69	0.12	0.00	40.54
XUF [%]	7.66	12.36	0.00	0.00	0.00	0.00	48.38	47.58	91.38	2.56	0.96	0.02	17.54

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Historical Summary

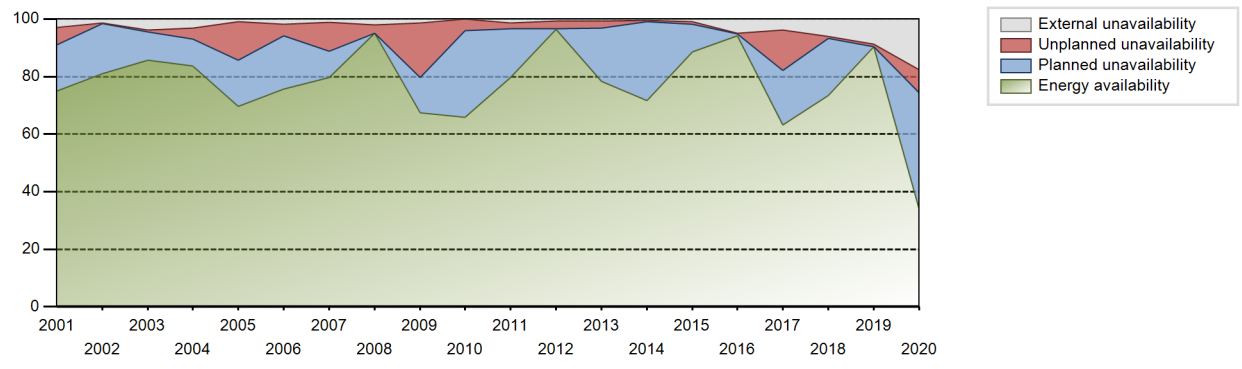
Lifetime energy generation	:	216776.86 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.09 %
Cumulative Energy Availability Factor (EAF)	:	78.02 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.73 %
Cumulative Unit Capability Factor (UCF)	:	81.12 %	Cumulative Planned Unavailability Factor (PUF)	:	14.15 %
Cumulative Load Factor (LF)	:	75.69 %	Cumulative Externally cause unavailability (XUF)	:	3.1 %
Cumulative Operating Factor (OF)	:	79.48 %			

Electricity Production (net) [GWh]



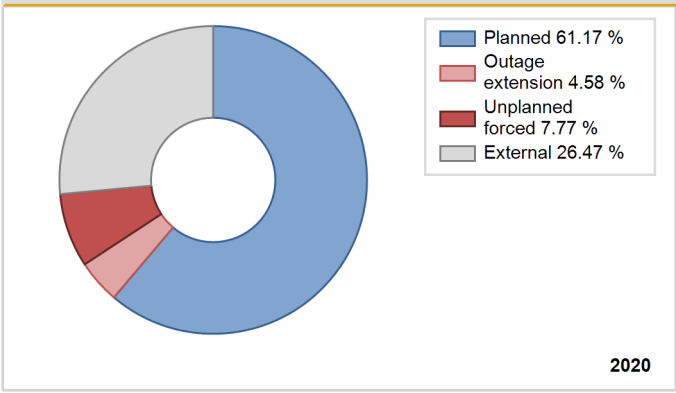
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2000	8429.16	5877	1455	96.94	96.94	98.43	97.13	1.64	1.62	1.43	0.00
2001	9524.35	6800	1455	75.00	78.03	74.73	77.63	6.98	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	3204	1500	33.73	51.27	33.70	36.48	9.13	8.19	40.54	17.54

Key Factors in Last 20 Years [%]

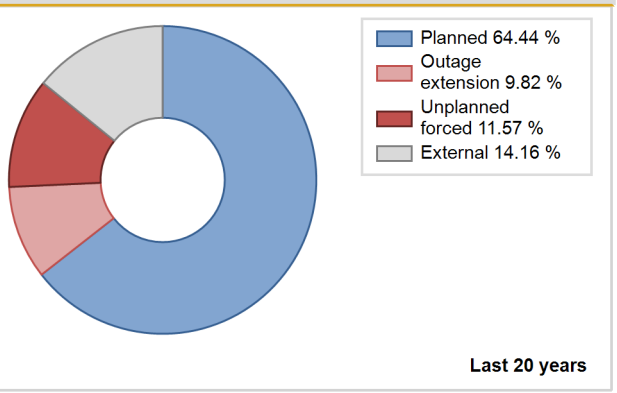


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2000 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					637	
B. Refuelling without maintenance				261		
C. Inspection, maintenance or repair combined with refuelling				693		
E. Testing of plant systems or components				91		
H. Nuclear regulatory requirements					1	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						10
L. Human factor related					53	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						34
O. Load dispatching, prioritization						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.)						24
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						50
Z. Other					86	
Subtotal				1045	777	130
Total	**0**			**1952**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2000 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		40
13. Reactor Auxiliary Systems		12
15. Reactor Cooling Systems		37
16. Steam generation systems		7
31. Turbine and auxiliaries		309
32. Feedwater and Main Steam System		18
34. Miscellaneous Systems		60
35. All other I&C Systems		1
41. Main Generator Systems		3
42. Electrical Power Supply Systems		62
Total		**551**

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2020 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

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	:	1985-12-31
Grid Date	:	1997-04-10
Commercial Date	:	2000-09-29
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]	:	-
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

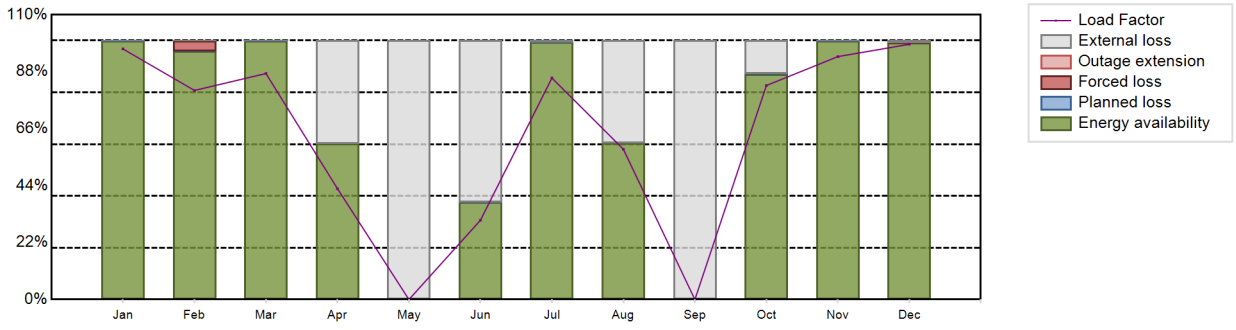
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	329.5
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.3
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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 (2020)

Net Energy Production	:	8328.39 GW(e).h
Energy Availability Factor (EAF)	:	70.01 %
Unit Capability Factor (UCF)	:	99.67 %
Load Factor (LF)	:	63.21 %
Operating Factor (OF)	:	69.49 %

Forced Loss Rate (FLR)	:	0.31 %
Unplanned Capability Loss Factor (UCL)	:	0.31 %
Planned Unavailability Factor (PUF)	:	0.02 %
Externally cause unavailability (XUF)	:	29.66 %
Total off-line time	:	2680 hours

Annual Summary



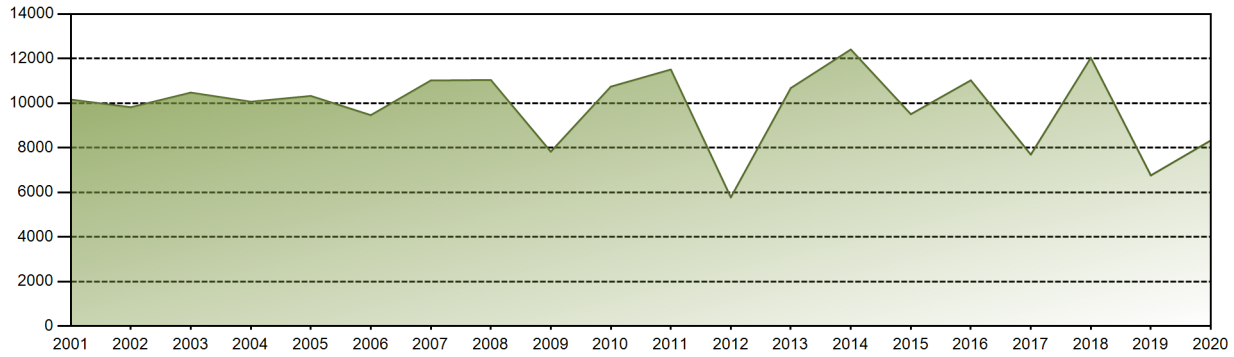
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	1080.02	843.06	972.84	462.63	0.00	330.68	954.68	647.68	0.00	923.56	1013.25	1099.96	8328.39
EAF [%]	99.87	95.84	99.93	60.17	0.06	37.62	99.38	60.31	0.06	87.04	99.75	99.14	70.01
UCF [%]	99.99	96.08	99.98	100.00	100.00	99.99	99.97	100.00	100.00	99.90	99.89	99.98	99.67
LF [%]	96.78	80.75	87.29	42.84	0.00	30.62	85.54	58.04	0.00	82.65	93.82	98.56	63.21
OF [%]	100.00	96.41	100.00	47.50	0.00	34.44	100.00	64.65	0.00	89.53	100.00	100.00	69.49
FLR [%]	0.00	3.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
UCL [%]	0.00	3.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
PUF [%]	0.01	0.01	0.02	0.00	0.00	0.01	0.03	0.00	0.00	0.10	0.11	0.02	0.02
XUF [%]	0.12	0.24	0.06	39.83	99.94	62.37	0.60	39.69	99.94	12.86	0.14	0.84	29.66

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Historical Summary

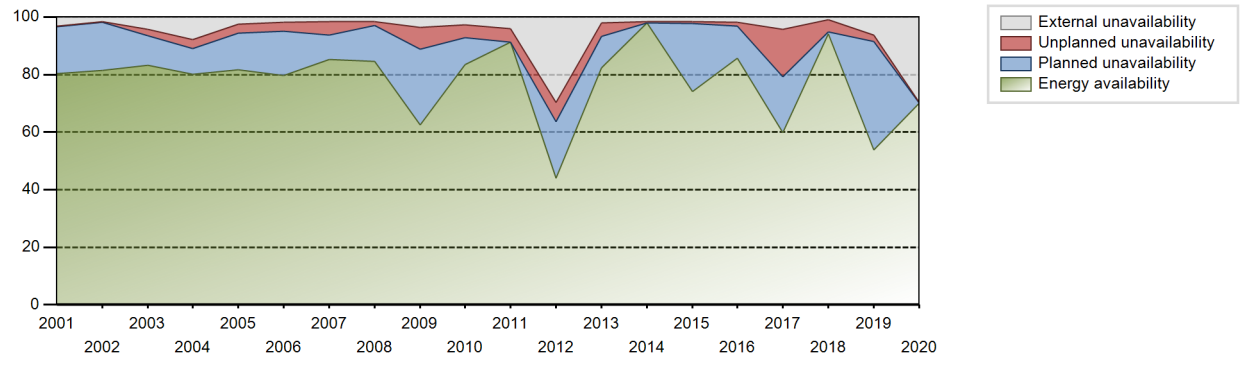
Lifetime energy generation	:	213805.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.78 %
Cumulative Energy Availability Factor (EAF)	:	77.91 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.68 %
Cumulative Unit Capability Factor (UCF)	:	83.48 %	Cumulative Planned Unavailability Factor (PUF)	:	12.84 %
Cumulative Load Factor (LF)	:	75.19 %	Cumulative Externally cause unavailability (XUF)	:	5.57 %
Cumulative Operating Factor (OF)	:	79.48 %			

Electricity Production (net) [GWh]



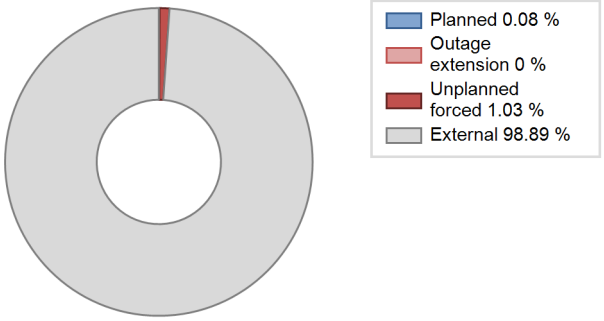
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2000	7213.35	5347	1455	90.19	90.26	92.15	94.70	9.74	9.74	0.00	0.06
2001	10159.53	7221	1455	80.36	83.42	79.71	82.43	0.36	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	6104	1500	70.01	99.67	63.21	69.49	0.31	0.31	0.02	29.66

Key Factors in Last 20 Years [%]

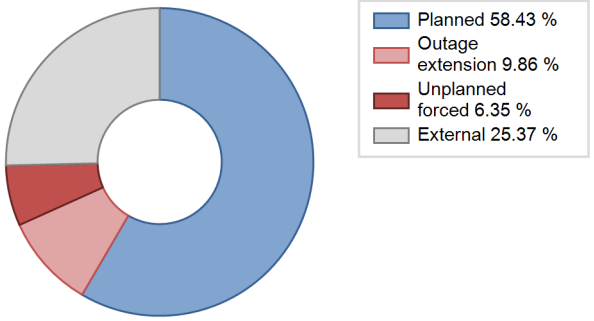


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2000 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					709	
B. Refuelling without maintenance				157		
C. Inspection, maintenance or repair combined with refuelling				847		
E. Testing of plant systems or components				79	0	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						45
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						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	153
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						6
Z. Other					49	
Subtotal				1083	787	229
Total		**0**			**2099**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2000 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		51
13. Reactor Auxiliary Systems		29
14. Safety Systems		10
15. Reactor Cooling Systems		6
16. Steam generation systems		16
21. Fuel Handling and Storage Facilities		8
31. Turbine and auxiliaries		305
32. Feedwater and Main Steam System		4
33. Circulating Water System		25
34. Miscellaneous Systems		119
35. All other I&C Systems		2
41. Main Generator Systems		12
42. Electrical Power Supply Systems		16
Total		**616**

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2020 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

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	:	1988-10-15
Grid Date	:	1997-12-24
Commercial Date	:	2002-01-29
Age at end of year	:	23 years

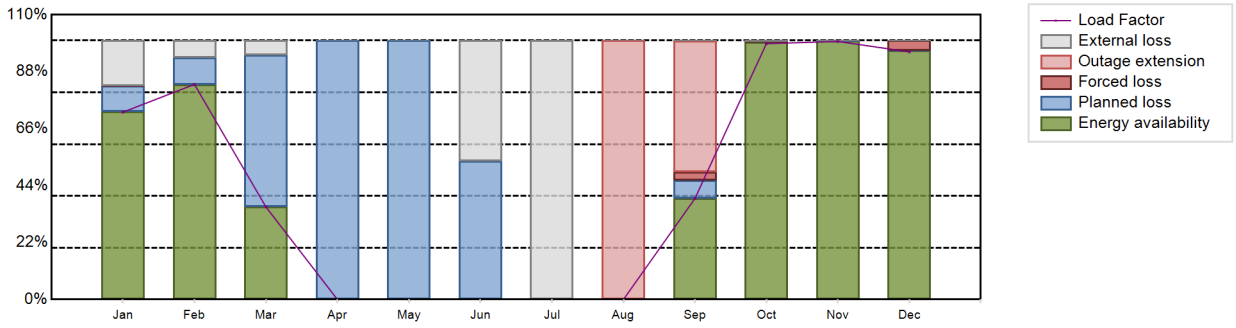
Design Characteristics

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]	:	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]	:	35000	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	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 (2020)

Net Energy Production	:	5723.66 GW(e).h	Forced Loss Rate (FLR)	:	0.99 %
Energy Availability Factor (EAF)	:	43.72 %	Unplanned Capability Loss Factor (UCL)	:	13.2 %
Unit Capability Factor (UCF)	:	58.55 %	Planned Unavailability Factor (PUF)	:	28.25 %
Load Factor (LF)	:	43.59 %	Externally cause unavailability (XUF)	:	14.83 %
Operating Factor (OF)	:	45.81 %	Total off-line time	:	4760 hours

Annual Summary



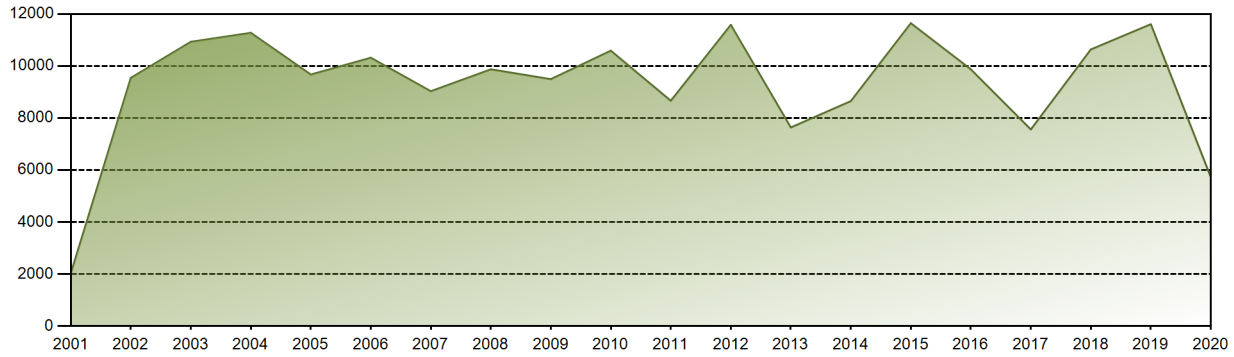
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	804.97	864.54	396.97	0.00	0.00	0.00	0.00	0.00	419.72	1100.69	1072.86	1063.90	5723.66
EAF [%]	72.52	83.08	35.74	0.00	0.00	0.00	0.00	0.00	39.13	99.48	99.77	96.22	43.72
UCF [%]	90.07	89.64	41.39	0.00	0.00	46.67	100.00	0.00	39.21	99.83	99.95	96.23	58.55
LF [%]	72.37	83.09	35.74	0.00	0.00	0.00	0.00	0.00	38.99	98.83	99.67	95.65	43.59
OF [%]	73.52	91.09	42.13	0.00	0.00	0.00	0.00	0.00	46.39	99.87	100.00	98.39	45.81
FLR [%]	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.58	0.01	0.00	3.76	0.99
UCL [%]	0.04	0.00	0.00	0.00	0.00	0.00	0.00	100.00	53.79	0.01	0.00	3.76	13.20
PUF [%]	9.89	10.36	58.61	100.00	100.00	53.33	0.00	0.00	7.00	0.16	0.05	0.01	28.25
XUF [%]	17.55	6.55	5.65	0.00	0.00	46.66	100.00	0.00	0.08	0.34	0.18	0.01	14.83

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Historical Summary

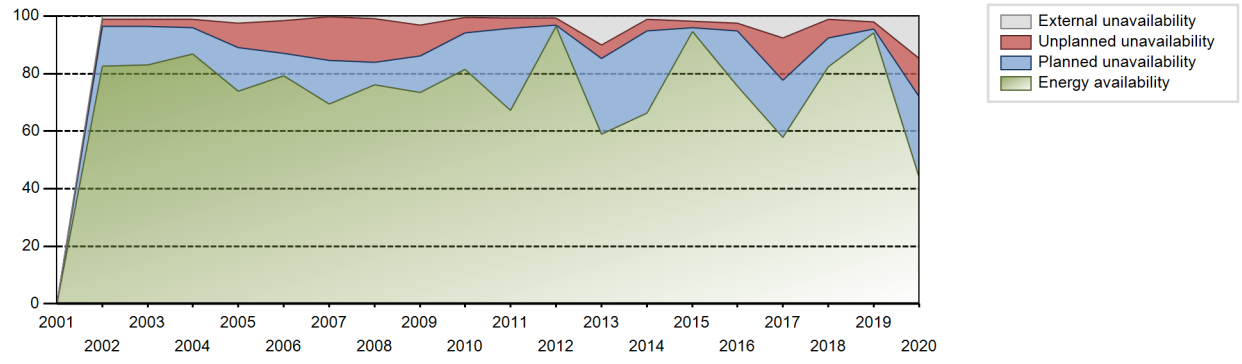
Lifetime energy generation	:	198830.86 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.88 %
Cumulative Energy Availability Factor (EAF)	:	75.91 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.89 %
Cumulative Unit Capability Factor (UCF)	:	78.82 %	Cumulative Planned Unavailability Factor (PUF)	:	14.3 %
Cumulative Load Factor (LF)	:	74.11 %	Cumulative Externally cause unavailability (XUF)	:	2.9 %
Cumulative Operating Factor (OF)	:	78.27 %			

Electricity Production (net) [GWh]



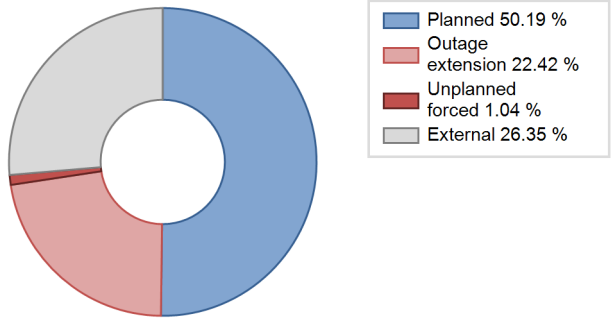
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	9544.10	7331	1495	82.62	83.86	74.72	84.81	2.71	2.34	13.81	1.24
2003	10932.08	7438	1495	83.06	84.14	83.48	84.91	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	4024	1495	43.72	58.55	43.59	45.81	0.99	13.20	28.25	14.83

Key Factors in Last 20 Years [%]

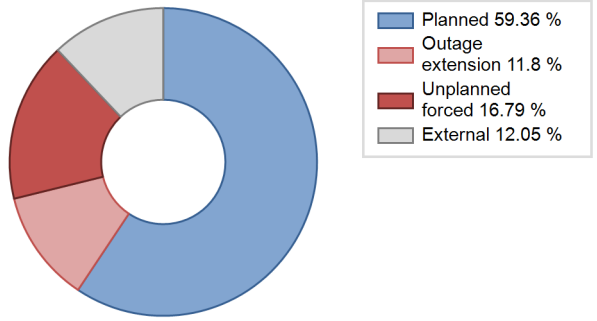


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2002 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					360	
B. Refuelling without maintenance				491		
C. Inspection, maintenance or repair combined with refuelling				520		
E. Testing of plant systems or components				37		
H. Nuclear regulatory requirements					3	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						2
L. Human factor related					30	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						9
O. Load dispatching, prioritization						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.)						94
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						11
Z. Other					52	
Subtotal				1048	445	123
Total		**0**			**1616**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2002 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		14
12. Reactor I&C Systems		24
13. Reactor Auxiliary Systems		11
14. Safety Systems		34
15. Reactor Cooling Systems		17
16. Steam generation systems		37
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		12
32. Feedwater and Main Steam System		15
33. Circulating Water System		7
34. Miscellaneous Systems		97
35. All other I&C Systems		13
41. Main Generator Systems		18
42. Electrical Power Supply Systems		108
Total		**416**

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2020 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	:	21 years

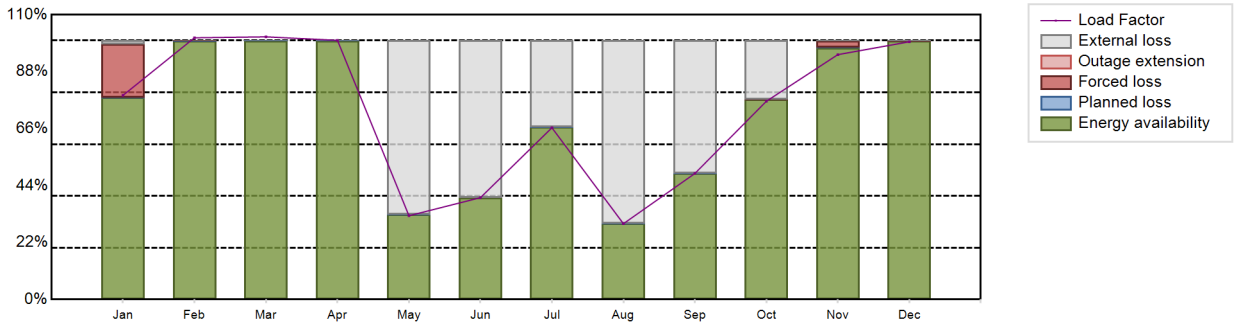
Design Characteristics

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	:	-
Moderator material	:	H2O	Containment design pressure [MPa]	:	4.3
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	-	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	35000	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	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 (2020)

Net Energy Production	:	9482.62 GW(e).h	Forced Loss Rate (FLR)	:	1.96 %
Energy Availability Factor (EAF)	:	72.26 %	Unplanned Capability Loss Factor (UCL)	:	1.96 %
Unit Capability Factor (UCF)	:	97.99 %	Planned Unavailability Factor (PUF)	:	0.05 %
Load Factor (LF)	:	72.21 %	Externally cause unavailability (XUF)	:	25.73 %
Operating Factor (OF)	:	93.16 %	Total off-line time	:	601 hours

Annual Summary



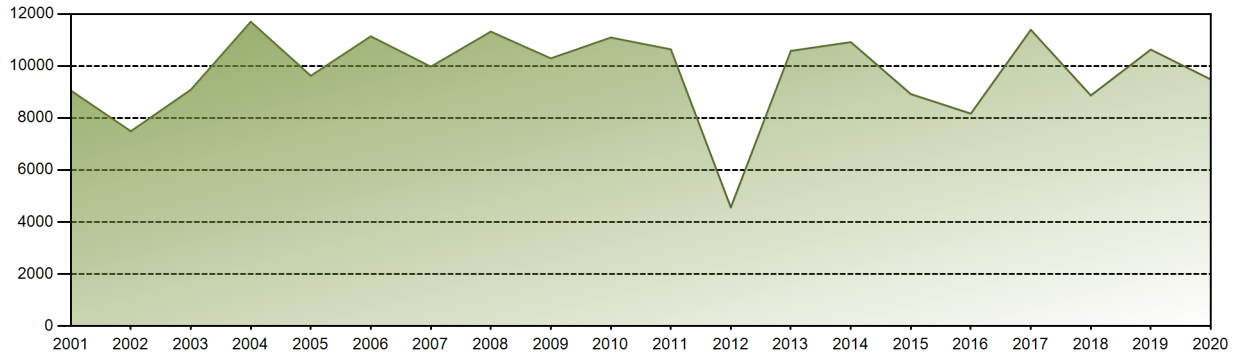
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	876.96	1051.82	1126.86	1077.44	359.99	423.51	737.99	325.72	524.05	853.01	1018.10	1107.19	9482.62
EAF [%]	77.98	99.96	99.97	99.96	32.86	39.42	66.52	29.28	48.72	77.21	97.07	99.89	72.26
UCF [%]	79.43	99.96	99.97	99.96	99.99	100.00	99.97	99.92	99.99	99.87	97.17	99.98	97.99
LF [%]	78.84	101.09	101.45	100.10	32.36	39.34	66.35	29.28	48.69	76.59	94.58	99.54	72.21
OF [%]	94.35	100.00	100.00	100.00	83.47	100.00	100.00	100.00	63.47	77.85	98.89	100.00	93.16
FLR [%]	20.56	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	2.58	0.00	1.96
UCL [%]	20.56	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	2.57	0.00	1.96
PUF [%]	0.01	0.01	0.03	0.04	0.01	0.00	0.03	0.08	0.01	0.10	0.26	0.02	0.05
XUF [%]	1.44	0.00	0.00	0.00	67.13	60.58	33.45	70.64	51.26	22.66	0.10	0.09	25.73

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Historical Summary

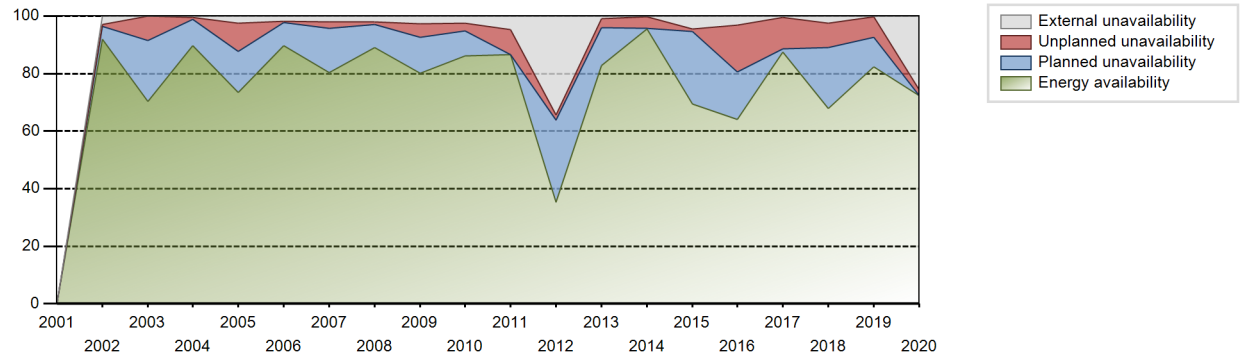
Lifetime energy generation	:	200945.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.48 %
Cumulative Energy Availability Factor (EAF)	:	78.4 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.04 %
Cumulative Unit Capability Factor (UCF)	:	83.37 %	Cumulative Planned Unavailability Factor (PUF)	:	11.59 %
Cumulative Load Factor (LF)	:	75.43 %	Cumulative Externally cause unavailability (XUF)	:	4.97 %
Cumulative Operating Factor (OF)	:	80.89 %			

Electricity Production (net) [GWh]



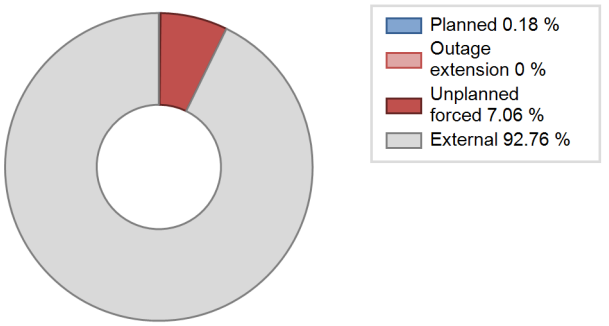
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	7491.29	6080	1495	91.94	94.81	70.33	85.80	0.68	0.65	4.55	2.86
2003	9084.75	6542	1495	70.38	70.48	69.37	74.68	10.67	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	8183	1495	72.26	97.99	72.21	93.16	1.96	1.96	0.05	25.73

Key Factors in Last 20 Years [%]

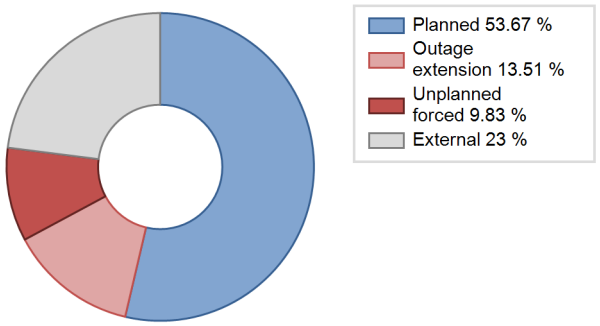


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2002 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					246	
B. Refuelling without maintenance				285		
C. Inspection, maintenance or repair combined with refuelling				663		
E. Testing of plant systems or components				22		
H. Nuclear regulatory requirements					107	
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						27
L. Human factor related					12	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
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.)						179
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						31
Z. Other					14	
Subtotal				970	379	244
Total	**0**			**1593**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2002 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		19
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems		18
14. Safety Systems		25
15. Reactor Cooling Systems		16
16. Steam generation systems		105
21. Fuel Handling and Storage Facilities		18
31. Turbine and auxiliaries		26
32. Feedwater and Main Steam System		9
33. Circulating Water System		2
34. Miscellaneous Systems		50
41. Main Generator Systems		1
42. Electrical Power Supply Systems		42
Total		**347**

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2020 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	:	37 years

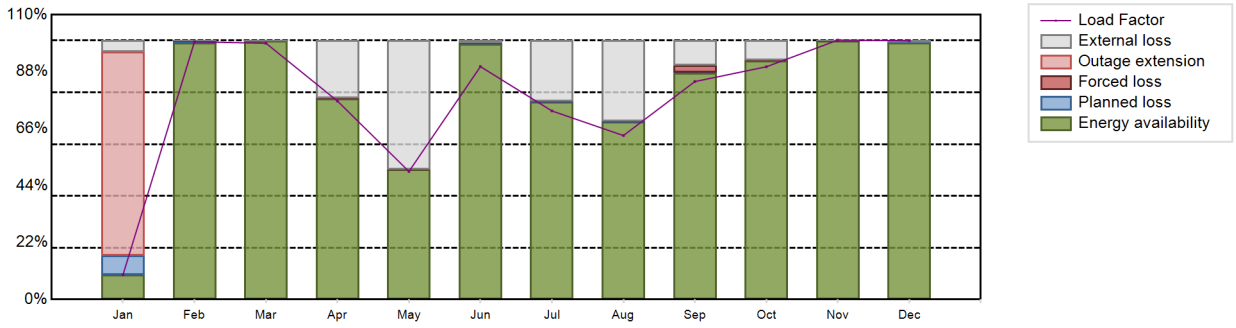
Design Characteristics

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 (2020)

Net Energy Production	:	6241.26 GW(e).h	Forced Loss Rate (FLR)	:	0.38 %
Energy Availability Factor (EAF)	:	79.62 %	Unplanned Capability Loss Factor (UCL)	:	7.01 %
Unit Capability Factor (UCF)	:	92.18 %	Planned Unavailability Factor (PUF)	:	0.81 %
Load Factor (LF)	:	77.65 %	Externally cause unavailability (XUF)	:	12.56 %
Operating Factor (OF)	:	81.5 %	Total off-line time	:	1625 hours

Annual Summary



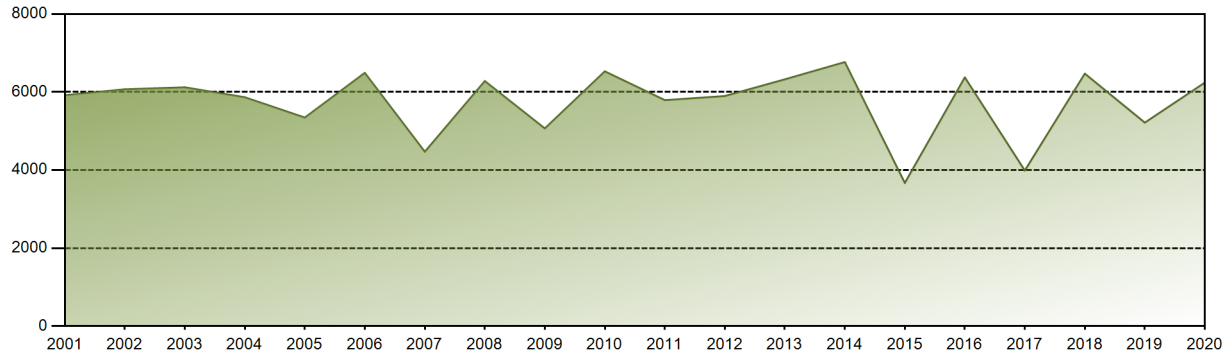
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	65.16	633.94	672.89	505.02	336.73	592.66	495.83	431.12	554.57	612.79	660.06	680.51	6241.26
EAF [%]	9.59	99.05	99.75	77.65	50.11	98.59	76.33	68.50	87.37	92.11	99.83	99.24	79.62
UCF [%]	14.02	99.06	99.75	99.77	99.79	99.48	99.74	99.66	96.85	99.60	99.85	99.93	92.18
LF [%]	9.57	99.54	98.98	76.66	49.46	89.96	72.83	63.33	84.18	89.89	100.19	99.96	77.65
OF [%]	16.94	100.00	100.00	78.33	51.61	100.00	78.49	70.30	91.94	93.02	100.00	100.00	81.50
FLR [%]	0.00	0.35	0.08	0.18	0.16	0.20	0.20	0.21	2.76	0.18	0.00	0.00	0.38
UCL [%]	78.56	0.35	0.08	0.18	0.16	0.20	0.20	0.21	2.75	0.18	0.00	0.00	7.01
PUF [%]	7.42	0.59	0.17	0.06	0.05	0.32	0.06	0.13	0.41	0.22	0.14	0.07	0.81
XUF [%]	4.43	0.01	0.00	22.12	49.68	0.89	23.41	31.16	9.48	7.49	0.02	0.69	12.56

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Historical Summary

Lifetime energy generation	:	208968.56 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.02 %
Cumulative Energy Availability Factor (EAF)	:	76.79 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.28 %
Cumulative Unit Capability Factor (UCF)	:	79.29 %	Cumulative Planned Unavailability Factor (PUF)	:	13.43 %
Cumulative Load Factor (LF)	:	71.32 %	Cumulative Externally cause unavailability (XUF)	:	2.5 %
Cumulative Operating Factor (OF)	:	77.96 %			

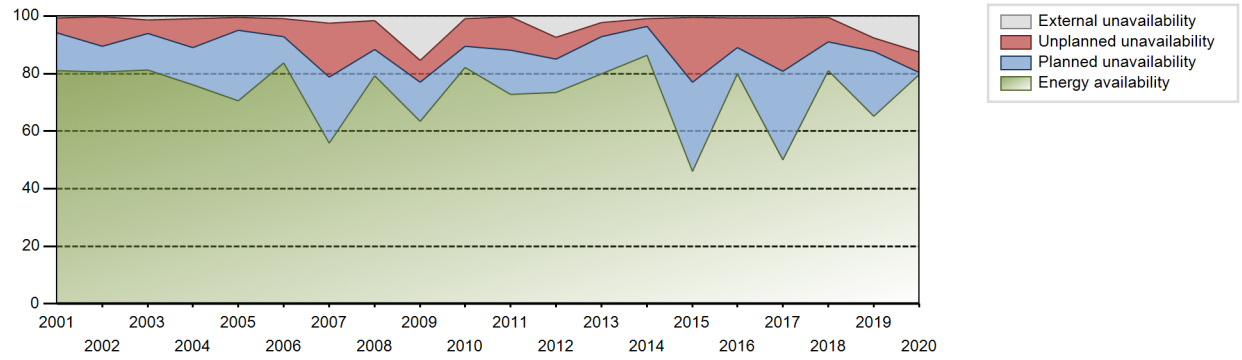
Electricity Production (net) [GWh]



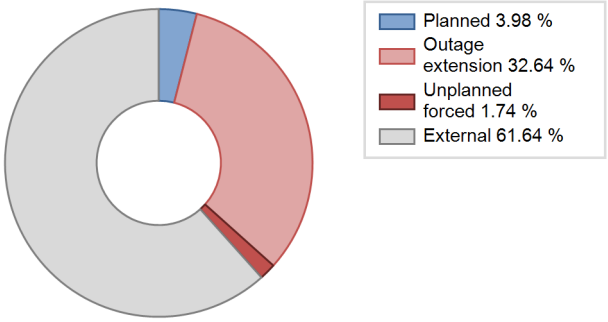
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	5482.00	7165	880	82.63	82.63	82.63	92.86	17.37	17.37	0.00	0.00
1985	5185.20	6615	880	71.95	77.18	67.26	75.51	3.24	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	7159	915	79.62	92.18	77.65	81.50	0.38	7.01	0.81	12.56

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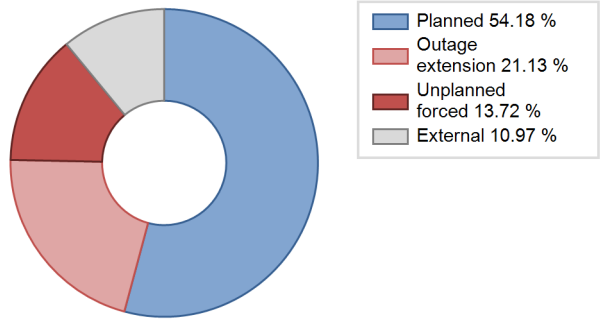
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					488	
B. Refuelling without maintenance				139		
C. Inspection, maintenance or repair combined with refuelling				930	14	
D. Inspection, maintenance or repair without refuelling				18		
E. Testing of plant systems or components				14		
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					60	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						12
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.)					14	64
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						1
Z. Other				2	38	
Subtotal				1103	618	86
Total		**0**			**1807**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		15
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems		39
14. Safety Systems		39
15. Reactor Cooling Systems		15
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		34
32. Feedwater and Main Steam System		7
33. Circulating Water System		2
34. Miscellaneous Systems		106
35. All other I&C Systems		2
41. Main Generator Systems		169
42. Electrical Power Supply Systems		24
Total		**478**

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2020 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	:	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]	:	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

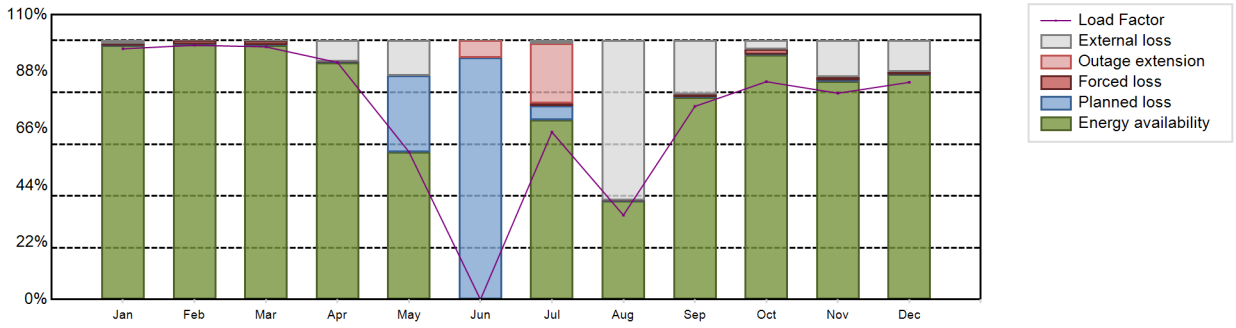
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5761.69 GW(e).h
Energy Availability Factor (EAF)	:	74.5 %
Unit Capability Factor (UCF)	:	85.9 %
Load Factor (LF)	:	71.69 %
Operating Factor (OF)	:	78.81 %

Forced Loss Rate (FLR)	:	0.96 %
Unplanned Capability Loss Factor (UCL)	:	3.35 %
Planned Unavailability Factor (PUF)	:	10.75 %
Externally cause unavailability (XUF)	:	11.4 %
Total off-line time	:	1861 hours

Annual Summary



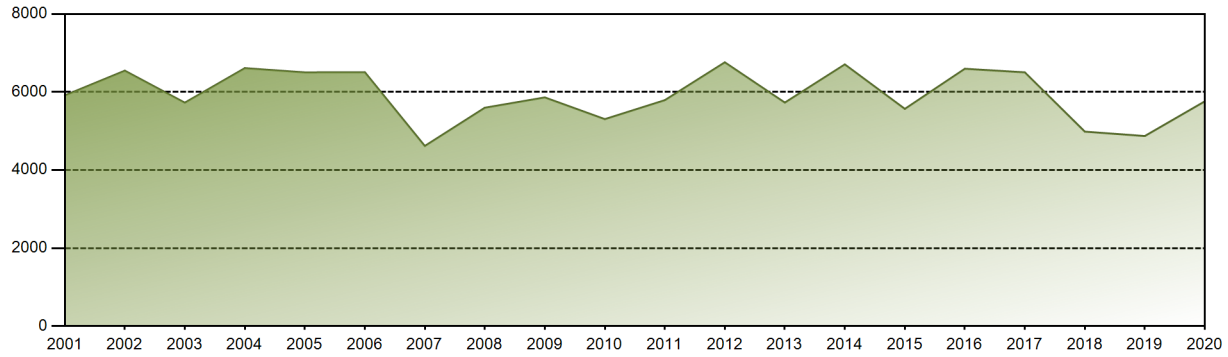
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	659.16	625.38	663.36	603.15	388.20	0.00	440.11	221.65	491.33	573.44	524.83	571.08	5761.69
EAF [%]	98.00	98.46	98.05	91.54	57.02	0.00	69.30	38.10	78.04	94.50	84.33	86.84	74.50
UCF [%]	99.24	98.46	98.10	99.68	70.50	0.00	70.39	99.75	98.72	97.91	98.47	98.95	85.90
LF [%]	96.83	98.20	97.58	91.55	57.02	0.00	64.65	32.56	74.58	84.12	79.66	83.89	71.69
OF [%]	100.00	100.00	100.00	100.00	70.97	0.00	76.75	38.98	81.67	96.78	90.69	89.92	78.81
FLR [%]	0.67	1.41	1.63	0.09	0.00	0.00	1.13	0.22	1.12	1.92	1.25	0.94	0.96
UCL [%]	0.67	1.41	1.63	0.09	0.00	6.66	24.03	0.22	1.12	1.91	1.25	0.94	3.35
PUF [%]	0.09	0.14	0.27	0.24	29.50	93.35	5.58	0.03	0.16	0.18	0.29	0.11	10.75
XUF [%]	1.23	0.00	0.04	8.13	13.47	0.00	1.09	61.65	20.68	3.41	14.14	12.11	11.40

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Historical Summary

Lifetime energy generation	:	210022.9 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.33 %
Cumulative Energy Availability Factor (EAF)	:	77.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.66 %
Cumulative Unit Capability Factor (UCF)	:	80.35 %	Cumulative Planned Unavailability Factor (PUF)	:	12.98 %
Cumulative Load Factor (LF)	:	72.97 %	Cumulative Externally cause unavailability (XUF)	:	3.06 %
Cumulative Operating Factor (OF)	:	79.87 %			

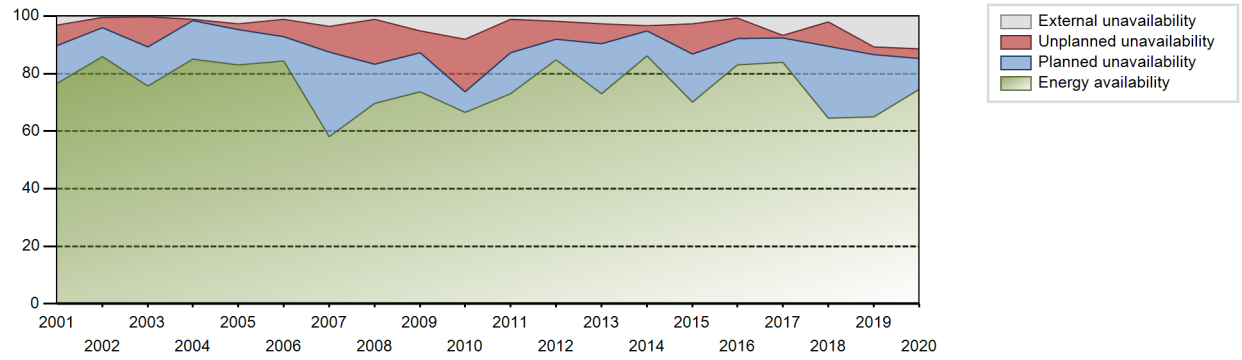
Electricity Production (net) [GWh]



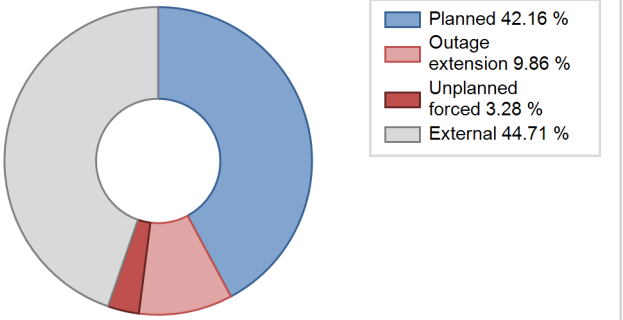
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	6103.20	8330	880	96.00	98.29	83.40	97.33	1.71	1.71	0.00	2.29
1986	4955.00	6258	880	70.06	70.42	64.28	71.44	22.40	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	6923	915	74.50	85.90	71.69	78.81	0.96	3.35	10.75	11.40

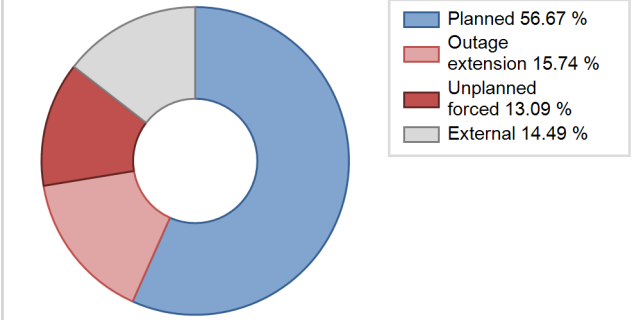
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					356	
B. Refuelling without maintenance				92		
C. Inspection, maintenance or repair combined with refuelling				922	6	
E. Testing of plant systems or components				7	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					45	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						32
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.)					8	32
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					3	9
Z. Other					42	
Subtotal				1021	465	75
Total	**0**			**1561**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		27
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		10
14. Safety Systems		10
15. Reactor Cooling Systems		8
16. Steam generation systems		22
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		87
32. Feedwater and Main Steam System		16
33. Circulating Water System		1
34. Miscellaneous Systems		45
35. All other I&C Systems		2
41. Main Generator Systems		104
42. Electrical Power Supply Systems		7
Total		**356**

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2020 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	:	36 years

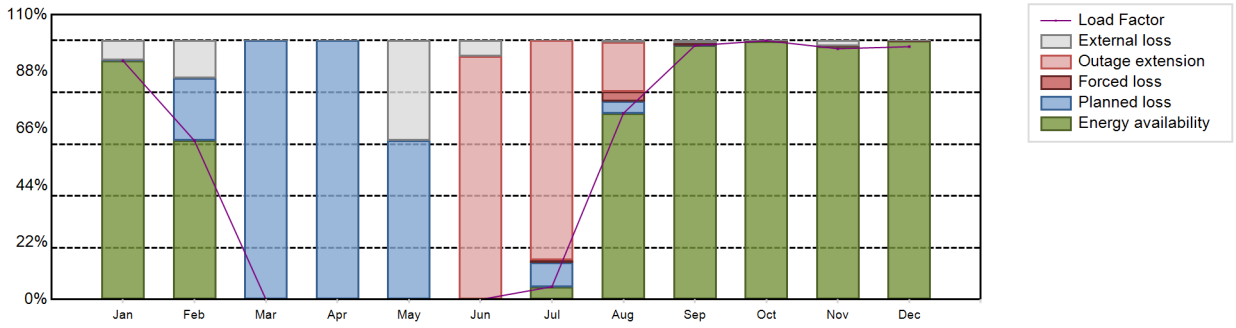
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	4171.74 GW(e).h
Energy Availability Factor (EAF)	:	52.12 %
Unit Capability Factor (UCF)	:	57.98 %
Load Factor (LF)	:	51.9 %
Operating Factor (OF)	:	55.98 %
Forced Loss Rate (FLR)	:	0.83 %
Unplanned Capability Loss Factor (UCL)	:	17 %
Planned Unavailability Factor (PUF)	:	25.02 %
Externally cause unavailability (XUF)	:	5.87 %
Total off-line time	:	3867 hours

Annual Summary



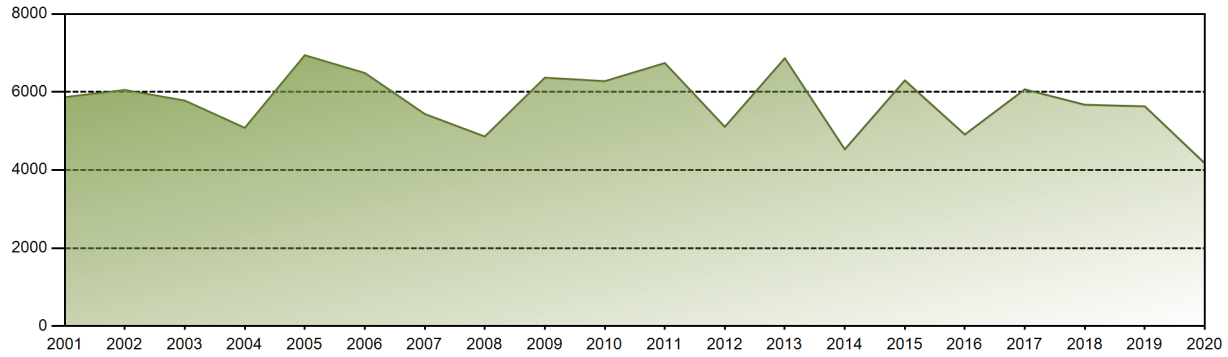
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	627.74	390.63	0.00	0.00	0.00	0.00	33.62	489.62	645.94	681.31	638.22	664.65	4171.74
EAF [%]	92.21	61.33	0.00	0.00	0.00	0.00	4.94	71.93	98.02	99.69	97.57	99.79	52.12
UCF [%]	99.85	75.82	0.00	0.00	38.71	6.02	4.94	72.45	98.86	99.78	99.60	99.92	57.98
LF [%]	92.21	61.34	0.00	0.00	0.00	0.00	4.94	71.92	98.05	99.95	96.88	97.63	51.90
OF [%]	100.00	76.29	0.00	0.00	0.00	0.00	15.19	80.78	100.00	99.87	100.00	100.00	55.98
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	14.28	4.88	1.04	0.10	0.08	0.01	0.83
UCL [%]	0.00	0.00	0.00	0.00	0.00	93.98	85.66	22.89	1.04	0.10	0.08	0.01	17.00
PUF [%]	0.15	24.18	100.00	100.00	61.29	0.00	9.40	4.66	0.10	0.13	0.32	0.06	25.02
XUF [%]	7.64	14.49	0.00	0.00	38.71	6.01	0.00	0.52	0.84	0.08	2.04	0.14	5.87

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Historical Summary

Lifetime energy generation	:	207969.03 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.49 %
Cumulative Energy Availability Factor (EAF)	:	76.97 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.84 %
Cumulative Unit Capability Factor (UCF)	:	80.47 %	Cumulative Planned Unavailability Factor (PUF)	:	12.69 %
Cumulative Load Factor (LF)	:	71.48 %	Cumulative Externally cause unavailability (XUF)	:	3.5 %
Cumulative Operating Factor (OF)	:	78.32 %			

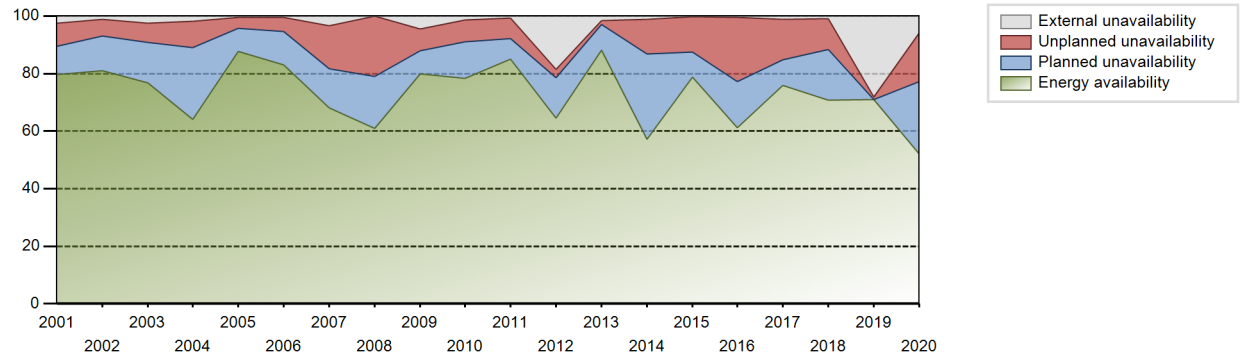
Electricity Production (net) [GWh]



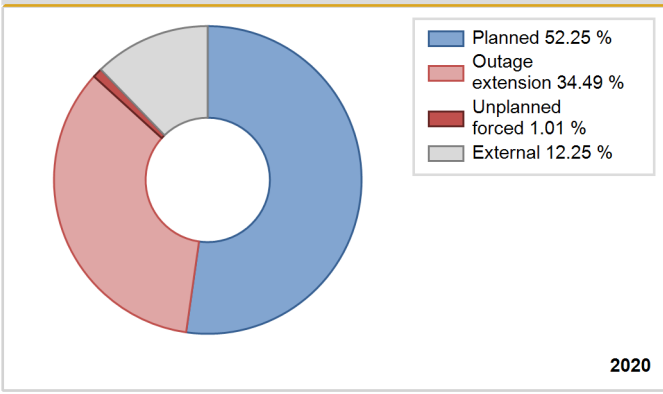
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	3272.00	4380	880	91.93	91.93	89.66	92.73	8.07	8.07	0.00	0.00
1985	5247.40	6557	880	72.54	74.60	68.07	74.85	8.27	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	52.12	57.98	51.90	55.98	0.83	17.00	25.02	5.87

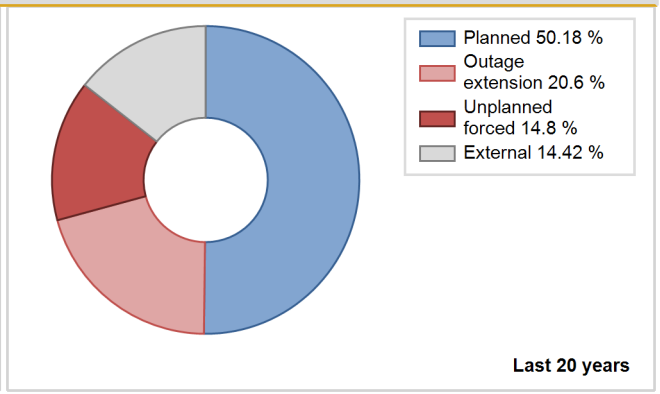
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					311	
B. Refuelling without maintenance				107		
C. Inspection, maintenance or repair combined with refuelling				873	23	
D. Inspection, maintenance or repair without refuelling					4	
E. Testing of plant systems or components				6		
J. Grid limitation, failure or grid unavailability						4
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						1
L. Human factor related					71	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						23
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.)						51
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						43
Z. Other					53	13
Subtotal				986	462	135
Total	**0**			**1583**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		6
12. Reactor I&C Systems		24
13. Reactor Auxiliary Systems		15
14. Safety Systems		17
15. Reactor Cooling Systems		60
16. Steam generation systems		21
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		49
32. Feedwater and Main Steam System		12
34. Miscellaneous Systems		77
35. All other I&C Systems		2
41. Main Generator Systems		16
42. Electrical Power Supply Systems		30
Total		**331**

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2020 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	:	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]	:	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

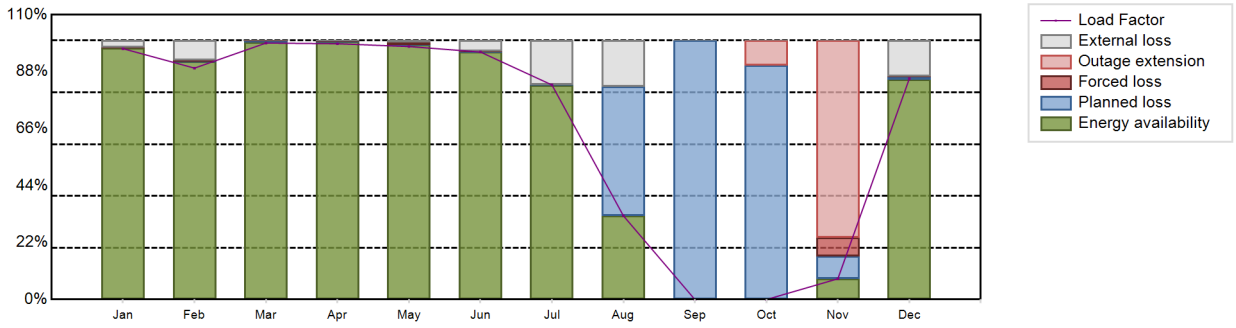
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5265.57 GW(e).h
Energy Availability Factor (EAF)	:	65.86 %
Unit Capability Factor (UCF)	:	71.21 %
Load Factor (LF)	:	65.51 %
Operating Factor (OF)	:	71.29 %

Forced Loss Rate (FLR)	:	1.03 %
Unplanned Capability Loss Factor (UCL)	:	7.79 %
Planned Unavailability Factor (PUF)	:	20.99 %
Externally cause unavailability (XUF)	:	5.35 %
Total off-line time	:	2522 hours

Annual Summary



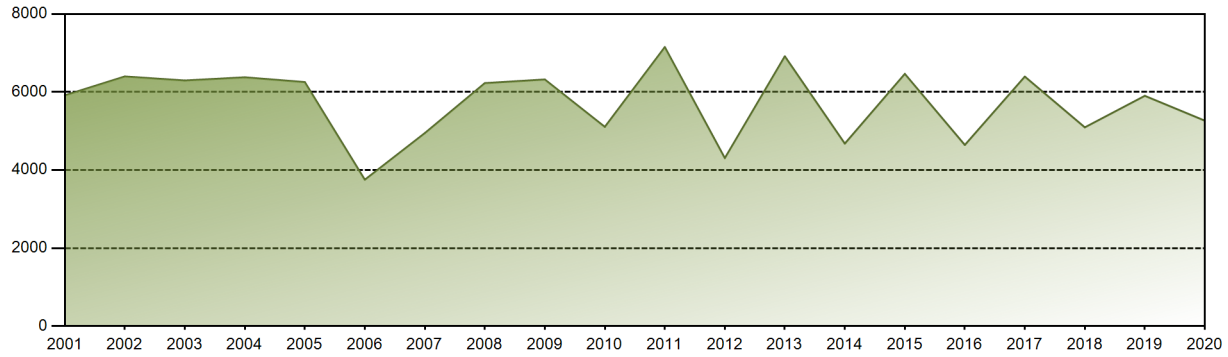
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	659.52	569.17	673.37	650.80	665.07	629.73	564.19	220.12	0.00	0.00	52.75	580.85	5265.57
EAF [%]	97.23	91.91	99.32	99.63	98.25	95.60	82.86	32.35	0.00	0.00	8.01	85.09	65.86
UCF [%]	99.93	99.44	99.32	99.88	98.90	99.63	99.84	50.17	0.00	0.00	8.01	98.91	71.21
LF [%]	96.88	89.37	99.05	98.79	97.70	95.59	82.88	32.33	0.00	0.00	8.01	85.32	65.51
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	45.03	0.00	0.00	23.89	86.56	71.29
FLR [%]	0.04	0.47	0.02	0.06	0.91	0.27	0.00	0.00	0.00	0.00	47.03	0.11	1.03
UCL [%]	0.04	0.47	0.02	0.06	0.91	0.27	0.00	0.00	0.00	9.66	83.17	0.11	7.79
PUF [%]	0.03	0.09	0.67	0.06	0.18	0.10	0.16	49.83	100.00	90.34	8.82	0.98	20.99
XUF [%]	2.70	7.52	0.00	0.25	0.65	4.03	16.98	17.83	0.00	0.00	0.00	13.82	5.35

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Historical Summary

Lifetime energy generation	:	204873.12 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.35 %
Cumulative Energy Availability Factor (EAF)	:	75.72 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.77 %
Cumulative Unit Capability Factor (UCF)	:	78.19 %	Cumulative Planned Unavailability Factor (PUF)	:	14.03 %
Cumulative Load Factor (LF)	:	71.39 %	Cumulative Externally cause unavailability (XUF)	:	2.48 %
Cumulative Operating Factor (OF)	:	76.87 %			

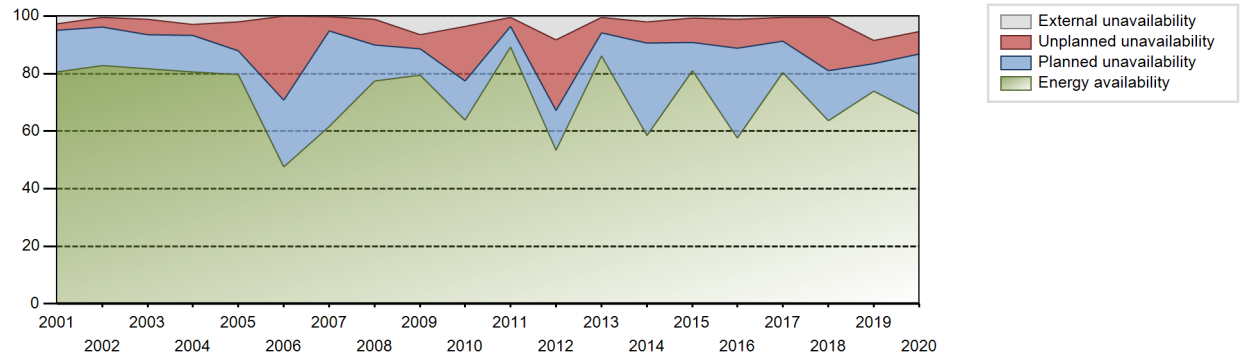
Electricity Production (net) [GWh]



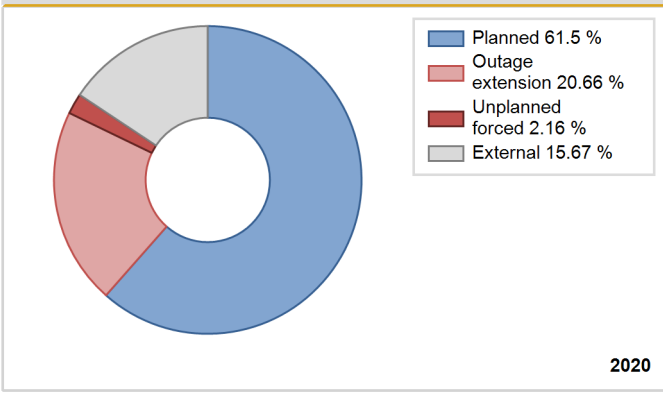
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	5773.60	7434	880	85.67	87.12	73.53	84.32	12.88	12.88	0.00	1.45
1986	5452.60	6816	880	76.67	80.33	70.73	77.81	0.60	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

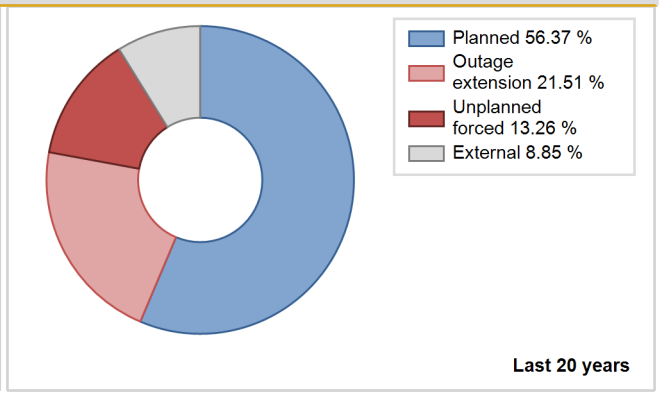
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					472	
B. Refuelling without maintenance				164		
C. Inspection, maintenance or repair combined with refuelling				814	38	
D. Inspection, maintenance or repair without refuelling				7		
E. Testing of plant systems or components				9	2	
G. Major backfitting, refurbishment or upgrading activities without refuelling				74		
H. Nuclear regulatory requirements					2	
J. Grid limitation, failure or grid unavailability						1
L. Human factor related					18	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						26
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					24	
Subtotal				1068	556	94
Total		**0**			**1718**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		25
14. Safety Systems		20
15. Reactor Cooling Systems		34
16. Steam generation systems		92
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries		76
32. Feedwater and Main Steam System		14
34. Miscellaneous Systems		135
41. Main Generator Systems		27
42. Electrical Power Supply Systems		30
Total		**472**

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2020 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

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	:	1975-02-01
Grid Date	:	1980-03-23
Commercial Date	:	1980-09-10
Age at end of year	:	40 years

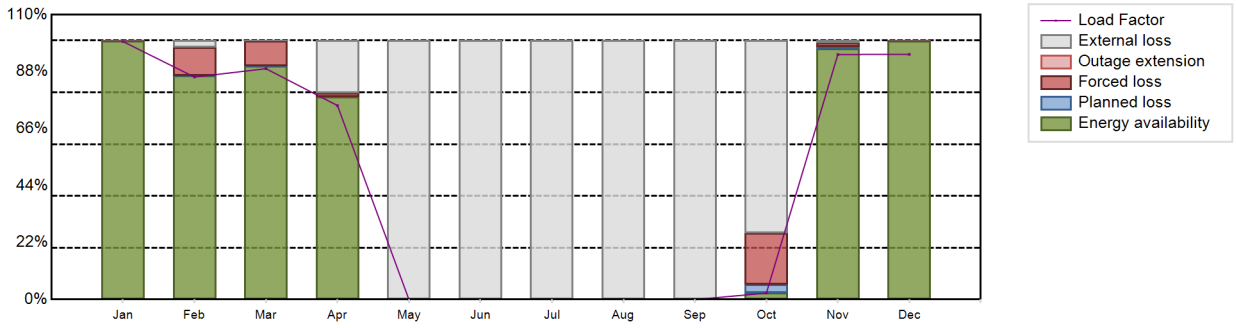
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	3511.39 GW(e).h
Energy Availability Factor (EAF)	:	45.96 %
Unit Capability Factor (UCF)	:	96.01 %
Load Factor (LF)	:	44.92 %
Operating Factor (OF)	:	47.03 %
Forced Loss Rate (FLR)	:	3.66 %
Unplanned Capability Loss Factor (UCL)	:	3.65 %
Planned Unavailability Factor (PUF)	:	0.34 %
Externally cause unavailability (XUF)	:	50.05 %
Total off-line time	:	4653 hours

Annual Summary



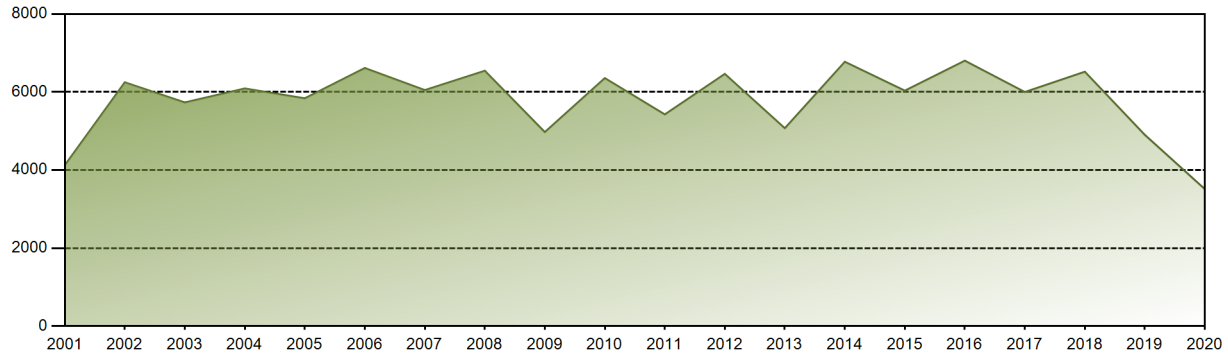
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	659.70	532.18	589.53	480.08	0.00	0.00	0.00	0.00	0.00	16.45	606.44	627.02	3511.39
EAF [%]	99.92	86.40	90.13	78.30	0.00	0.00	0.00	0.00	0.00	2.50	96.87	99.88	45.96
UCF [%]	99.92	89.04	90.19	98.57	100.00	100.00	100.00	100.00	100.00	76.77	97.74	99.88	96.01
LF [%]	99.63	85.91	89.15	74.92	0.00	0.00	0.00	0.00	0.00	2.48	94.64	94.69	44.92
OF [%]	100.00	89.66	90.85	80.00	0.00	0.00	0.00	0.00	0.00	6.44	100.00	100.00	47.03
FLR [%]	0.06	10.94	9.77	1.42	0.00	0.00	0.00	0.00	0.00	20.68	1.54	0.12	3.66
UCL [%]	0.06	10.94	9.76	1.42	0.00	0.00	0.00	0.00	0.00	20.02	1.53	0.12	3.65
PUF [%]	0.01	0.02	0.05	0.01	0.00	0.00	0.00	0.00	0.00	3.21	0.73	0.00	0.34
XUF [%]	0.00	2.65	0.06	20.27	100.00	100.00	100.00	100.00	100.00	74.27	0.87	0.00	50.05

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Historical Summary

Lifetime energy generation	:	227598.56 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.02 %
Cumulative Energy Availability Factor (EAF)	:	76 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.15 %
Cumulative Unit Capability Factor (UCF)	:	78.52 %	Cumulative Planned Unavailability Factor (PUF)	:	14.33 %
Cumulative Load Factor (LF)	:	72.06 %	Cumulative Externally cause unavailability (XUF)	:	2.52 %
Cumulative Operating Factor (OF)	:	78.08 %			

Electricity Production (net) [GWh]

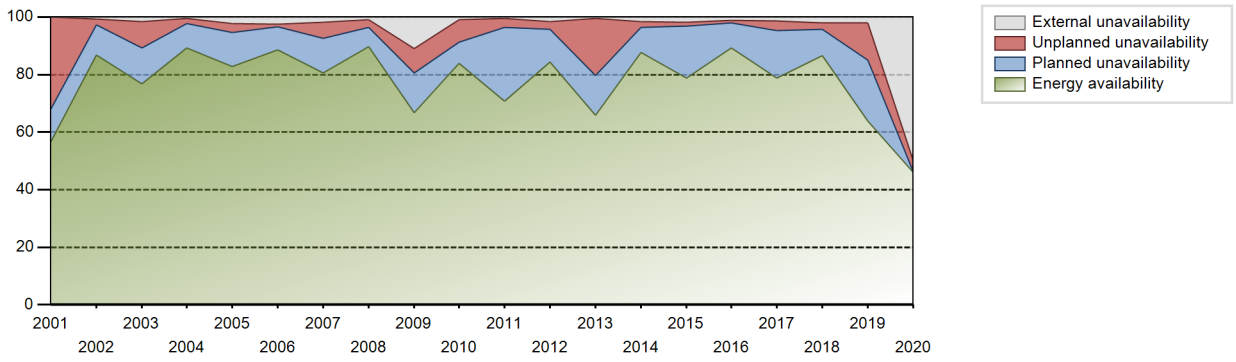


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	2764.00	3950	898	61.91	61.91	69.14	73.12	5.60	3.67	34.41	0.00
1981	4322.10	5270	900	55.90	55.90	54.82	60.16	14.79	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

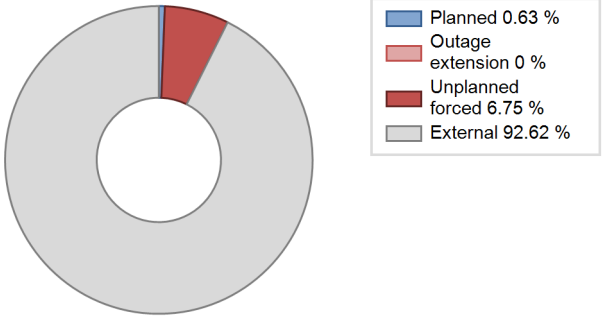
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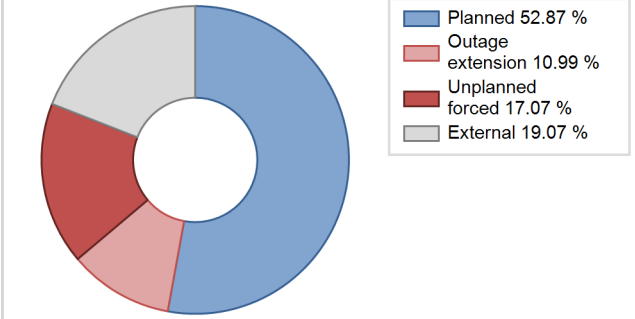
2017	6000.03	7027	890	78.72	79.99	76.96	80.22	0.30	3.42	16.59	1.27
2018	6520.92	7824	890	86.61	88.58	83.64	89.32	1.40	2.23	9.19	1.97
2019	4901.76	5699	890	63.90	65.93	62.87	65.06	10.34	12.95	21.11	2.03
2020	3511.39	4131	890	45.96	96.01	44.92	47.03	3.66	3.65	0.34	50.05

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					316	
B. Refuelling without maintenance				135		
C. Inspection, maintenance or repair combined with refuelling				1002	26	
D. Inspection, maintenance or repair without refuelling				47	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					28	
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.)						53
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					5	1
Z. Other					132	
Subtotal				1186	509	60
Total	**0**			**1755**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		10
12. Reactor I&C Systems		29
13. Reactor Auxiliary Systems		12
14. Safety Systems		9
15. Reactor Cooling Systems		32
16. Steam generation systems		38
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		15
32. Feedwater and Main Steam System		22
33. Circulating Water System		1
34. Miscellaneous Systems		82
35. All other I&C Systems		1
41. Main Generator Systems		44
42. Electrical Power Supply Systems		18
Total		**315**

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2020 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

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	:	1975-04-01
Grid Date	:	1980-12-10
Commercial Date	:	1981-02-16
Age at end of year	:	40 years

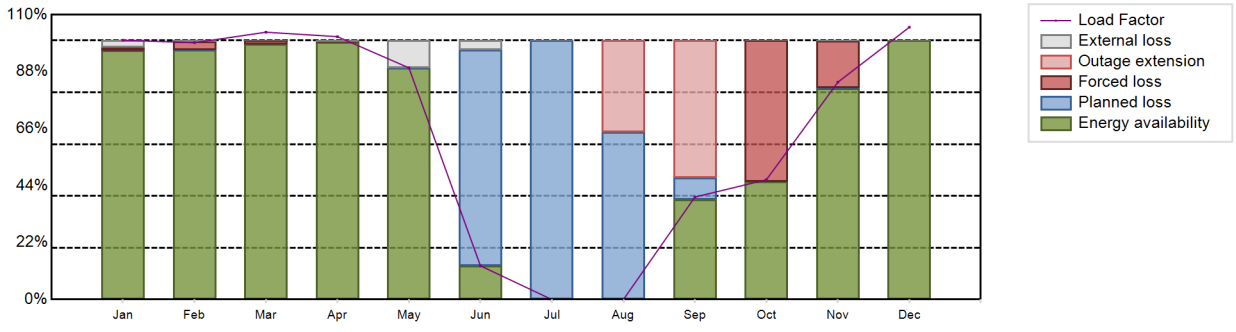
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	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 (2020)

Net Energy Production	:	5081.11 GW(e).h	Forced Loss Rate (FLR)	:	9.29 %
Energy Availability Factor (EAF)	:	63.08 %	Unplanned Capability Loss Factor (UCL)	:	13.96 %
Unit Capability Factor (UCF)	:	64.56 %	Planned Unavailability Factor (PUF)	:	21.48 %
Load Factor (LF)	:	64.99 %	Externally cause unavailability (XUF)	:	1.48 %
Operating Factor (OF)	:	68.44 %	Total off-line time	:	2772 hours

Annual Summary



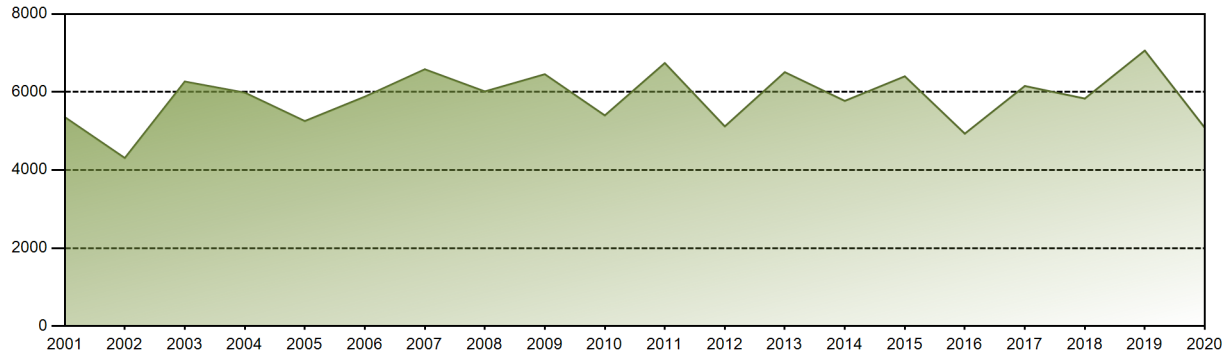
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	663.12	614.42	682.67	650.58	592.42	83.42	0.00	0.00	253.55	306.74	537.88	696.30	5081.11
EAF [%]	96.13	96.32	98.56	99.45	89.47	13.02	0.00	0.00	38.53	45.49	81.62	100.00	63.08
UCF [%]	98.87	96.64	98.56	99.82	99.97	16.60	0.00	0.00	38.53	45.49	81.70	100.00	64.56
LF [%]	100.15	99.19	103.24	101.53	89.47	13.02	0.00	0.00	39.57	46.26	83.94	105.16	64.99
OF [%]	100.00	100.00	100.00	100.00	100.00	16.67	0.00	0.00	47.08	59.33	100.00	100.00	68.44
FLR [%]	1.11	3.35	1.44	0.18	0.00	0.00	0.00	0.00	0.00	54.51	18.25	0.00	9.29
UCL [%]	1.11	3.34	1.44	0.18	0.00	0.00	0.00	35.48	52.94	54.51	18.24	0.00	13.96
PUF [%]	0.03	0.01	0.00	0.00	0.03	83.40	100.00	64.52	8.54	0.00	0.06	0.00	21.48
XUF [%]	2.73	0.32	0.00	0.37	10.50	3.58	0.00	0.00	0.00	0.00	0.09	0.00	1.48

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Historical Summary

Lifetime energy generation	:	222441.52 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.68 %
Cumulative Energy Availability Factor (EAF)	:	77 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7 %
Cumulative Unit Capability Factor (UCF)	:	78.7 %	Cumulative Planned Unavailability Factor (PUF)	:	14.29 %
Cumulative Load Factor (LF)	:	71.27 %	Cumulative Externally cause unavailability (XUF)	:	1.7 %
Cumulative Operating Factor (OF)	:	77.17 %			

Electricity Production (net) [GWh]

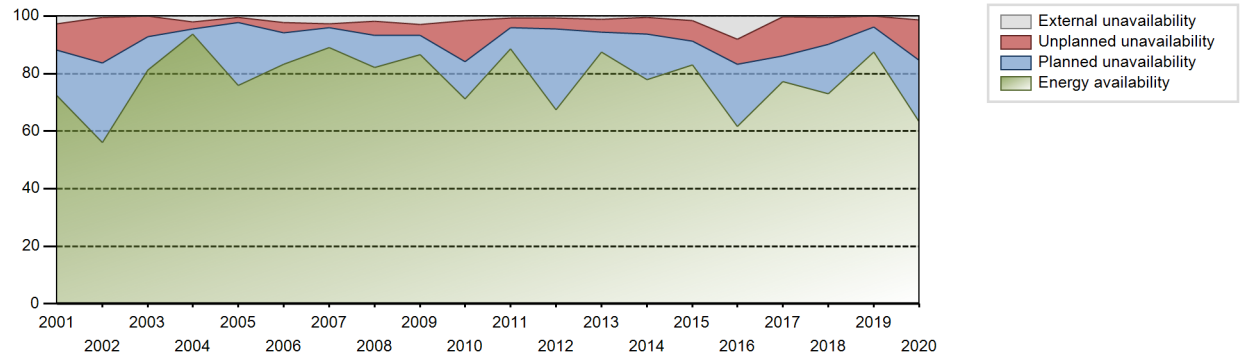


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	5818.40	7306	900	75.54	75.54	73.88	81.74	3.68	2.89	21.58	0.00
1982	4110.80	4848	890	53.04	53.04	52.73	55.34	19.31	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

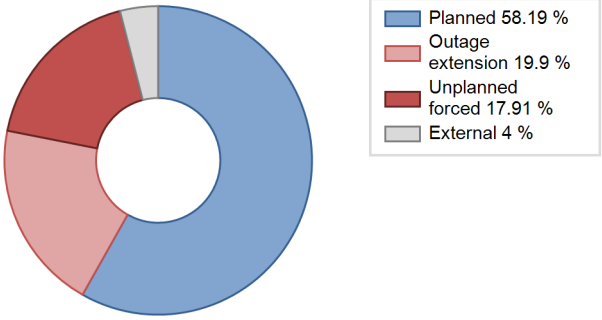
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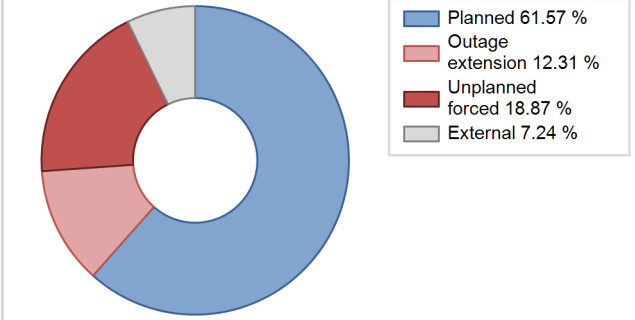
2018	5831.89	6585	890	72.94	73.46	74.80	75.17	5.93	9.23	17.30	0.53
2019	7062.17	7793	890	87.56	87.57	90.58	88.96	4.20	3.84	8.58	0.01
2020	5081.11	6012	890	63.08	64.56	64.99	68.44	9.29	13.96	21.48	1.48

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					344	
B.	Refuelling without maintenance				117		
C.	Inspection, maintenance or repair combined with refuelling				961	12	
D.	Inspection, maintenance or repair without refuelling				57		
E.	Testing of plant systems or components				3	0	
H.	Nuclear regulatory requirements					3	
J.	Grid limitation, failure or grid unavailability						3
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						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.)						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	21
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					9	
Z.	Other					101	16
Subtotal					1138	484	42
Total			**0**			**1664**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		4
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		11
14. Safety Systems		22
15. Reactor Cooling Systems		36
16. Steam generation systems		37
21. Fuel Handling and Storage Facilities		7
31. Turbine and auxiliaries		52
32. Feedwater and Main Steam System		14
34. Miscellaneous Systems		79
35. All other I&C Systems		0
41. Main Generator Systems		37
42. Electrical Power Supply Systems		48
Total		**359**

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2020 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

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	:	1975-09-01
Grid Date	:	1981-01-30
Commercial Date	:	1981-05-27
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

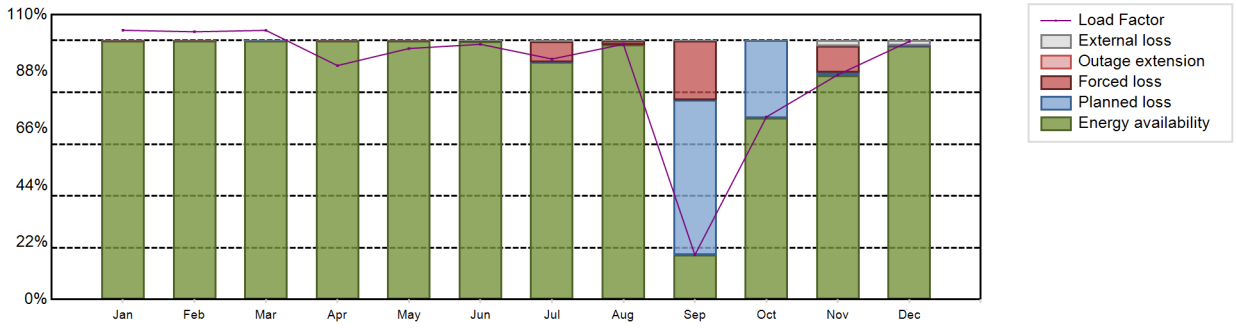
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	5.45
Output voltage [kV]	:	-
Primary means of condenser cooling	:	-
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 (2020)

Net Energy Production	:	6930.71 GW(e).h
Energy Availability Factor (EAF)	:	88.5 %
Unit Capability Factor (UCF)	:	88.9 %
Load Factor (LF)	:	88.65 %
Operating Factor (OF)	:	90.26 %

Forced Loss Rate (FLR)	:	3.82 %
Unplanned Capability Loss Factor (UCL)	:	3.53 %
Planned Unavailability Factor (PUF)	:	7.57 %
Externally cause unavailability (XUF)	:	0.4 %
Total off-line time	:	856 hours

Annual Summary



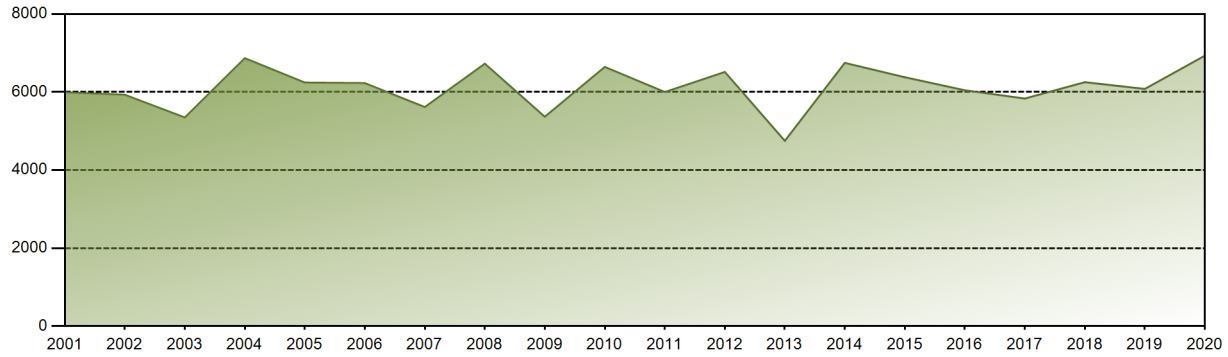
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	688.52	640.51	687.33	578.95	641.87	631.65	615.10	652.70	110.41	467.37	556.29	660.01	6930.71
EAF [%]	99.98	99.90	99.97	99.92	99.99	99.68	91.76	98.31	17.10	70.11	86.47	97.90	88.50
UCF [%]	99.98	99.90	99.97	99.92	99.99	99.73	92.15	98.53	17.12	70.11	88.69	99.80	88.90
LF [%]	103.98	103.40	103.94	90.35	96.94	98.57	92.89	98.57	17.23	70.49	86.81	99.67	88.65
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	17.50	73.96	90.56	100.00	90.26
FLR [%]	0.01	0.09	0.00	0.07	0.00	0.20	7.84	1.38	57.20	0.00	10.27	0.16	3.82
UCL [%]	0.01	0.09	0.00	0.07	0.00	0.20	7.84	1.38	22.88	0.00	10.15	0.16	3.53
PUF [%]	0.01	0.01	0.03	0.01	0.01	0.07	0.01	0.09	60.00	29.89	1.16	0.04	7.57
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.05	0.39	0.22	0.02	0.00	2.22	1.90	0.40

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Historical Summary

Lifetime energy generation	:	231675.3 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.49 %
Cumulative Energy Availability Factor (EAF)	:	78.02 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.89 %
Cumulative Unit Capability Factor (UCF)	:	79.83 %	Cumulative Planned Unavailability Factor (PUF)	:	14.28 %
Cumulative Load Factor (LF)	:	74.61 %	Cumulative Externally cause unavailability (XUF)	:	1.81 %
Cumulative Operating Factor (OF)	:	79.46 %			

Electricity Production (net) [GWh]

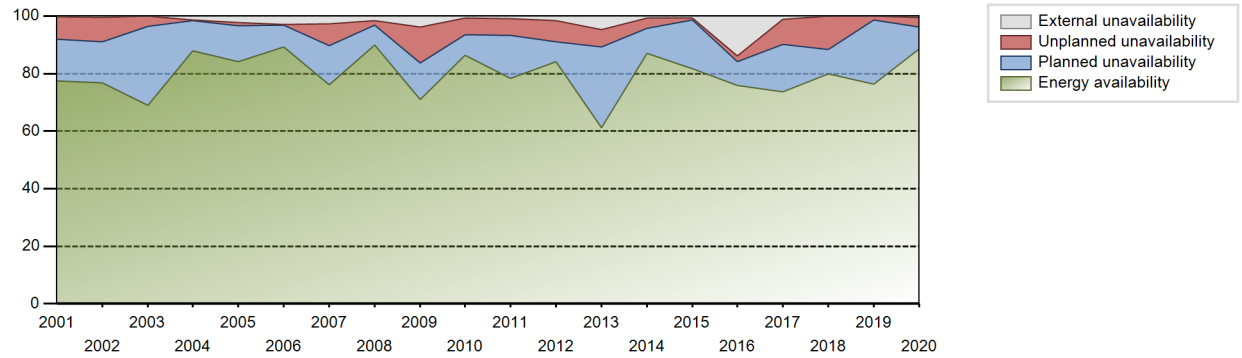


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	5123.40	6452	900	83.51	83.51	81.70	86.95	3.93	3.41	13.08	0.00
1982	3767.60	4632	890	48.72	48.72	48.32	52.88	22.04	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

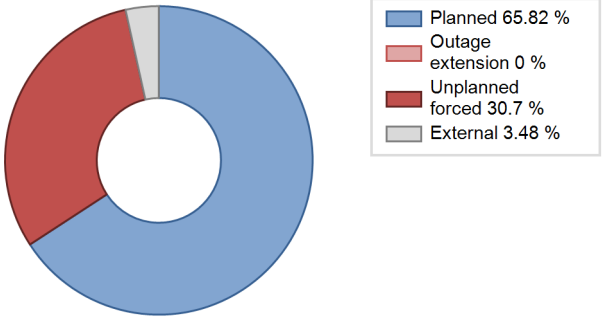
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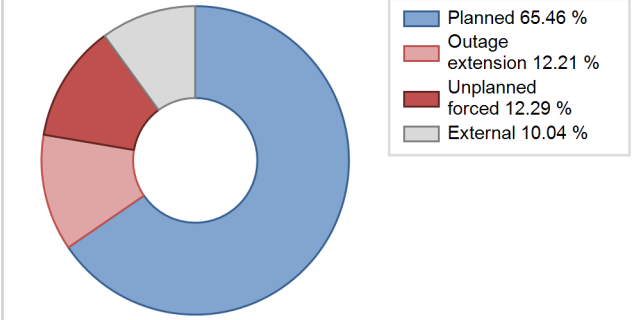
2018	6252.31	7054	890	79.82	79.84	80.19	80.53	7.26	11.58	8.58	0.02
2019	6079.01	6794	890	76.33	76.40	77.97	77.56	1.66	1.29	22.31	0.08
2020	6930.71	7928	890	88.50	88.90	88.65	90.26	3.82	3.53	7.57	0.40

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					309	
B.	Refuelling without maintenance				97		
C.	Inspection, maintenance or repair combined with refuelling				1077	7	
D.	Inspection, maintenance or repair without refuelling				21	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					25	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						0
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.)					3	47
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					5	1
Z.	Other					73	
Subtotal					1199	424	50
Total			**0**			**1673**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	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		29
15. Reactor Cooling Systems		47
16. Steam generation systems		65
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System		8
33. Circulating Water System		1
34. Miscellaneous Systems		76
35. All other I&C Systems		2
41. Main Generator Systems		24
42. Electrical Power Supply Systems		37
Total		**336**

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2020 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	:	39 years

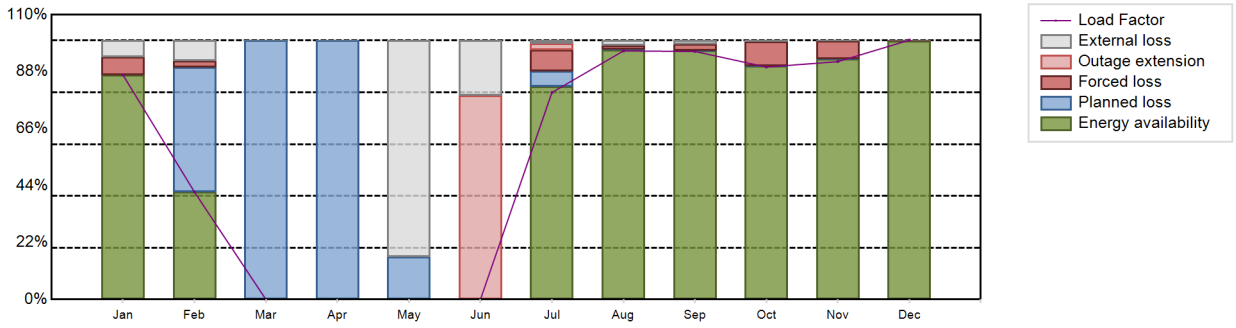
Design Characteristics

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]	:	5.61
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 (2020)

Net Energy Production	:	4457.67 GW(e).h	Forced Loss Rate (FLR)	:	4.5 %
Energy Availability Factor (EAF)	:	57.37 %	Unplanned Capability Loss Factor (UCL)	:	9.85 %
Unit Capability Factor (UCF)	:	67.77 %	Planned Unavailability Factor (PUF)	:	22.38 %
Load Factor (LF)	:	57.02 %	Externally cause unavailability (XUF)	:	10.4 %
Operating Factor (OF)	:	60.74 %	Total off-line time	:	3449 hours

Annual Summary



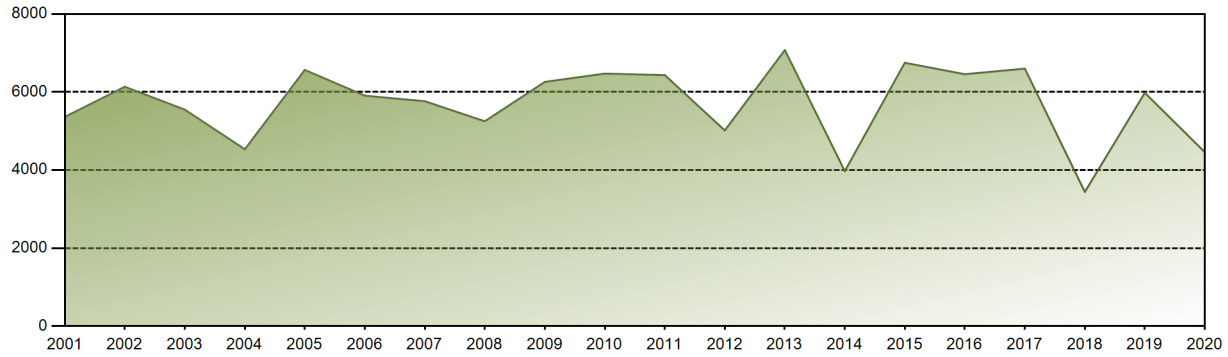
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	574.17	257.12	0.00	0.00	0.00	0.00	529.47	635.69	613.96	595.25	588.68	663.31	4457.67
EAF [%]	86.72	41.51	0.00	0.00	0.00	0.00	82.21	96.44	96.09	90.16	92.88	99.98	57.37
UCF [%]	93.18	49.35	0.00	0.00	83.61	21.29	83.41	98.21	97.54	90.53	92.89	99.98	67.77
LF [%]	86.71	41.51	0.00	0.00	0.00	0.00	79.96	96.00	95.81	89.77	91.87	100.17	57.02
OF [%]	100.00	51.87	0.00	0.00	0.00	0.00	92.47	100.00	100.00	90.34	91.81	100.00	60.74
FLR [%]	6.82	4.60	0.00	0.00	0.00	0.03	9.03	1.67	2.42	9.47	7.07	0.02	4.50
UCL [%]	6.82	2.38	0.00	0.00	0.00	78.70	10.72	1.67	2.42	9.47	7.06	0.02	9.85
PUF [%]	0.00	48.27	100.00	100.00	16.39	0.01	5.87	0.12	0.04	0.00	0.04	0.00	22.38
XUF [%]	6.46	7.84	0.00	0.00	83.61	21.28	1.20	1.77	1.45	0.38	0.02	0.00	10.40

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Historical Summary

Lifetime energy generation	:	218864.65 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.54 %
Cumulative Energy Availability Factor (EAF)	:	75.51 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.43 %
Cumulative Unit Capability Factor (UCF)	:	77.92 %	Cumulative Planned Unavailability Factor (PUF)	:	13.65 %
Cumulative Load Factor (LF)	:	71.5 %	Cumulative Externally cause unavailability (XUF)	:	2.41 %
Cumulative Operating Factor (OF)	:	77.56 %			

Electricity Production (net) [GWh]

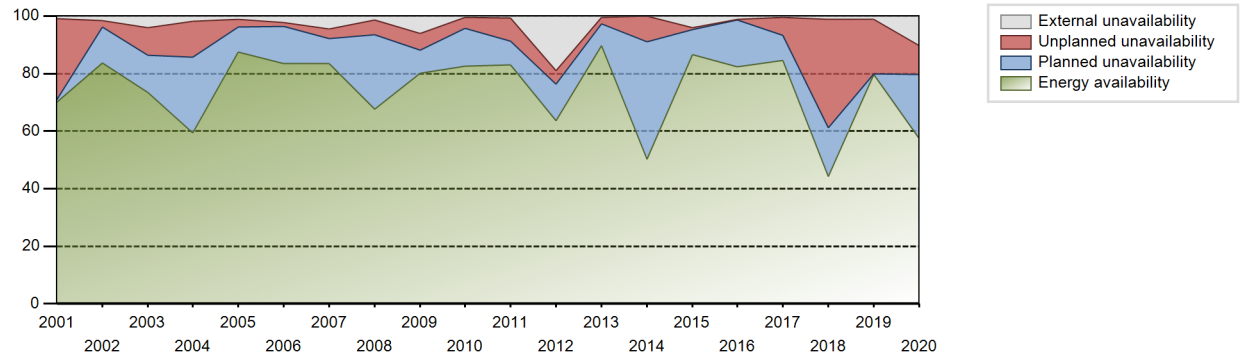


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	1569.50	2392	894	77.30	77.30	77.30	79.30	0.00	0.00	22.70	0.00
1982	5745.60	7413	890	81.81	81.81	73.70	84.62	18.19	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

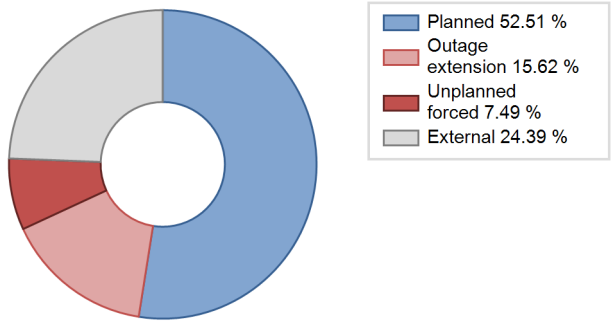
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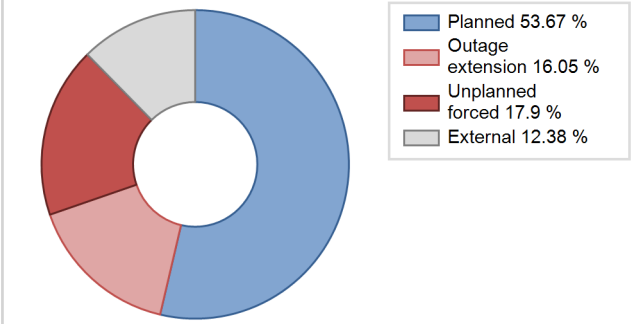
2018	3438.52	4116	890	44.32	45.36	44.10	46.99	4.16	37.73	16.91	1.03
2019	5979.78	7196	890	79.76	80.98	76.70	82.15	19.00	19.00	0.03	1.21
2020	4457.67	5335	890	57.37	67.77	57.02	60.74	4.50	9.85	22.38	10.40

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					491	
B.	Refuelling without maintenance				102		
C.	Inspection, maintenance or repair combined with refuelling				983	22	
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)						13
L.	Human factor related					19	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						6
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	66
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					7	1
Z.	Other					67	6
Subtotal					1093	613	93
Total			**0**			**1799**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		39
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		40
14. Safety Systems		9
15. Reactor Cooling Systems		14
16. Steam generation systems		140
21. Fuel Handling and Storage Facilities		10
31. Turbine and auxiliaries		32
32. Feedwater and Main Steam System		24
33. Circulating Water System		1
34. Miscellaneous Systems		92
35. All other I&C Systems		1
41. Main Generator Systems		74
42. Electrical Power Supply Systems		8
Total		**488**

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2020 Operating Experience

FR-11 FESSENHEIM-1 FRANCE

Status at end of year	:	**Permanent Shutdown**
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	:	920 MWe
Reference unit power (net)	:	880 MWe

Key Dates

Construction Date	:	1971-09-01
Grid Date	:	1977-04-06
Commercial Date	:	1978-01-01
Age at end of year	:	43 years

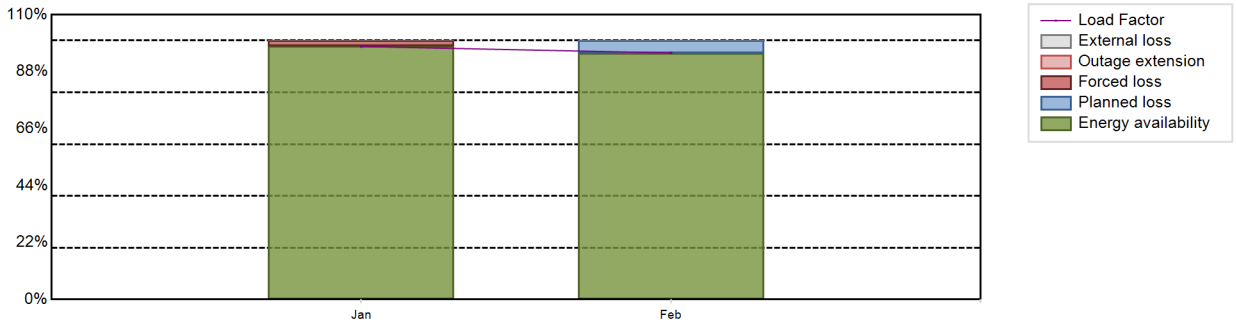
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
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]	:	5
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	14	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	33	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	44000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	5.257
Active core height/length [m]	:	3.66	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	157	Primary means of condenser cooling	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	17.8	Number of main condensate pumps	:	-
Number of control rod assemblies	:	48	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 (2020)

Net Energy Production	:	1082.25 GW(e).h	Forced Loss Rate (FLR)	:	1.29 %
Energy Availability Factor (EAF)	:	96.7 %	Unplanned Capability Loss Factor (UCL)	:	1.26 %
Unit Capability Factor (UCF)	:	96.7 %	Planned Unavailability Factor (PUF)	:	2.03 %
Load Factor (LF)	:	96.68 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	98.27 %	Total off-line time	:	22 hours

Annual Summary



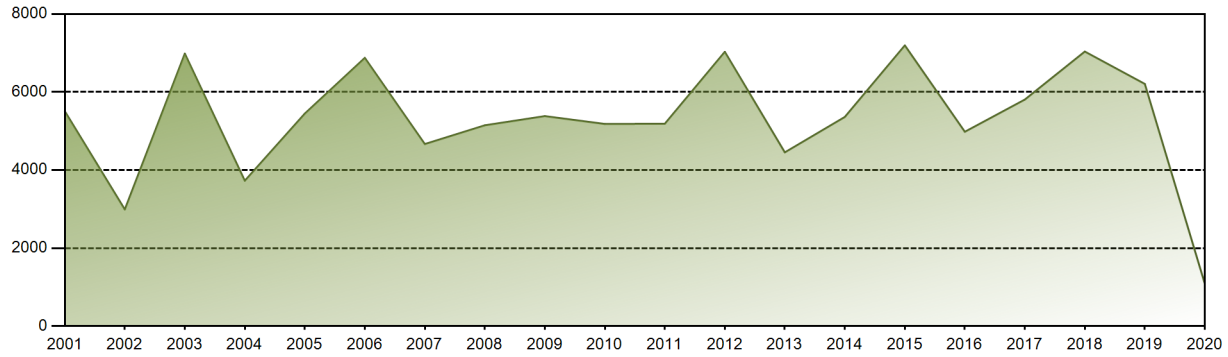
	Oct	Nov	Dec	Mar	Apr	May	Jun	Jul	Sep	Aug	Jan	Feb	Annual
GW(e)-h											639.78	442.47	1082.25
EAF [%]											97.84	95.10	96.70
UCF [%]											97.84	95.10	96.70
LF [%]											97.72	95.23	96.68
OF [%]											100.00	95.83	98.27
FLR [%]											2.16	0.00	1.29
UCL [%]											2.16	0.00	1.26
PUF [%]											0.00	4.90	2.03
XUF [%]											0.00	0.00	0.00

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Historical Summary

Lifetime energy generation	:	226734.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	11.57 %
Cumulative Energy Availability Factor (EAF)	:	72.18 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.82 %
Cumulative Unit Capability Factor (UCF)	:	73.61 %	Cumulative Planned Unavailability Factor (PUF)	:	14.57 %
Cumulative Load Factor (LF)	:	69.46 %	Cumulative Externally cause unavailability (XUF)	:	1.43 %
Cumulative Operating Factor (OF)	:	74.07 %			

Electricity Production (net) [GWh]

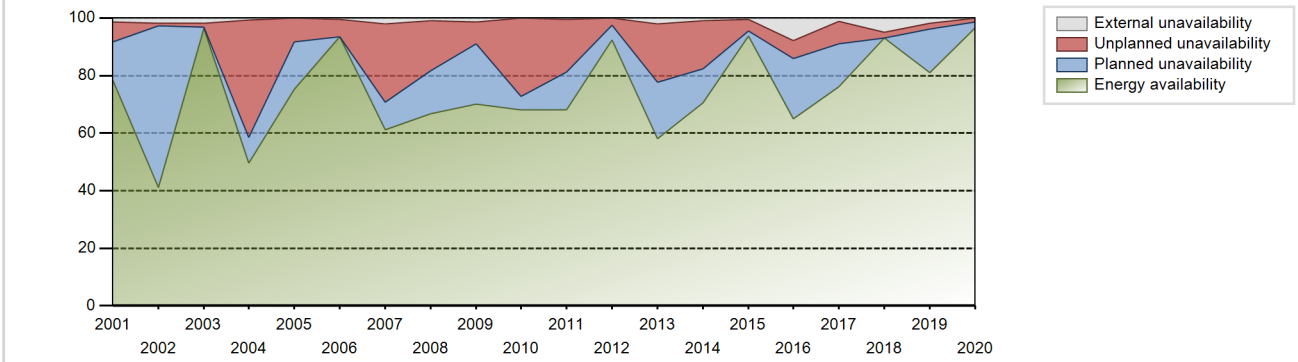


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1978	6079.20	7302	890	78.17	78.17	77.97	83.36	21.83	21.83	0.00	0.00
1979	4542.00	5338	890	58.75	58.75	58.26	60.94	3.91	2.39	38.85	0.00
1980	5510.00	6350	890	70.74	70.74	70.48	72.29	15.86	13.34	15.92	0.00
1981	5065.30	5844	890	65.30	65.30	64.97	66.71	17.87	14.21	20.49	0.00
1982	1848.20	2138	880	24.01	24.01	23.98	24.41	75.17	72.68	3.31	0.00
1983	5690.00	6701	880	75.33	75.33	73.81	76.50	2.54	1.97	22.71	0.00
1984	6503.00	7731	880	85.18	85.18	84.13	88.01	4.53	4.04	10.78	0.00
1985	6044.60	7105	880	79.84	80.36	78.41	81.11	4.16	3.49	16.15	0.53
1986	5661.30	6702	880	74.74	75.06	73.44	76.51	13.65	11.87	13.08	0.32
1987	5029.60	6147	880	73.60	74.13	65.24	70.17	25.87	25.87	0.00	0.53
1988	5399.00	7069	880	77.87	86.47	69.85	80.48	0.89	0.78	12.76	8.60
1989	3253.33	4108	880	43.44	46.13	42.20	46.89	26.19	16.37	37.50	2.69
1990	5036.69	6481	880	74.58	79.61	65.34	73.98	8.38	7.28	13.11	5.02
1991	4053.54	4900	880	55.47	55.75	52.58	55.94	23.22	16.86	27.39	0.27
1992	4867.06	6079	880	66.87	67.18	62.96	69.21	31.61	31.05	1.77	0.31
1993	5548.68	7161	880	74.64	80.96	71.98	81.75	2.78	2.31	16.73	6.32
1994	6186.14	7508	880	86.45	87.39	80.25	85.71	0.96	0.84	11.76	0.94
1995	5856.09	6990	880	84.68	85.51	75.97	79.79	0.92	0.79	13.70	0.83
1996	6164.97	7544	880	85.21	85.35	79.75	85.88	2.19	1.91	12.74	0.14
1997	5826.79	7209	880	81.53	81.60	75.59	82.29	4.77	4.09	14.31	0.07
1998	4617.05	5727	880	61.66	64.30	59.89	65.38	7.87	5.50	30.20	2.64
1999	5228.79	6283	880	70.80	71.16	67.83	71.72	6.81	5.20	23.64	0.36
2000	5782.65	7145	880	80.82	81.08	74.81	81.34	11.07	10.10	8.83	0.25
2001	5507.53	7095	880	78.36	79.64	71.44	80.99	8.04	6.96	13.40	1.28
2002	2989.75	3832	880	41.08	42.92	38.78	43.74	2.12	0.93	56.15	1.84
2003	6985.20	8518	880	96.45	98.18	90.61	97.24	1.54	1.53	0.29	1.72
2004	3726.49	4500	880	49.64	50.24	48.21	51.23	44.83	40.82	8.94	0.60
2005	5448.42	6673	880	75.32	75.38	70.68	76.18	2.30	8.17	16.45	0.06
2006	6875.72	8338	880	93.50	94.09	89.19	95.18	5.90	5.90	0.01	0.58
2007	4666.98	5715	880	61.11	63.24	60.54	65.24	11.57	27.22	9.54	2.13
2008	5147.36	6120	880	66.84	67.85	66.59	69.67	2.69	17.25	14.89	1.01
2009	5382.77	6365	880	70.10	71.39	69.83	72.66	9.81	7.76	20.85	1.29
2010	5181.48	6209	880	68.01	68.10	67.22	70.88	11.12	27.10	4.80	0.09
2011	5187.84	6197	880	68.03	68.45	67.30	70.74	4.96	18.42	13.13	0.42
2012	7031.35	8158	880	92.44	92.50	90.96	92.87	2.48	2.35	5.15	0.06
2013	4453.46	5419	880	58.06	60.17	57.77	61.86	15.40	20.17	19.66	2.10
2014	5361.14	6441	880	70.47	71.47	69.55	73.53	17.19	16.67	11.86	1.00

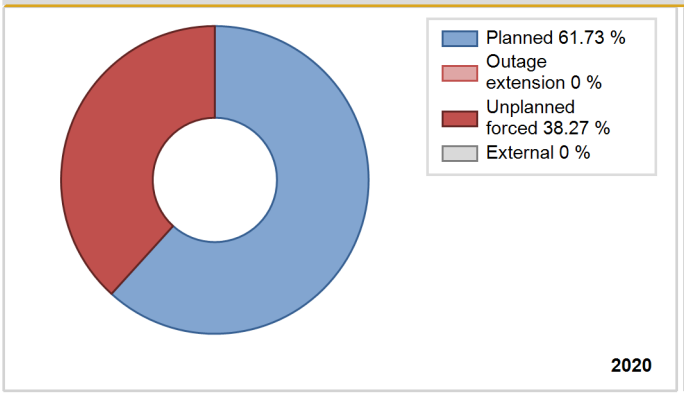
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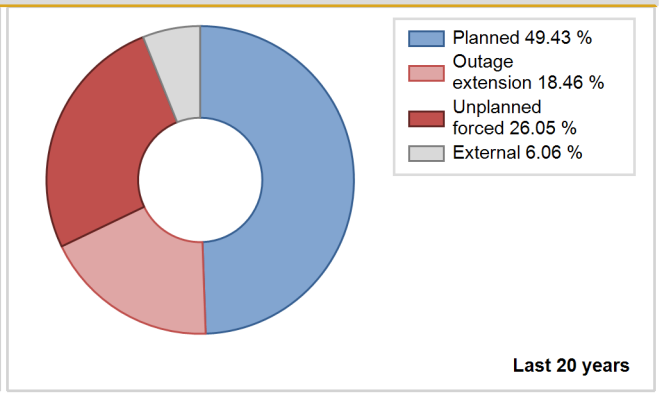
2015	7194.82	8433	880	93.80	94.39	93.33	96.27	4.01	3.94	1.67	0.60
2016	4981.46	6167	880	64.89	72.67	64.44	70.21	5.03	6.19	21.14	7.78
2017	5807.00	6803	880	76.11	77.29	75.33	77.66	3.34	7.82	14.89	1.18
2018	7037.75	8504	880	93.10	98.06	91.29	97.08	1.91	1.91	0.03	4.97
2019	6208.07	7325	880	81.03	82.73	80.53	83.62	2.55	2.16	15.10	1.70
2020	1082.25	1250	880	96.70	96.70	96.68	98.27	1.29	1.26	2.03	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1978 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					784	
B. Refuelling without maintenance				77		
C. Inspection, maintenance or repair combined with refuelling				1099	10	
D. Inspection, maintenance or repair without refuelling				53	8	
E. Testing of plant systems or components				12	1	
H. Nuclear regulatory requirements					43	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						3
L. Human factor related					84	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						5
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.)					5	16
Z. Other					2	1
Subtotal				1241	937	25
Total		**0**			**2203**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1978 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		237
12. Reactor I&C Systems		38
13. Reactor Auxiliary Systems		9
14. Safety Systems		49
15. Reactor Cooling Systems		48
16. Steam generation systems		38
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		122
32. Feedwater and Main Steam System		26
34. Miscellaneous Systems		78
35. All other I&C Systems		6
41. Main Generator Systems		84
42. Electrical Power Supply Systems		52
Total		**789**

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2020 Operating Experience

FR-12 FESSENHEIM-2 FRANCE



Status at end of year	:	**Permanent Shutdown**
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	:	920 MWe
Reference unit power (net)	:	880 MWe

Key Dates

Construction Date	:	1972-02-01
Grid Date	:	1977-10-07
Commercial Date	:	1978-04-01
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]	:	16
Part of the core refuelled [%]	:	33
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]	:	17.8
Number of control rod assemblies	:	48
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

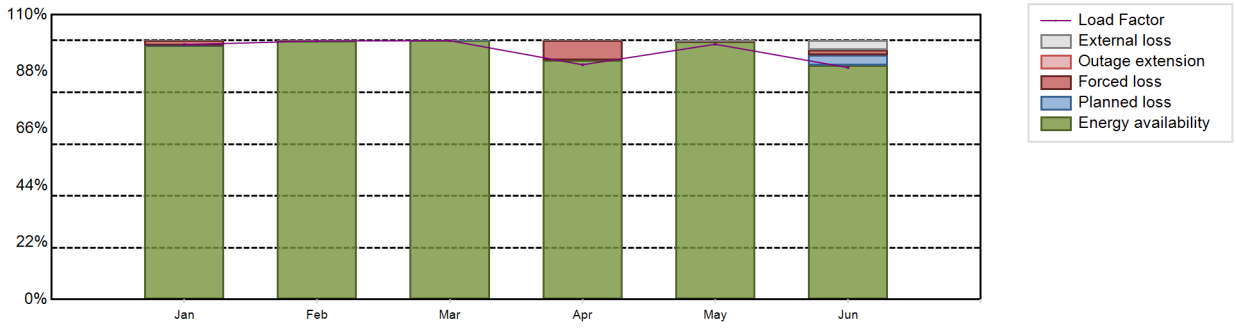
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	332
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	5.257
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 (2020)

Net Energy Production	:	3697.08 GW(e).h
Energy Availability Factor (EAF)	:	96.78 %
Unit Capability Factor (UCF)	:	97.43 %
Load Factor (LF)	:	96.2 %
Operating Factor (OF)	:	97.25 %

Forced Loss Rate (FLR)	:	1.91 %
Unplanned Capability Loss Factor (UCL)	:	1.9 %
Planned Unavailability Factor (PUF)	:	0.67 %
Externally cause unavailability (XUF)	:	0.65 %
Total off-line time	:	120 hours

Annual Summary



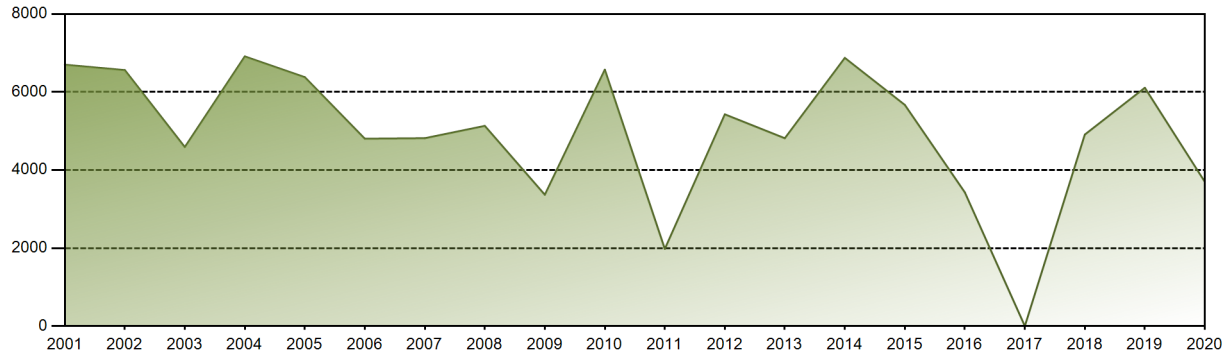
	Sep	Oct	Nov	Dec	Jul	Aug	Jan	Feb	Mar	Apr	May	Jun	Annual
GW(e)-h							644.48	611.46	653.71	574.45	645.44	567.54	3697.08
EAF [%]							98.08	99.98	99.99	92.40	99.65	90.44	96.78
UCF [%]							98.08	99.98	99.99	92.40	99.99	94.06	97.43
LF [%]							98.44	99.83	99.98	90.67	98.58	89.57	96.20
OF [%]							98.39	100.00	100.00	92.50	100.00	92.50	97.25
FLR [%]							1.92	0.02	0.00	7.60	0.00	1.99	1.91
UCL [%]							1.92	0.02	0.00	7.60	0.00	1.91	1.90
PUF [%]							0.00	0.00	0.01	0.00	0.01	4.02	0.67
XUF [%]							0.00	0.00	0.00	0.00	0.33	3.62	0.65

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Historical Summary

Lifetime energy generation	:	220567.97 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.09 %
Cumulative Energy Availability Factor (EAF)	:	70.8 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.29 %
Cumulative Unit Capability Factor (UCF)	:	72.16 %	Cumulative Planned Unavailability Factor (PUF)	:	14.55 %
Cumulative Load Factor (LF)	:	67.29 %	Cumulative Externally cause unavailability (XUF)	:	1.36 %
Cumulative Operating Factor (OF)	:	72.15 %			

Electricity Production (net) [GWh]

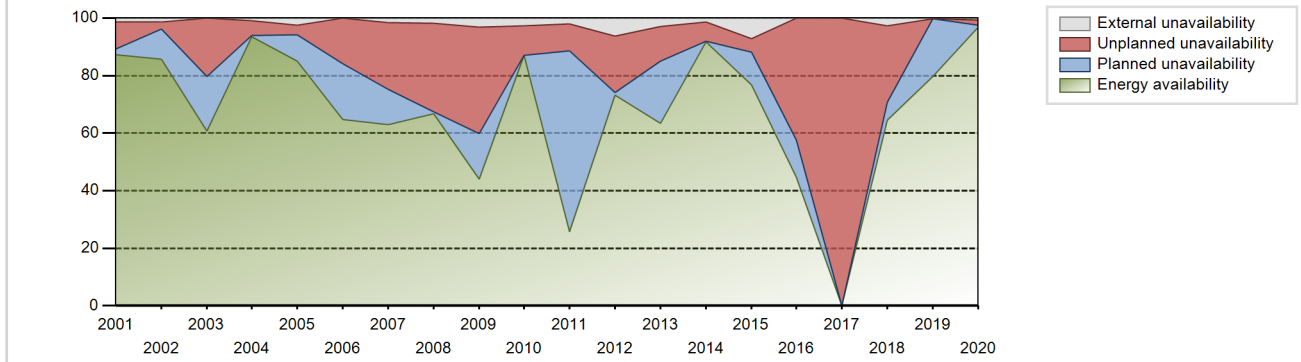


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1978	5760.40	7032	890	81.80	82.75	81.47	85.58	17.25	17.25	0.00	0.95
1979	4521.00	5684	890	58.68	58.68	57.99	64.89	6.28	3.93	37.39	0.00
1980	5601.00	6603	890	72.21	72.21	71.64	75.17	14.40	12.15	15.64	0.00
1981	6055.00	7117	890	79.45	79.45	77.66	81.24	4.79	4.00	16.55	0.00
1982	6047.90	8247	880	93.12	93.12	78.45	94.14	6.87	6.87	0.00	0.00
1983	4315.00	5206	880	58.18	58.18	55.97	59.43	20.64	15.13	26.69	0.00
1984	6459.00	7860	880	88.44	88.44	83.56	89.48	2.18	1.97	9.59	0.00
1985	5917.20	7248	880	78.64	80.02	76.76	82.74	4.74	3.99	15.99	1.38
1986	5522.50	6573	880	73.20	73.43	71.64	75.03	17.34	15.41	11.16	0.23
1987	6150.10	7335	880	82.64	83.64	79.78	83.73	4.49	3.93	12.43	1.00
1988	4830.00	6158	880	69.81	72.42	62.48	70.10	15.48	13.26	14.32	2.61
1989	5643.37	6944	880	96.16	97.01	73.21	79.27	2.93	2.93	0.07	0.85
1990	3552.40	4612	880	49.62	52.01	46.08	52.65	8.36	4.74	43.24	2.39
1991	5308.43	6537	880	72.78	73.30	68.86	74.62	12.15	10.14	16.56	0.52
1992	2202.03	2699	880	29.94	29.94	28.49	30.73	42.88	22.47	47.59	0.00
1993	5775.09	7167	880	77.57	81.03	74.92	81.82	5.47	4.69	14.28	3.46
1994	5294.89	6807	880	98.22	98.51	68.69	77.71	1.48	1.47	0.01	0.29
1995	5098.25	6305	880	70.48	71.52	66.14	71.97	17.84	15.53	12.95	1.04
1996	6192.10	7515	880	84.43	84.91	80.11	85.55	2.76	2.41	12.68	0.48
1997	5808.56	6982	880	80.01	80.56	75.35	79.70	1.59	1.31	18.13	0.55
1998	5597.00	6797	880	73.67	75.94	72.61	77.59	12.40	10.75	13.31	2.27
1999	6392.59	7708	880	86.40	87.09	82.93	87.99	1.31	1.16	11.75	0.68
2000	3730.37	4514	880	51.05	51.39	48.26	51.39	17.15	10.64	37.97	0.34
2001	6699.95	7876	880	87.27	88.59	86.91	89.91	9.56	9.37	2.04	1.32
2002	6562.58	7729	880	85.64	87.08	85.13	88.23	2.66	2.38	10.53	1.45
2003	4589.49	5434	880	60.67	60.67	59.54	62.03	25.14	20.37	18.95	0.00
2004	6913.74	8435	880	93.55	94.47	89.44	96.03	5.24	5.23	0.30	0.92
2005	6381.24	7813	880	85.07	87.62	82.77	89.18	1.76	3.38	9.00	2.55
2006	4803.12	5844	880	64.69	64.69	62.31	66.71	13.06	15.76	19.55	0.00
2007	4816.72	5781	880	62.91	64.51	62.48	65.99	15.38	23.23	12.26	1.60
2008	5131.40	6384	880	66.79	68.52	66.38	72.68	31.06	30.87	0.60	1.73
2009	3366.58	4206	880	43.92	47.10	43.67	48.01	4.83	37.00	15.90	3.18
2010	6573.08	8100	880	87.02	89.83	85.27	92.47	10.05	10.04	0.12	2.81
2011	1976.89	2521	880	25.68	27.75	25.64	28.78	3.50	9.23	63.02	2.07
2012	5427.83	6584	880	73.11	79.29	70.22	74.95	2.06	19.60	1.10	6.18
2013	4815.26	5841	880	63.34	66.22	62.46	66.68	1.98	12.02	21.76	2.88
2014	6874.97	8244	880	91.71	93.09	89.18	94.11	6.73	6.71	0.20	1.38

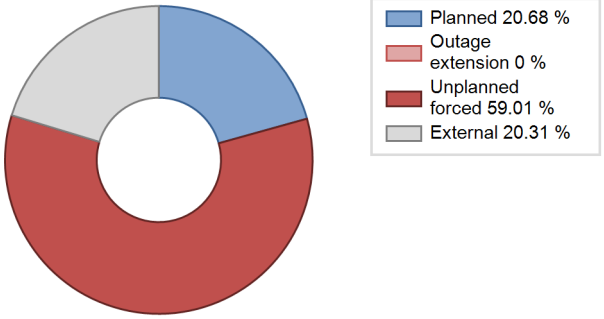
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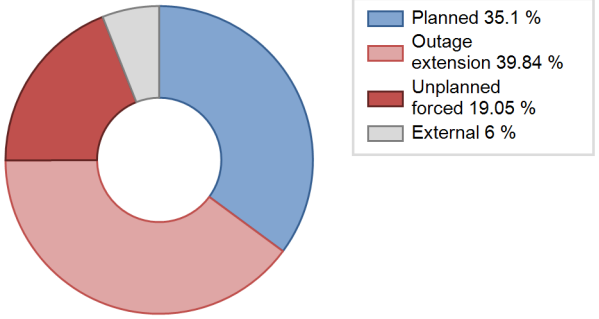
2015	5669.65	6904	880	76.73	83.88	73.55	78.81	2.53	4.65	11.47	7.15
2016	3428.20	3960	880	44.58	44.72	44.35	45.08	0.56	42.35	12.93	0.14
2017	0.00	0	880	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2018	4909.07	6006	880	64.50	67.30	63.68	68.56	6.93	26.51	6.19	2.79
2019	6108.70	7064	880	79.65	79.87	79.24	80.64	0.00	0.00	20.12	0.22
2020	3697.08	4247	880	96.78	97.43	96.20	97.25	1.91	1.90	0.67	0.65

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1978 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					622	3
B. Refuelling without maintenance				40		
C. Inspection, maintenance or repair combined with refuelling				1144	5	
D. Inspection, maintenance or repair without refuelling				47	19	
E. Testing of plant systems or components				17	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					349	
J. Grid limitation, failure or grid unavailability						1
L. Human factor related					13	1
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						11
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.)						25
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						24
Z. Other					13	
Subtotal				1249	1022	65
Total	**0**			**2336**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1978 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		47
12. Reactor I&C Systems		31
13. Reactor Auxiliary Systems		49
14. Safety Systems		26
15. Reactor Cooling Systems		23
16. Steam generation systems		486
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		66
32. Feedwater and Main Steam System		53
33. Circulating Water System		4
34. Miscellaneous Systems		120
35. All other I&C Systems		0
41. Main Generator Systems		51
42. Electrical Power Supply Systems		9
Total		**974**

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2020 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

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	:	1979-12-01
Grid Date	:	1985-12-04
Commercial Date	:	1986-12-01
Age at end of year	:	35 years

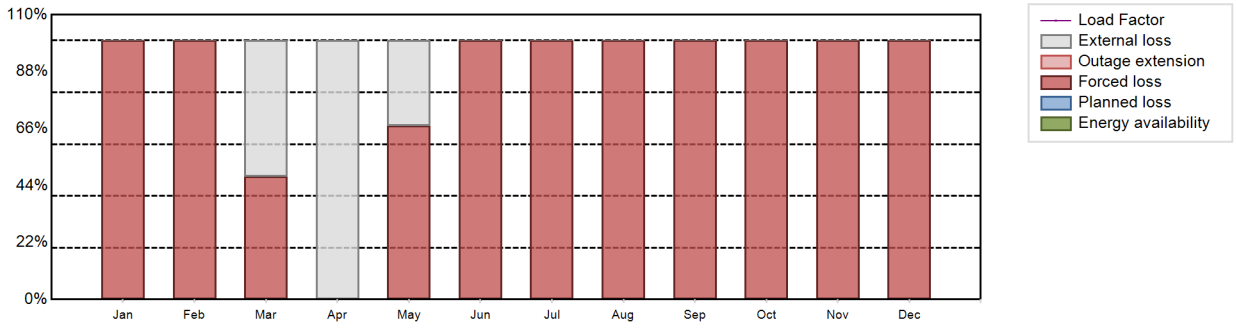
Design Characteristics

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]	:	12
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	:	none

Annual Production Results (2020)

Net Energy Production	:	0 GW(e).h
Energy Availability Factor (EAF)	:	0 %
Unit Capability Factor (UCF)	:	15.43 %
Load Factor (LF)	:	0 %
Operating Factor (OF)	:	0 %
Forced Loss Rate (FLR)	:	84.57 %
Unplanned Capability Loss Factor (UCL)	:	84.57 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	15.43 %
Total off-line time	:	8784 hours

Annual Summary



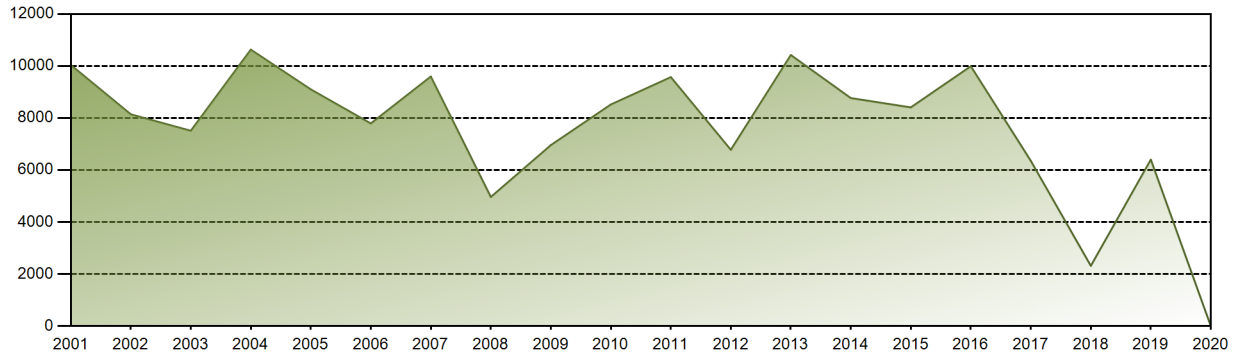
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	52.49	100.00	32.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.43
LF [%]	0.00	0.00	0.00	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	47.51	0.00	67.07	100.00	100.00	100.00	100.00	100.00	100.00	100.00	84.57
UCL [%]	100.00	100.00	47.51	0.00	67.07	100.00	100.00	100.00	100.00	100.00	100.00	100.00	84.57
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	52.49	100.00	32.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.43

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Historical Summary

Lifetime energy generation	:	264895.71 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.51 %
Cumulative Energy Availability Factor (EAF)	:	69.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	15.08 %
Cumulative Unit Capability Factor (UCF)	:	72.5 %	Cumulative Planned Unavailability Factor (PUF)	:	12.41 %
Cumulative Load Factor (LF)	:	65.73 %	Cumulative Externally cause unavailability (XUF)	:	2.65 %
Cumulative Operating Factor (OF)	:	72.15 %			

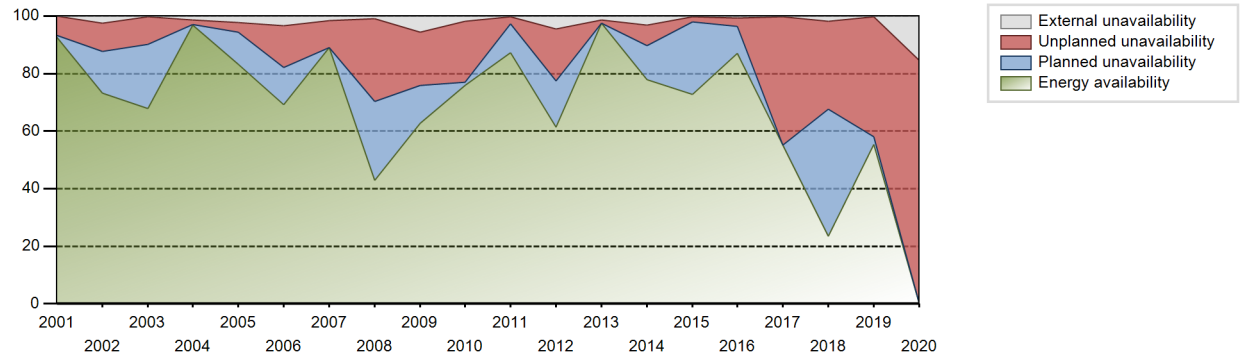
Electricity Production (net) [GWh]



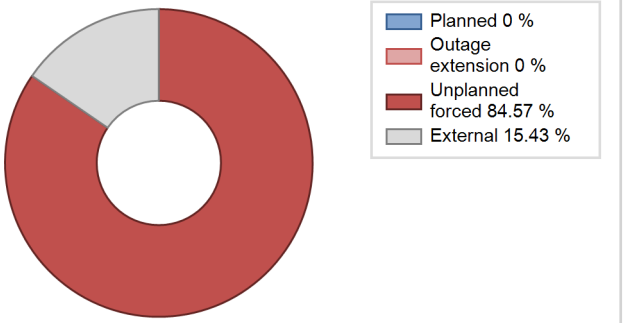
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	5273.00	4840	1290	97.32	97.34	100.64	97.58	2.66	2.66	0.00	0.02
1987	7150.80	5656	1290	62.17	63.23	63.28	64.57	15.78	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

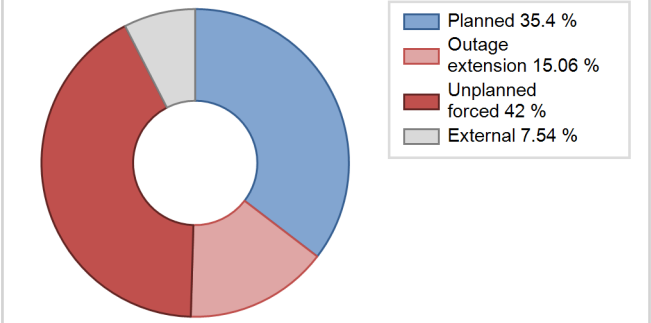
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					1027	
B. Refuelling without maintenance				101		
C. Inspection, maintenance or repair combined with refuelling				922		
D. Inspection, maintenance or repair without refuelling				23		
E. Testing of plant systems or components				9	1	
J. Grid limitation, failure or grid unavailability						10
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.)						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.)					1	36
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						6
Z. Other					17	1
Subtotal				1055	1059	75
Total		**0**			**2189**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		90
12. Reactor I&C Systems		36
13. Reactor Auxiliary Systems		40
14. Safety Systems		11
15. Reactor Cooling Systems		18
16. Steam generation systems		49
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		138
32. Feedwater and Main Steam System		61
33. Circulating Water System		15
34. Miscellaneous Systems		167
35. All other I&C Systems		2
41. Main Generator Systems		105
42. Electrical Power Supply Systems		265
Total		**1006**

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2020 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

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	:	1980-05-01
Grid Date	:	1986-07-18
Commercial Date	:	1987-03-09
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]	:	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

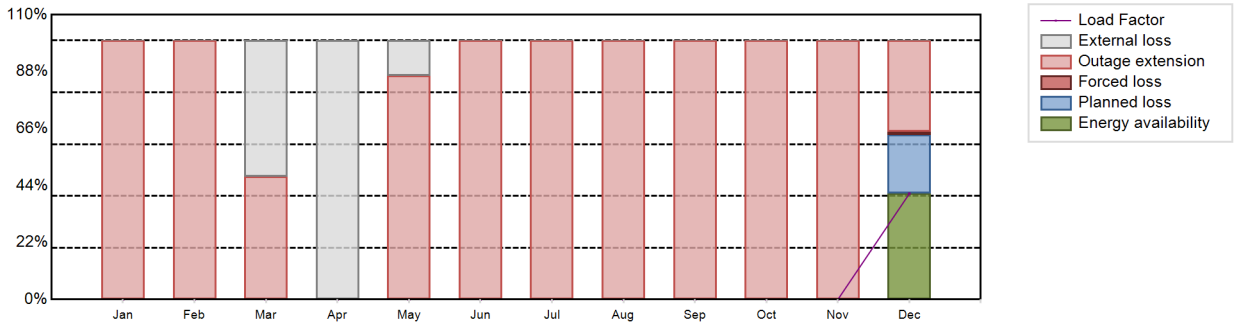
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	328.7
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.1
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	404.48 GW(e).h
Energy Availability Factor (EAF)	:	3.47 %
Unit Capability Factor (UCF)	:	17.25 %
Load Factor (LF)	:	3.46 %
Operating Factor (OF)	:	5.44 %

Forced Loss Rate (FLR)	:	0.7 %
Unplanned Capability Loss Factor (UCL)	:	80.83 %
Planned Unavailability Factor (PUF)	:	1.91 %
Externally cause unavailability (XUF)	:	13.79 %
Total off-line time	:	8306 hours

Annual Summary



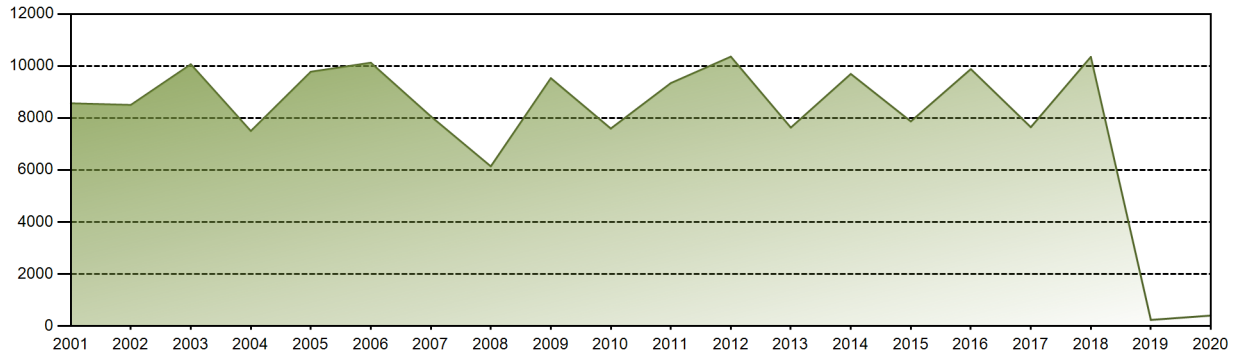
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	404.48	404.48
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.93	3.47
UCF [%]	0.00	0.00	52.49	100.00	13.58	0.00	0.00	0.00	0.00	0.00	0.00	40.93	17.25
LF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.88	3.46
OF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.25	5.44
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.39	0.70
UCL [%]	100.00	100.00	47.51	0.00	86.42	100.00	100.00	100.00	100.00	100.00	100.00	36.48	80.83
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.59	1.91
XUF [%]	0.00	0.00	52.49	100.00	13.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.79

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Historical Summary

Lifetime energy generation	:	270622.3 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.78 %
Cumulative Energy Availability Factor (EAF)	:	73.08 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.14 %
Cumulative Unit Capability Factor (UCF)	:	75.08 %	Cumulative Planned Unavailability Factor (PUF)	:	13.78 %
Cumulative Load Factor (LF)	:	67.85 %	Cumulative Externally cause unavailability (XUF)	:	2 %
Cumulative Operating Factor (OF)	:	73.85 %			

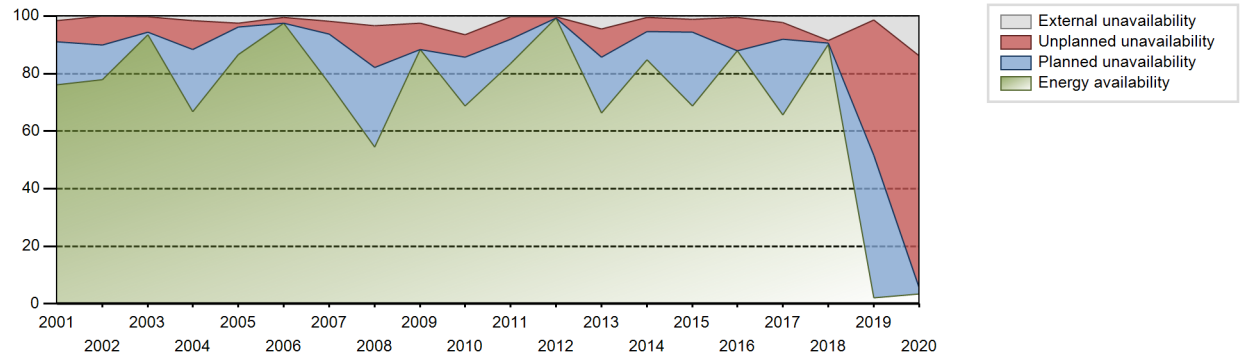
Electricity Production (net) [GWh]



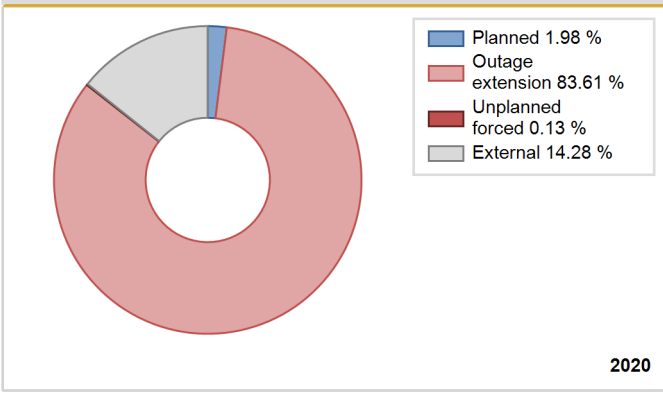
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	7140.20	6310	1290	88.69	88.92	58.89	69.36	11.08	11.08	0.00	0.23
1988	7106.00	5674	1330	65.40	67.44	60.82	64.59	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	478	1330	3.47	17.25	3.46	5.44	0.70	80.83	1.91	13.79

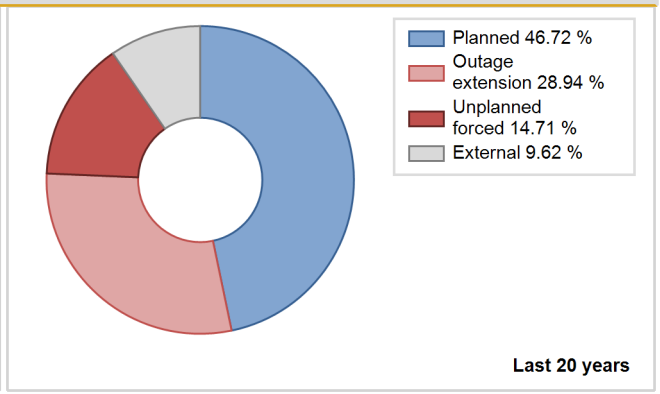
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					690	
B. Refuelling without maintenance				67		
C. Inspection, maintenance or repair combined with refuelling				1016	23	
D. Inspection, maintenance or repair without refuelling				68		
E. Testing of plant systems or components				17	1	0
H. Nuclear regulatory requirements					14	
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					7	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						11
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	23
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				1		8
Z. Other					17	
Subtotal				1169	753	49
Total		**0**			**1971**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		9
12. Reactor I&C Systems		27
13. Reactor Auxiliary Systems		39
14. Safety Systems		15
15. Reactor Cooling Systems		136
16. Steam generation systems		51
17. Safety I&C Systems (excluding reactor I&C)		3
21. Fuel Handling and Storage Facilities		6
31. Turbine and auxiliaries		81
32. Feedwater and Main Steam System		32
33. Circulating Water System		2
34. Miscellaneous Systems		154
35. All other I&C Systems		5
41. Main Generator Systems		41
42. Electrical Power Supply Systems		81
Total		**682**

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2020 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	:	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]	:	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

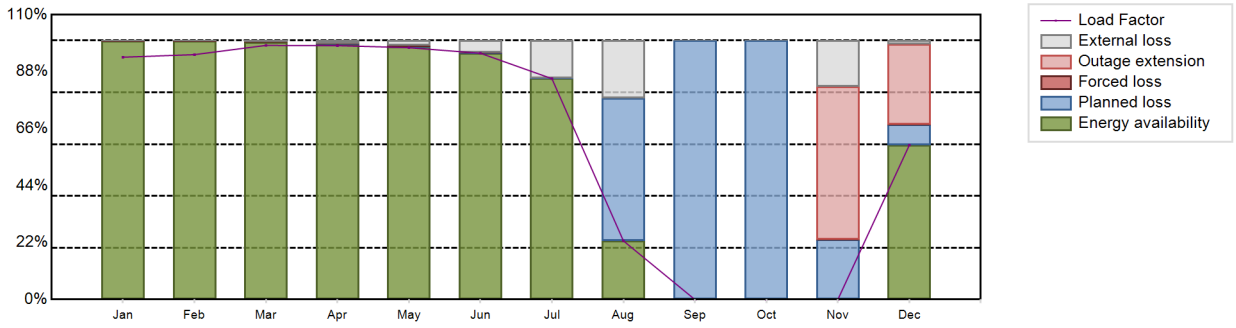
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	328.7
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.1
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7133.37 GW(e).h
Energy Availability Factor (EAF)	:	63.13 %
Unit Capability Factor (UCF)	:	68.53 %
Load Factor (LF)	:	61.99 %
Operating Factor (OF)	:	66.39 %

Forced Loss Rate (FLR)	:	0.12 %
Unplanned Capability Loss Factor (UCL)	:	7.54 %
Planned Unavailability Factor (PUF)	:	23.93 %
Externally cause unavailability (XUF)	:	5.39 %
Total off-line time	:	2952 hours

Annual Summary



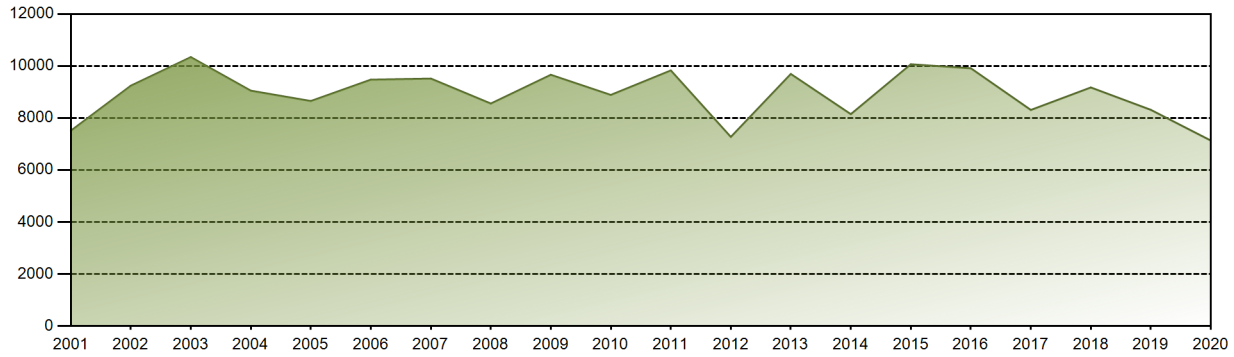
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	912.15	862.40	955.32	924.79	947.97	897.05	831.47	220.88	0.00	0.00	0.00	581.34	7133.37
EAF [%]	99.85	99.85	99.48	98.40	97.65	95.21	85.37	22.66	0.00	0.00	0.01	59.74	63.13
UCF [%]	99.92	99.95	99.78	99.60	99.62	99.89	99.94	45.00	0.00	0.00	17.78	61.15	68.53
LF [%]	93.59	94.59	98.15	98.05	97.26	95.11	85.31	22.66	0.00	0.00	0.00	59.65	61.99
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	29.30	0.00	0.00	0.00	67.61	66.39
FLR [%]	0.05	0.02	0.19	0.25	0.31	0.07	0.00	0.00	0.00	0.00	0.10	0.11	0.12
UCL [%]	0.05	0.02	0.19	0.25	0.31	0.07	0.00	0.00	0.00	0.00	59.00	31.09	7.54
PUF [%]	0.03	0.03	0.03	0.15	0.08	0.03	0.06	55.00	100.00	100.00	23.22	7.75	23.93
XUF [%]	0.07	0.10	0.30	1.19	1.97	4.69	14.57	22.34	0.00	0.00	17.77	1.42	5.39

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Historical Summary

Lifetime energy generation	:	263833.93 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.04 %
Cumulative Energy Availability Factor (EAF)	:	82.45 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.9 %
Cumulative Unit Capability Factor (UCF)	:	85.45 %	Cumulative Planned Unavailability Factor (PUF)	:	11.65 %
Cumulative Load Factor (LF)	:	76.14 %	Cumulative Externally cause unavailability (XUF)	:	2.99 %
Cumulative Operating Factor (OF)	:	84.43 %			

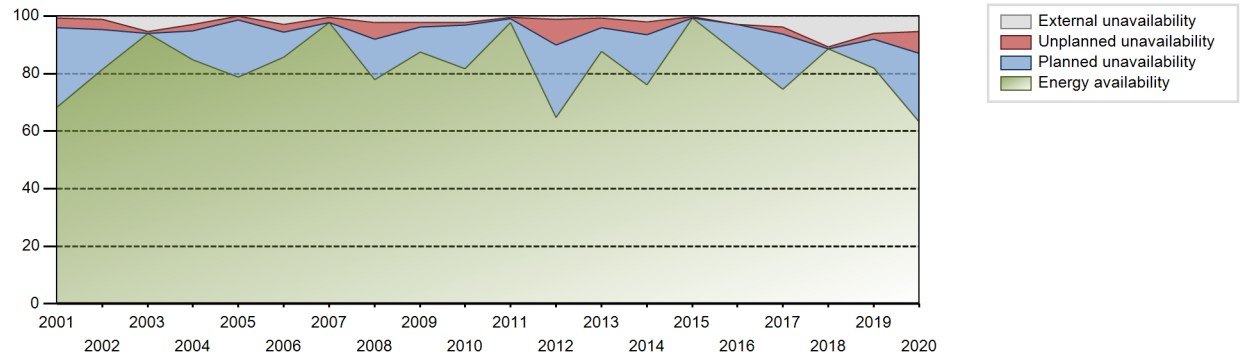
Electricity Production (net) [GWh]



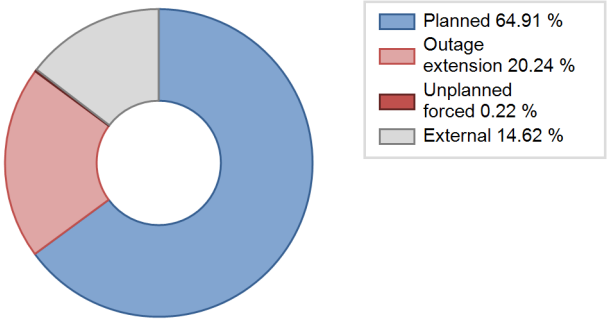
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1991	9536.95	8167	1310	96.09	97.76	84.48	94.91	2.21	2.21	0.02	1.68
1992	7065.89	6128	1310	64.35	67.86	61.40	69.76	4.27	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	5832	1310	63.13	68.53	61.99	66.39	0.12	7.54	23.93	5.39

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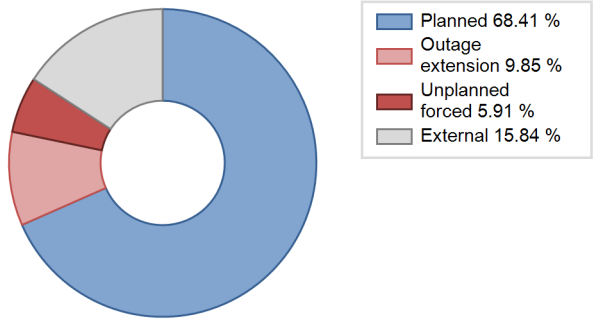
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1991 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					178	
B. Refuelling without maintenance				100		
C. Inspection, maintenance or repair combined with refuelling				786	2	
D. Inspection, maintenance or repair without refuelling				38		
E. Testing of plant systems or components				41		
F. Major backfitting, refurbishment or upgrading activities with refuelling				4		
H. Nuclear regulatory requirements					4	
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						4
L. Human factor related					23	1
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						21
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.)					0	25
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						30
Z. Other					9	1
Subtotal				969	216	85
Total		**0**			**1270**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1991 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		5
14. Safety Systems		8
15. Reactor Cooling Systems		17
16. Steam generation systems		12
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		60
35. All other I&C Systems		2
41. Main Generator Systems		28
42. Electrical Power Supply Systems		6
Total		**183**

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2020 Operating Experience

FR-68 GOLFECH-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	:	1984-10-01
Grid Date	:	1993-06-18
Commercial Date	:	1994-03-04
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]	:	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

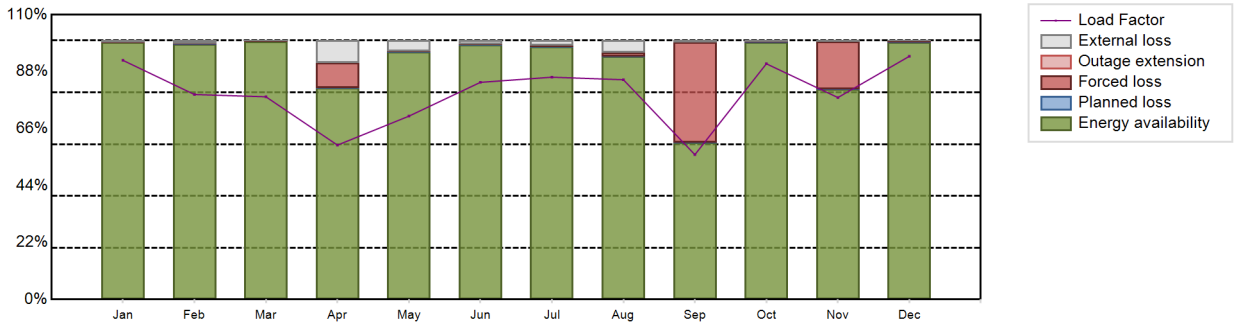
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	328.7
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.1
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	9160.17 GW(e).h
Energy Availability Factor (EAF)	:	92.19 %
Unit Capability Factor (UCF)	:	94.18 %
Load Factor (LF)	:	79.6 %
Operating Factor (OF)	:	92.71 %

Forced Loss Rate (FLR)	:	5.75 %
Unplanned Capability Loss Factor (UCL)	:	5.74 %
Planned Unavailability Factor (PUF)	:	0.08 %
Externally cause unavailability (XUF)	:	1.99 %
Total off-line time	:	640 hours

Annual Summary



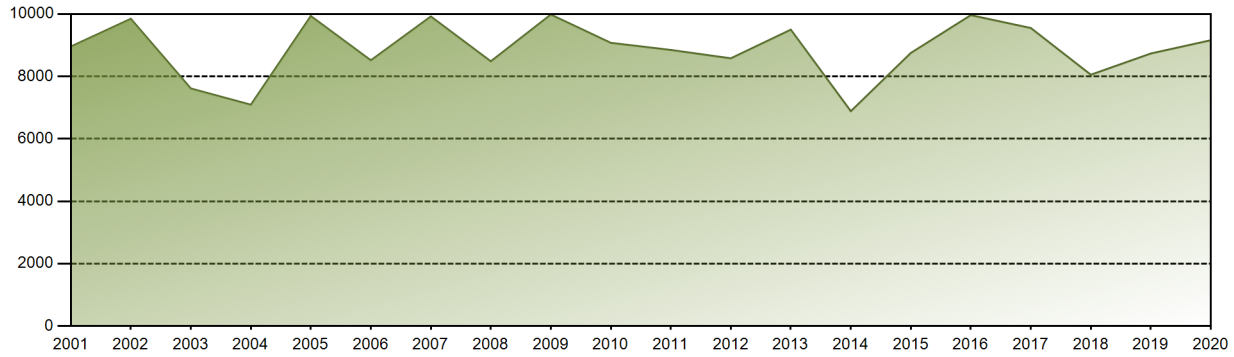
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	900.32	721.88	762.03	562.51	690.31	791.17	836.94	827.39	527.63	888.64	735.73	915.62	9160.17
EAF [%]	99.36	98.65	99.73	81.78	95.53	98.27	97.50	93.93	60.54	99.34	81.15	99.42	92.19
UCF [%]	99.90	99.87	99.78	90.30	99.73	99.72	99.41	98.44	61.23	99.73	81.43	99.57	94.18
LF [%]	92.37	79.17	78.29	59.64	70.83	83.88	85.87	84.89	55.94	91.05	78.00	93.94	79.60
OF [%]	100.00	100.00	100.00	82.22	93.28	97.50	97.85	96.91	61.67	99.87	82.22	100.00	92.71
FLR [%]	0.03	0.04	0.12	9.67	0.19	0.18	0.50	1.49	38.72	0.20	18.48	0.40	5.75
UCL [%]	0.03	0.04	0.12	9.67	0.19	0.18	0.50	1.49	38.69	0.20	18.46	0.40	5.74
PUF [%]	0.07	0.09	0.10	0.03	0.08	0.11	0.10	0.07	0.08	0.07	0.11	0.03	0.08
XUF [%]	0.54	1.22	0.05	8.52	4.19	1.44	1.90	4.52	0.69	0.39	0.28	0.15	1.99

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Historical Summary

Lifetime energy generation	:	238250.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.67 %
Cumulative Energy Availability Factor (EAF)	:	83.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.67 %
Cumulative Unit Capability Factor (UCF)	:	85.59 %	Cumulative Planned Unavailability Factor (PUF)	:	10.75 %
Cumulative Load Factor (LF)	:	76.38 %	Cumulative Externally cause unavailability (XUF)	:	1.66 %
Cumulative Operating Factor (OF)	:	85.17 %			

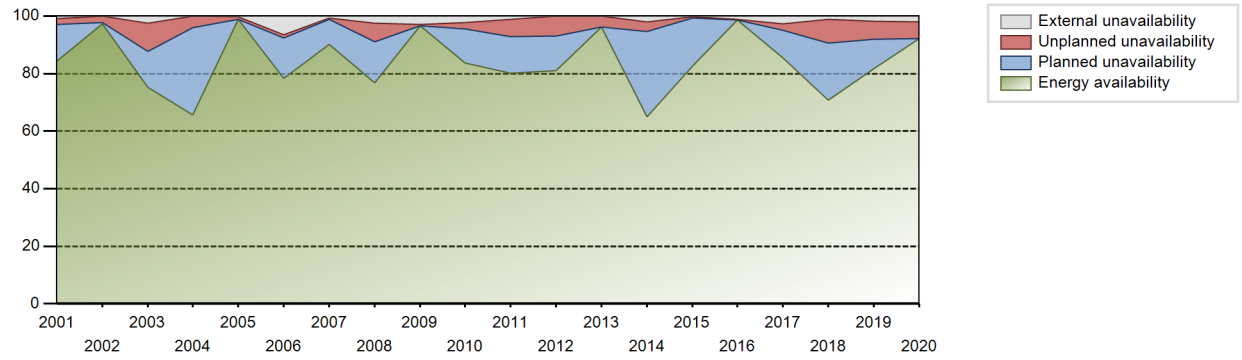
Electricity Production (net) [GWh]



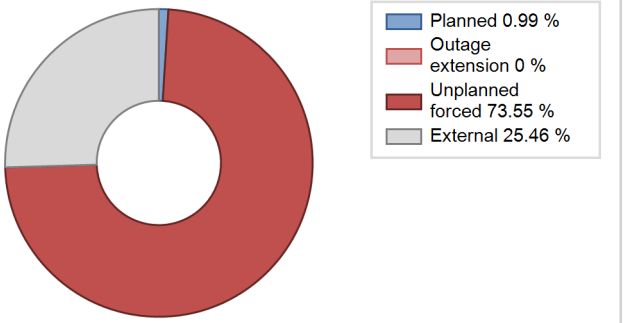
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1994	7281.51	6577	1310	99.45	99.75	67.64	80.50	0.25	0.25	0.01	0.30
1995	7030.15	6002	1310	62.92	66.66	61.26	68.52	12.67	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	8144	1310	92.19	94.18	79.60	92.71	5.75	5.74	0.08	1.99

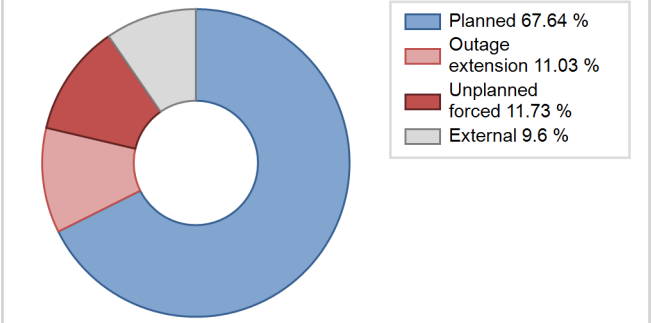
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1994 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					278	
B. Refuelling without maintenance				131		
C. Inspection, maintenance or repair combined with refuelling				746	1	
D. Inspection, maintenance or repair without refuelling				5		
E. Testing of plant systems or components				33		
H. Nuclear regulatory requirements					1	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						1
L. Human factor related					16	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						12
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.)					24	4
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					3	2
Z. Other					9	16
Subtotal				915	332	38
Total		**0**			**1285**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1994 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		36
13. Reactor Auxiliary Systems		4
14. Safety Systems		7
15. Reactor Cooling Systems		7
16. Steam generation systems		2
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		28
32. Feedwater and Main Steam System		1
33. Circulating Water System		1
34. Miscellaneous Systems		85
41. Main Generator Systems		92
42. Electrical Power Supply Systems		8
Total		**273**

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2020 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

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	:	1975-02-01
Grid Date	:	1980-03-13
Commercial Date	:	1980-11-25
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]	:	-
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

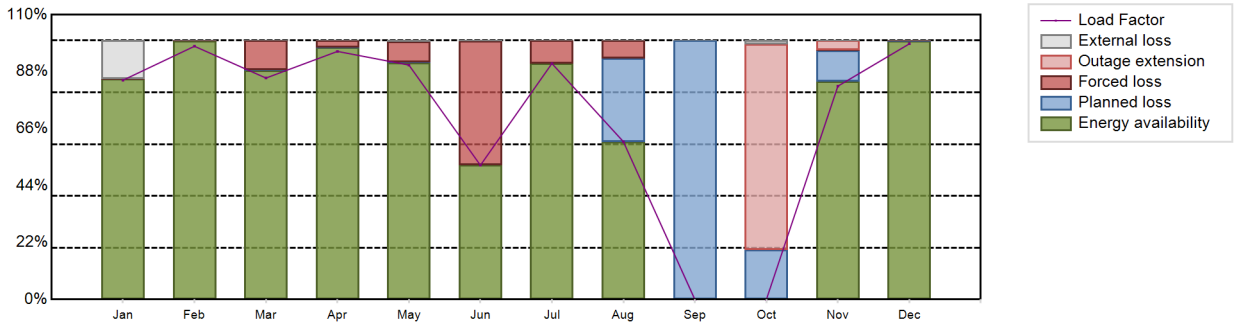
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5590.4 GW(e).h
Energy Availability Factor (EAF)	:	70.85 %
Unit Capability Factor (UCF)	:	72.28 %
Load Factor (LF)	:	69.94 %
Operating Factor (OF)	:	76.66 %

Forced Loss Rate (FLR)	:	8.97 %
Unplanned Capability Loss Factor (UCL)	:	14.15 %
Planned Unavailability Factor (PUF)	:	13.58 %
Externally cause unavailability (XUF)	:	1.42 %
Total off-line time	:	2050 hours

Annual Summary



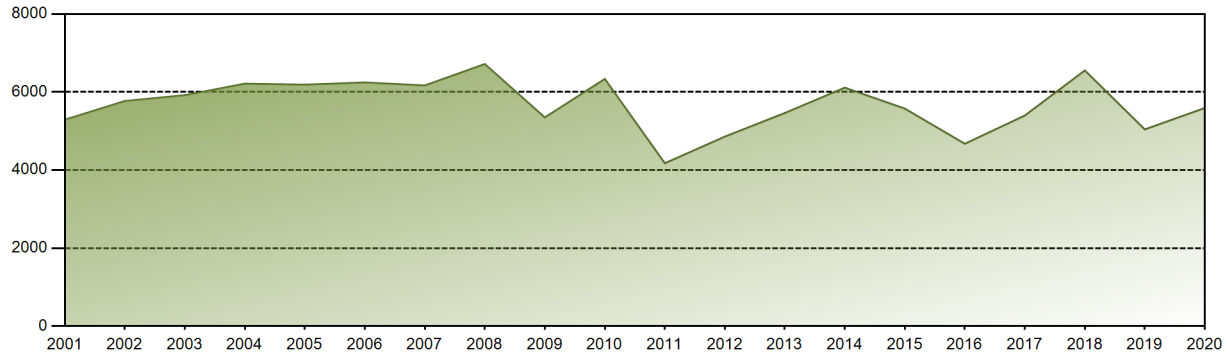
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	573.49	619.52	578.34	627.85	613.06	339.73	617.14	412.71	0.00	0.00	539.94	668.62	5590.40
EAF [%]	85.17	99.90	88.52	97.40	91.54	51.99	91.15	60.96	0.00	0.01	84.19	99.80	70.85
UCF [%]	99.92	99.90	88.52	97.40	92.02	52.07	91.15	60.96	0.00	1.48	84.20	99.80	72.28
LF [%]	84.71	97.81	85.54	95.83	90.55	51.85	91.15	60.96	0.00	0.00	82.41	98.76	69.94
OF [%]	100.00	100.00	96.37	100.00	100.00	60.42	100.00	67.88	0.00	0.00	95.28	100.00	76.66
FLR [%]	0.06	0.10	11.30	2.56	7.92	47.93	8.85	9.95	0.00	0.00	0.22	0.19	8.97
UCL [%]	0.06	0.10	11.28	2.55	7.92	47.93	8.85	6.74	0.00	79.33	3.75	0.19	14.15
PUF [%]	0.02	0.00	0.20	0.05	0.06	0.00	0.00	32.30	100.00	19.19	12.06	0.02	13.58
XUF [%]	14.75	0.00	0.00	0.00	0.49	0.08	0.00	0.00	0.00	1.47	0.01	0.00	1.42

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Historical Summary

Lifetime energy generation	:	224753.61 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.78 %
Cumulative Energy Availability Factor (EAF)	:	74.47 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.17 %
Cumulative Unit Capability Factor (UCF)	:	76.38 %	Cumulative Planned Unavailability Factor (PUF)	:	14.46 %
Cumulative Load Factor (LF)	:	69.88 %	Cumulative Externally cause unavailability (XUF)	:	1.91 %
Cumulative Operating Factor (OF)	:	76.18 %			

Electricity Production (net) [GWh]

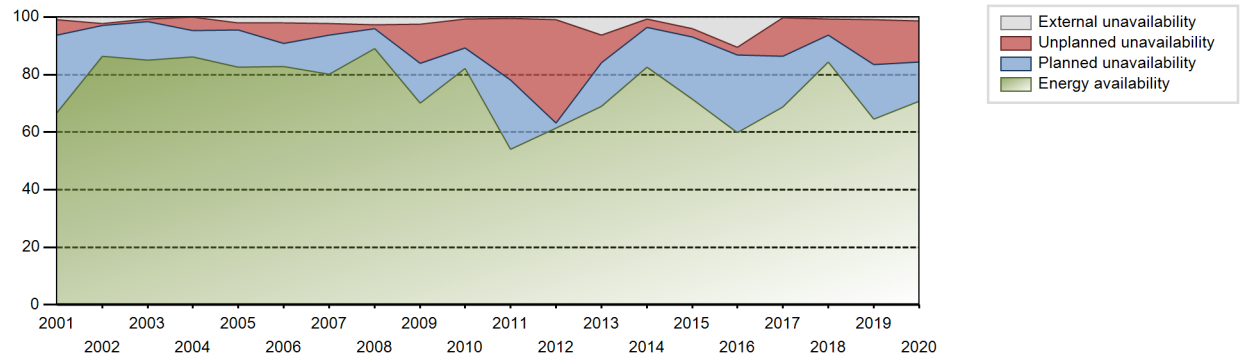


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	1466.00	2477	918	72.30	72.30	72.03	74.06	21.78	20.13	7.57	0.00
1981	5001.80	5785	920	63.25	63.25	62.06	66.04	11.18	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

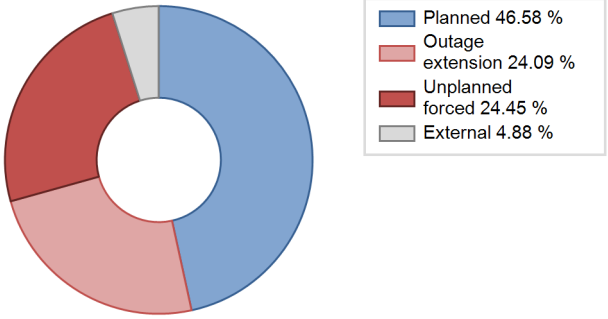
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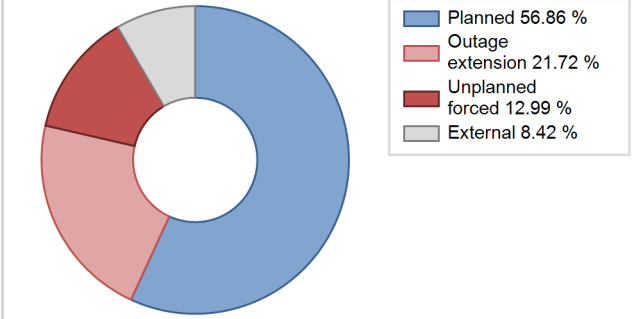
2017	5397.15	6249	910	68.65	68.97	67.70	71.34	1.77	13.22	17.81	0.32
2018	6553.27	7548	910	84.31	84.97	82.21	86.16	2.50	5.72	9.31	0.65
2019	5041.04	5827	910	64.56	65.44	63.24	66.52	2.62	15.61	18.95	0.87
2020	5590.40	6734	910	70.85	72.28	69.94	76.66	8.97	14.15	13.58	1.42

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					609	
B. Refuelling without maintenance				140		
C. Inspection, maintenance or repair combined with refuelling				1027	12	
D. Inspection, maintenance or repair without refuelling				19	3	
E. Testing of plant systems or components				11	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)						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.)						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	24
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						16
Z. Other					36	3
Subtotal				1197	682	53
Total		**0**			**1932**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		197
12. Reactor I&C Systems		10
13. Reactor Auxiliary Systems		16
14. Safety Systems		8
15. Reactor Cooling Systems		73
16. Steam generation systems		71
21. Fuel Handling and Storage Facilities		0
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System		46
33. Circulating Water System		8
34. Miscellaneous Systems		104
35. All other I&C Systems		0
41. Main Generator Systems		10
42. Electrical Power Supply Systems		26
Total		**604**

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2020 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

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	:	1975-03-01
Grid Date	:	1980-08-26
Commercial Date	:	1980-12-01
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	:	41
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

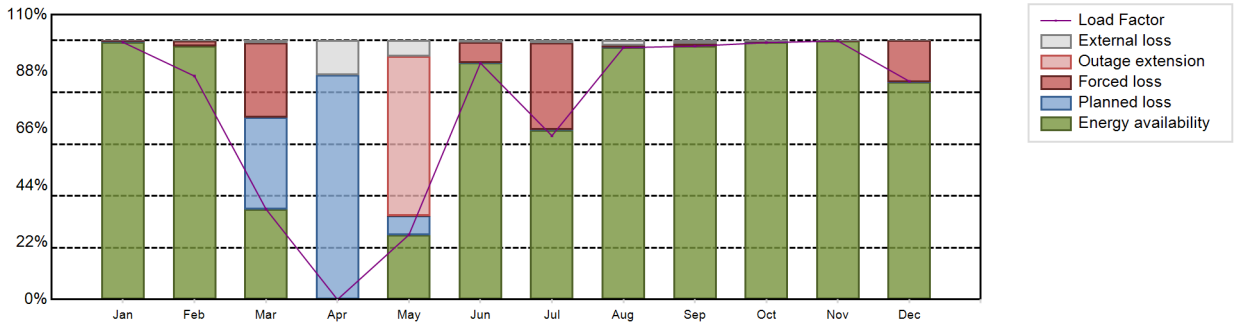
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	5.45
Output voltage [kV]	:	-
Primary means of condenser cooling	:	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 (2020)

Net Energy Production	:	5847.85 GW(e).h
Energy Availability Factor (EAF)	:	74.3 %
Unit Capability Factor (UCF)	:	76.38 %
Load Factor (LF)	:	73.16 %
Operating Factor (OF)	:	75.89 %

Forced Loss Rate (FLR)	:	9.1 %
Unplanned Capability Loss Factor (UCL)	:	12.86 %
Planned Unavailability Factor (PUF)	:	10.76 %
Externally cause unavailability (XUF)	:	2.09 %
Total off-line time	:	2118 hours

Annual Summary



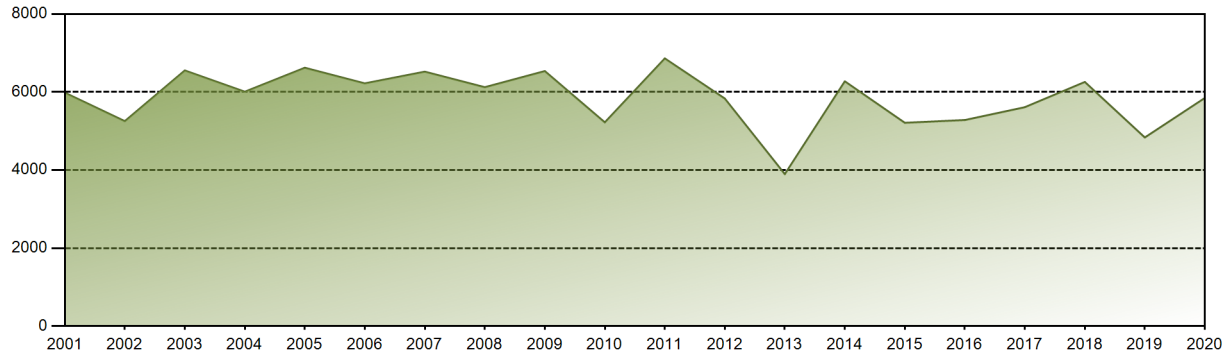
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	672.53	546.53	236.27	0.00	169.16	598.19	428.18	658.51	641.06	672.59	654.30	570.54	5847.85
EAF [%]	99.47	97.88	34.95	0.01	25.02	91.39	65.47	97.38	97.96	99.34	99.90	83.98	74.30
UCF [%]	99.47	97.95	35.73	13.33	31.06	92.07	66.33	99.20	99.14	99.67	99.94	83.98	76.38
LF [%]	99.33	86.29	34.94	0.00	24.99	91.30	63.24	97.26	97.84	99.21	99.86	84.27	73.16
OF [%]	100.00	100.00	35.80	0.00	32.39	93.47	65.05	100.00	100.00	99.87	100.00	85.22	75.89
FLR [%]	0.40	2.05	44.70	0.00	0.24	7.85	33.59	0.78	0.86	0.20	0.06	16.00	9.10
UCL [%]	0.40	2.05	28.88	0.00	61.69	7.84	33.55	0.78	0.86	0.20	0.06	15.99	12.86
PUF [%]	0.14	0.00	35.40	86.67	7.26	0.09	0.12	0.02	0.00	0.13	0.00	0.03	10.76
XUF [%]	0.00	0.06	0.78	13.33	6.04	0.68	0.86	1.82	1.18	0.33	0.05	0.00	2.09

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Historical Summary

Lifetime energy generation	:	233370.78 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.65 %
Cumulative Energy Availability Factor (EAF)	:	77.24 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.15 %
Cumulative Unit Capability Factor (UCF)	:	79.45 %	Cumulative Planned Unavailability Factor (PUF)	:	14.4 %
Cumulative Load Factor (LF)	:	72.75 %	Cumulative Externally cause unavailability (XUF)	:	2.21 %
Cumulative Operating Factor (OF)	:	79.19 %			

Electricity Production (net) [GWh]

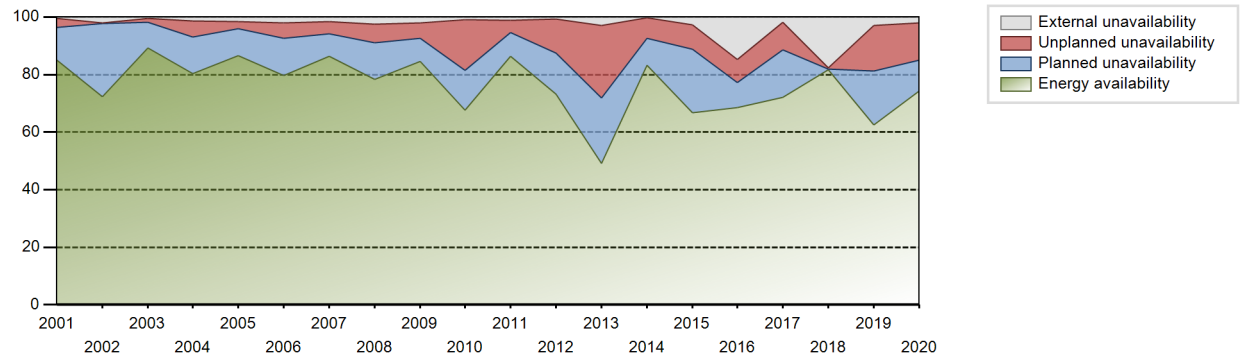


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	1282.00	1916	914	74.70	74.70	75.24	76.75	25.30	25.30	0.00	0.00
1981	5949.20	7276	920	81.21	81.21	73.82	83.06	2.26	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

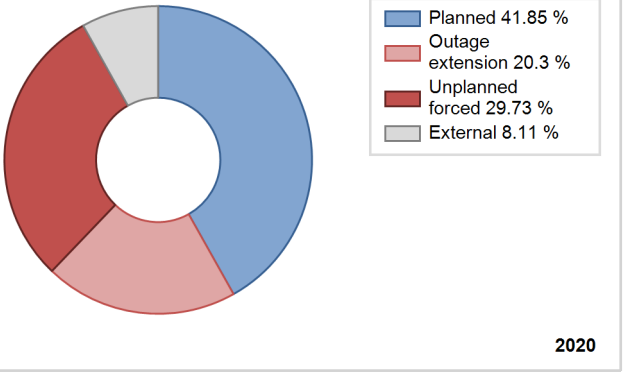
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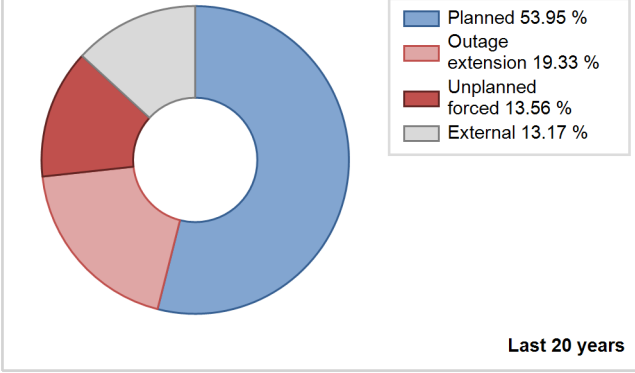
2017	5611.13	6531	910	72.19	74.06	70.39	74.55	1.30	9.61	16.33	1.87
2018	6258.08	7767	910	81.64	99.35	78.50	88.66	0.32	0.32	0.33	17.71
2019	4834.97	5890	910	62.58	65.56	60.65	67.24	11.33	15.73	18.71	2.98
2020	5847.85	6666	910	74.30	76.38	73.16	75.89	9.10	12.86	10.76	2.09

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					329	
B. Refuelling without maintenance				102		
C. Inspection, maintenance or repair combined with refuelling				970	32	
D. Inspection, maintenance or repair without refuelling				55		
E. Testing of plant systems or components				20		
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)						8
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
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.)						40
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						25
Z. Other				15	45	41
Subtotal				1162	418	119
Total		**0**			**1699**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		11
12. Reactor I&C Systems		21
13. Reactor Auxiliary Systems		11
14. Safety Systems		8
15. Reactor Cooling Systems		18
16. Steam generation systems		45
21. Fuel Handling and Storage Facilities		10
31. Turbine and auxiliaries		20
32. Feedwater and Main Steam System		20
33. Circulating Water System		5
34. Miscellaneous Systems		139
35. All other I&C Systems		0
41. Main Generator Systems		28
42. Electrical Power Supply Systems		20
Total		**356**

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2020 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	:	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	:	45
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

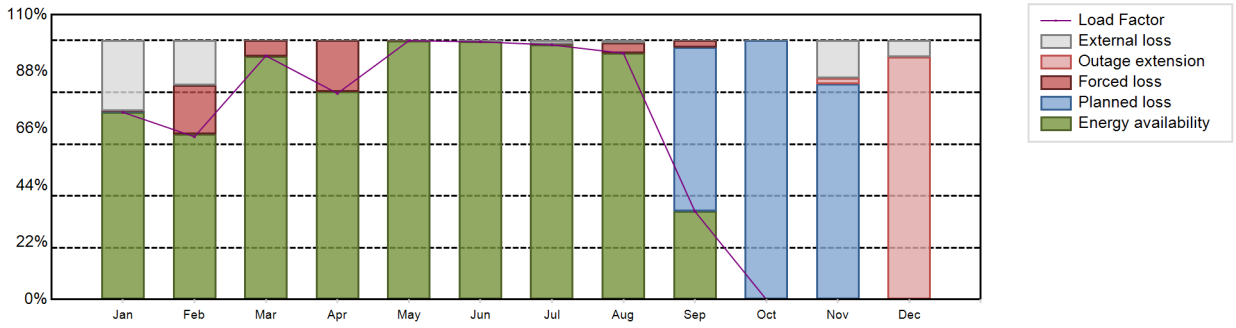
Operating coolant pressure [MPa]	:	15.2
Reactor outlet temperature [°C]	:	323
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4907.62 GW(e).h
Energy Availability Factor (EAF)	:	61.5 %
Unit Capability Factor (UCF)	:	67.15 %
Load Factor (LF)	:	61.4 %
Operating Factor (OF)	:	66.95 %

Forced Loss Rate (FLR)	:	5.88 %
Unplanned Capability Loss Factor (UCL)	:	12.3 %
Planned Unavailability Factor (PUF)	:	20.54 %
Externally cause unavailability (XUF)	:	5.66 %
Total off-line time	:	2903 hours

Annual Summary



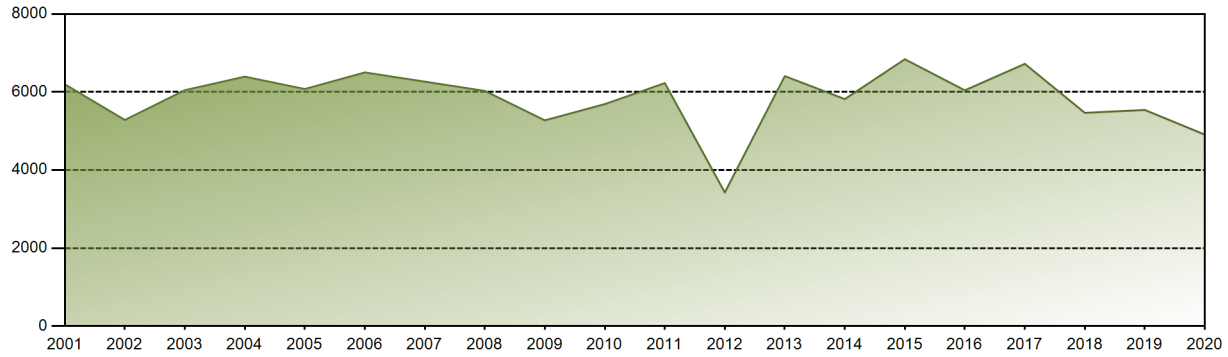
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	489.46	398.28	636.52	521.57	676.91	652.07	665.72	643.84	223.26	0.00	0.00	0.00	4907.62
EAF [%]	72.28	63.76	93.79	80.33	99.89	99.54	98.34	95.11	34.08	0.00	0.10	0.01	61.50
UCF [%]	99.55	81.03	93.79	80.33	99.89	100.00	99.71	96.12	34.08	0.00	14.66	6.46	67.15
LF [%]	72.29	62.88	94.14	79.61	99.98	99.52	98.33	95.10	34.07	0.00	0.00	0.00	61.40
OF [%]	100.00	78.45	100.00	87.78	100.00	100.00	100.00	100.00	36.67	0.00	0.00	0.00	66.95
FLR [%]	0.17	18.97	6.21	19.67	0.00	0.00	0.07	3.88	6.84	0.00	0.00	0.00	5.88
UCL [%]	0.17	18.97	6.21	19.67	0.00	0.00	0.07	3.88	2.50	0.00	2.25	93.54	12.30
PUF [%]	0.28	0.00	0.00	0.00	0.11	0.00	0.23	0.00	63.42	100.00	83.10	0.00	20.54
XUF [%]	27.27	17.27	0.00	0.00	0.00	0.46	1.36	1.00	0.00	0.00	14.56	6.45	5.66

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Historical Summary

Lifetime energy generation	:	233508.97 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.55 %
Cumulative Energy Availability Factor (EAF)	:	77.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.33 %
Cumulative Unit Capability Factor (UCF)	:	78.78 %	Cumulative Planned Unavailability Factor (PUF)	:	13.89 %
Cumulative Load Factor (LF)	:	73.47 %	Cumulative Externally cause unavailability (XUF)	:	1.49 %
Cumulative Operating Factor (OF)	:	78.92 %			

Electricity Production (net) [GWh]

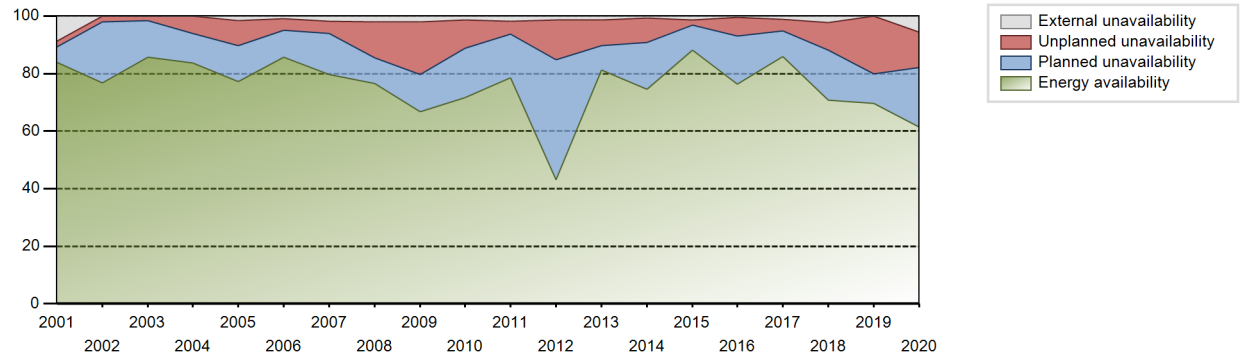


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	5170.10	6405	920	84.42	84.42	78.30	86.88	14.93	14.82	0.76	0.00
1982	3445.00	4260	910	47.62	47.62	43.22	48.63	27.74	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

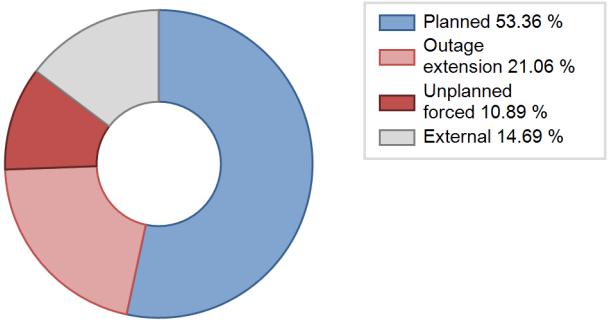
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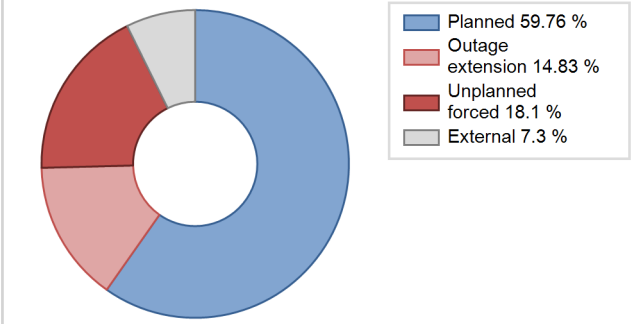
2018	5466.29	6525	910	70.81	73.03	68.57	74.49	3.18	9.66	17.31	2.22
2019	5539.99	6877	910	69.60	69.61	69.50	78.50	19.25	20.06	10.33	0.02
2020	4907.62	5881	910	61.50	67.15	61.40	66.95	5.88	12.30	20.54	5.66

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					400	
B.	Refuelling without maintenance				149		
C.	Inspection, maintenance or repair combined with refuelling				959	20	
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)						6
L.	Human factor related					11	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						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
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						1
Z.	Other					38	45
Subtotal					1115	472	62
Total			**0**			**1649**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		10
12. Reactor I&C Systems		21
13. Reactor Auxiliary Systems		18
14. Safety Systems		11
15. Reactor Cooling Systems		28
16. Steam generation systems		53
17. Safety I&C Systems (excluding reactor I&C)		5
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		28
32. Feedwater and Main Steam System		21
34. Miscellaneous Systems		89
35. All other I&C Systems		1
41. Main Generator Systems		84
42. Electrical Power Supply Systems		24
Total		**402**

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2020 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	:	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	:	45
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

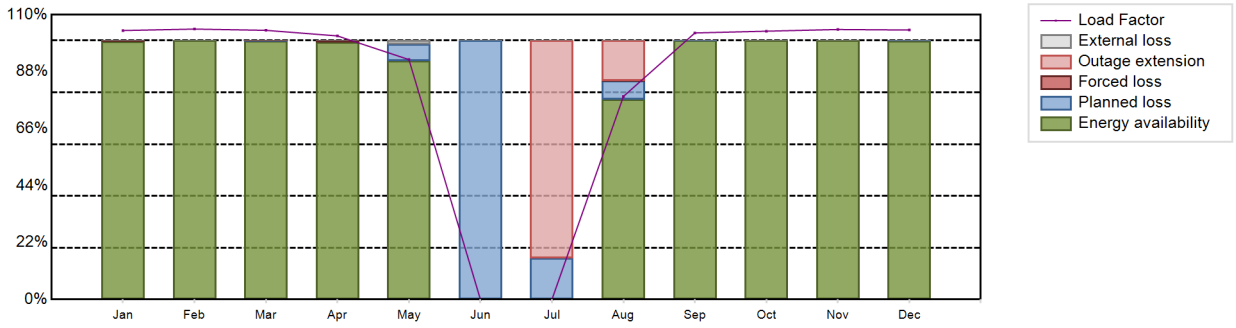
Operating coolant pressure [MPa]	:	15.2
Reactor outlet temperature [°C]	:	323
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	6658.46 GW(e).h
Energy Availability Factor (EAF)	:	80.63 %
Unit Capability Factor (UCF)	:	80.75 %
Load Factor (LF)	:	83.3 %
Operating Factor (OF)	:	81.45 %

Forced Loss Rate (FLR)	:	0.12 %
Unplanned Capability Loss Factor (UCL)	:	8.53 %
Planned Unavailability Factor (PUF)	:	10.72 %
Externally cause unavailability (XUF)	:	0.12 %
Total off-line time	:	1629 hours

Annual Summary



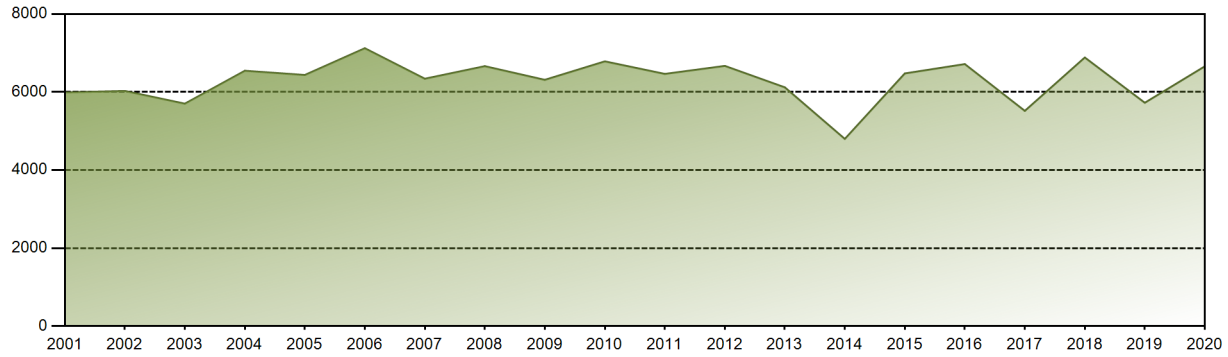
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	703.34	661.62	702.92	667.07	627.39	0.00	0.00	530.89	674.58	702.60	683.31	704.72	6658.46
EAF [%]	99.62	100.00	99.93	99.36	92.07	0.00	0.01	77.23	100.00	100.00	100.00	99.85	80.63
UCF [%]	99.62	100.00	99.93	99.36	93.44	0.00	0.01	77.23	100.00	100.00	100.00	99.85	80.75
LF [%]	103.89	104.46	103.96	101.81	92.67	0.00	0.00	78.41	102.96	103.64	104.29	104.09	83.30
OF [%]	100.00	100.00	100.00	100.00	93.55	0.00	0.00	84.41	100.00	99.87	100.00	100.00	81.45
FLR [%]	0.38	0.00	0.06	0.64	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.12
UCL [%]	0.38	0.00	0.06	0.64	0.00	0.00	84.07	15.62	0.00	0.00	0.00	0.00	8.53
PUF [%]	0.00	0.00	0.01	0.00	6.56	100.00	15.92	7.15	0.00	0.00	0.00	0.15	10.72
XUF [%]	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12

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Historical Summary

Lifetime energy generation	:	238125.3 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.19 %
Cumulative Energy Availability Factor (EAF)	:	78.75 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.93 %
Cumulative Unit Capability Factor (UCF)	:	80.23 %	Cumulative Planned Unavailability Factor (PUF)	:	13.84 %
Cumulative Load Factor (LF)	:	75.82 %	Cumulative Externally cause unavailability (XUF)	:	1.48 %
Cumulative Operating Factor (OF)	:	80.26 %			

Electricity Production (net) [GWh]

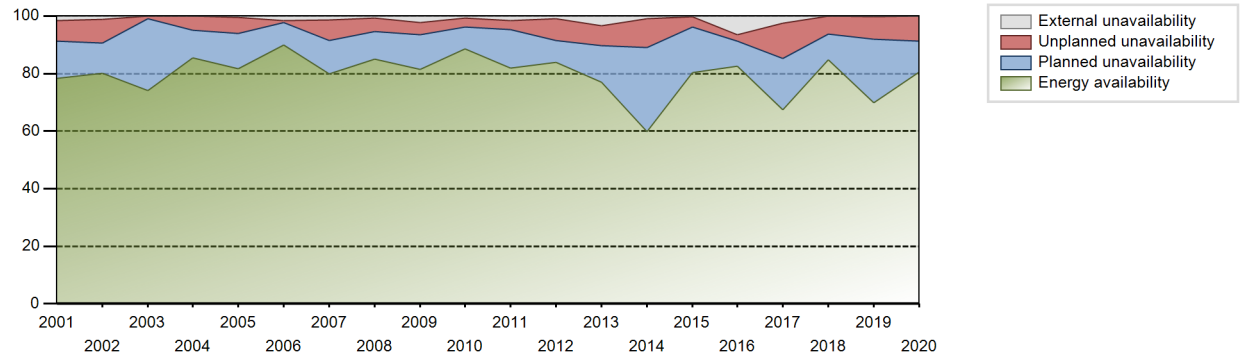


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	2636.60	3434	915	85.39	85.39	84.78	91.98	2.84	2.50	12.12	0.00
1982	5498.20	7193	910	80.76	80.76	68.97	82.11	19.24	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

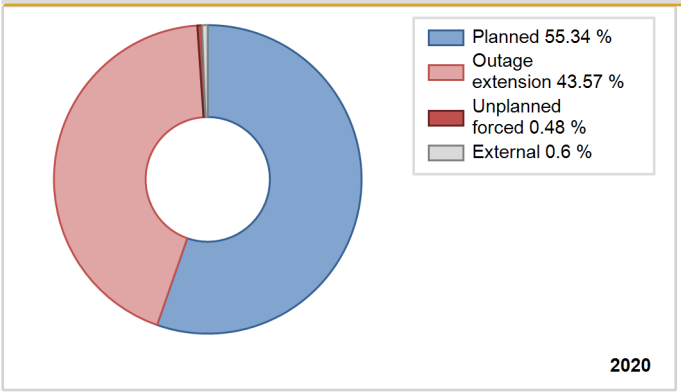
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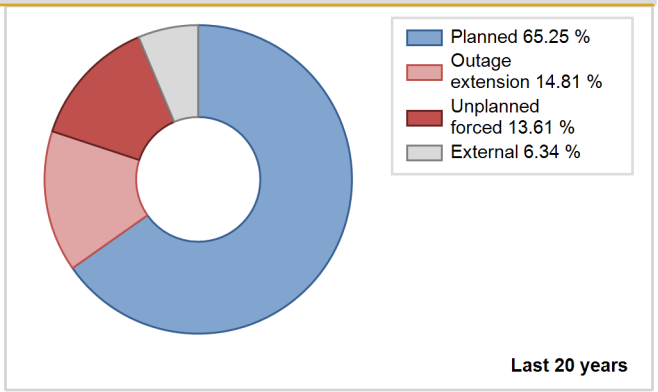
2018	6884.99	7474	910	84.81	84.81	86.37	85.32	4.34	6.19	9.00	0.00
2019	5724.80	6192	910	69.76	69.91	71.81	70.68	3.50	7.85	22.24	0.15
2020	6658.46	7155	910	80.63	80.75	83.30	81.45	0.12	8.53	10.72	0.12

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					409	
B. Refuelling without maintenance				104		
C. Inspection, maintenance or repair combined with refuelling				1011	7	
D. Inspection, maintenance or repair without refuelling				5	3	
E. Testing of plant systems or components				4	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.)						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	29
Z. Other					16	23
Subtotal				1124	450	55
Total	**0**			**1629**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		26
12. Reactor I&C Systems		44
13. Reactor Auxiliary Systems		8
14. Safety Systems		14
15. Reactor Cooling Systems		25
16. Steam generation systems		65
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries		28
32. Feedwater and Main Steam System		23
33. Circulating Water System		6
34. Miscellaneous Systems		81
35. All other I&C Systems		7
41. Main Generator Systems		40
42. Electrical Power Supply Systems		58
Total		**429**

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2020 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

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	:	1984-08-28
Commercial Date	:	1985-01-15
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]	:	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

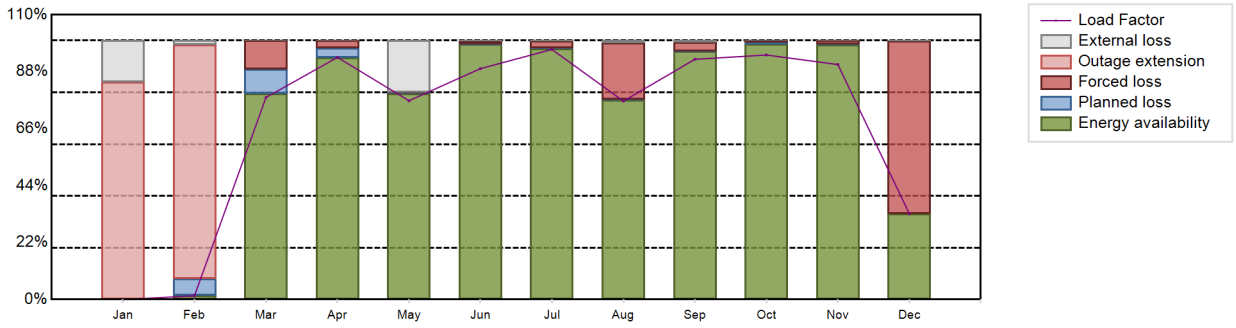
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5493.2 GW(e).h
Energy Availability Factor (EAF)	:	71.15 %
Unit Capability Factor (UCF)	:	74.5 %
Load Factor (LF)	:	68.72 %
Operating Factor (OF)	:	74.8 %

Forced Loss Rate (FLR)	:	11.28 %
Unplanned Capability Loss Factor (UCL)	:	23.73 %
Planned Unavailability Factor (PUF)	:	1.77 %
Externally cause unavailability (XUF)	:	3.35 %
Total off-line time	:	2214 hours

Annual Summary



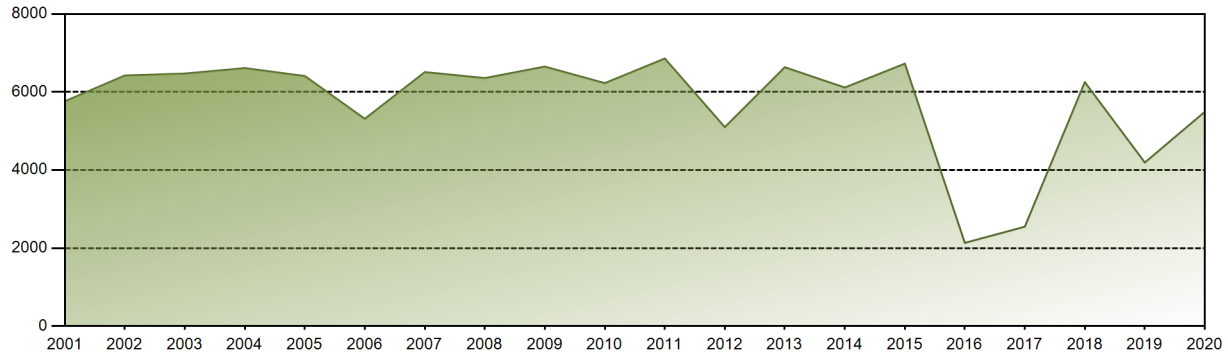
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	9.18	527.62	612.73	519.83	584.30	653.85	518.85	607.79	640.27	594.56	224.22	5493.20
EAF [%]	0.01	1.47	79.50	93.52	79.59	98.56	96.89	77.13	95.80	98.73	98.25	33.11	71.15
UCF [%]	16.14	3.05	79.50	93.52	99.63	98.73	96.99	78.11	96.44	98.73	98.25	33.12	74.50
LF [%]	0.00	1.45	78.04	93.52	76.78	89.18	96.57	76.64	92.76	94.44	90.75	33.12	68.72
OF [%]	0.00	8.05	84.52	97.50	87.50	100.00	100.00	85.35	100.00	99.87	100.00	33.60	74.80
FLR [%]	0.00	0.00	12.17	2.87	0.32	1.24	2.88	21.82	3.38	0.56	1.28	66.88	11.28
UCL [%]	83.86	90.36	11.02	2.76	0.32	1.24	2.87	21.81	3.38	0.56	1.27	66.88	23.73
PUF [%]	0.00	6.59	9.48	3.72	0.05	0.03	0.14	0.09	0.18	0.71	0.48	0.00	1.77
XUF [%]	16.12	1.58	0.00	0.00	20.04	0.18	0.10	0.97	0.64	0.00	0.00	0.01	3.35

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Historical Summary

Lifetime energy generation	:	209390.8 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.94 %
Cumulative Energy Availability Factor (EAF)	:	76.57 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.65 %
Cumulative Unit Capability Factor (UCF)	:	78.3 %	Cumulative Planned Unavailability Factor (PUF)	:	13.05 %
Cumulative Load Factor (LF)	:	72.64 %	Cumulative Externally cause unavailability (XUF)	:	1.73 %
Cumulative Operating Factor (OF)	:	78.57 %			

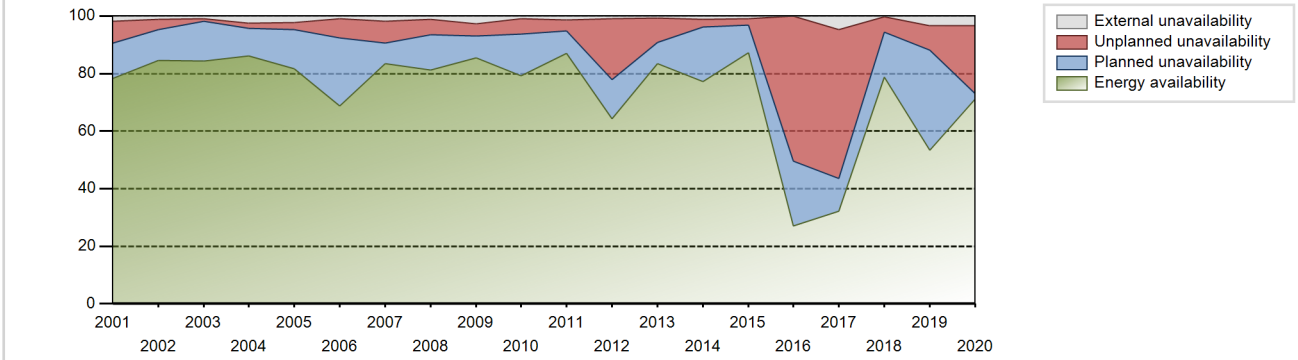
Electricity Production (net) [GWh]



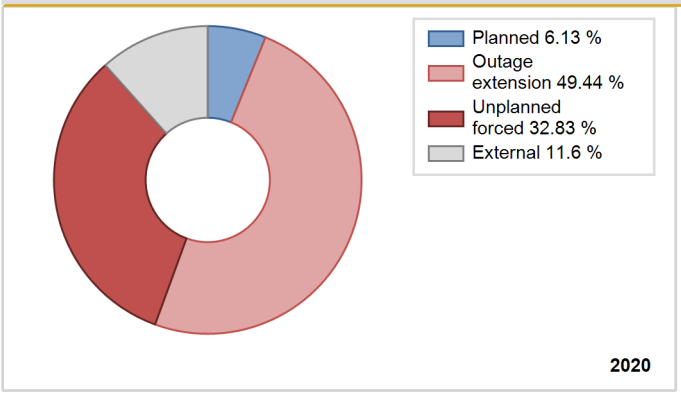
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	6768.40	7785	910	90.02	90.06	84.91	88.87	9.94	9.94	0.00	0.04
1986	5152.60	6673	910	75.24	77.10	64.64	76.18	3.23	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	6570	910	71.15	74.50	68.72	74.80	11.28	23.73	1.77	3.35

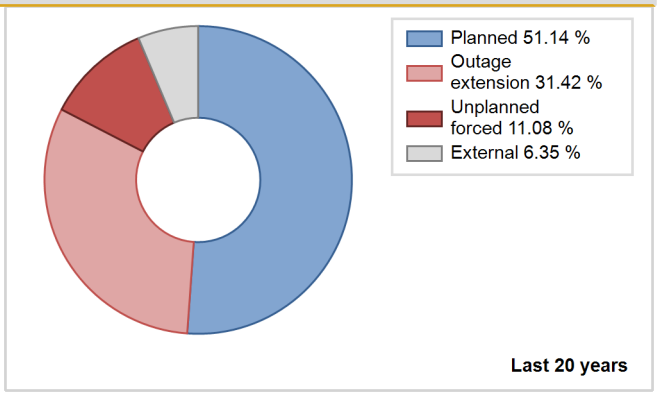
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					360	
B. Refuelling without maintenance				123		
C. Inspection, maintenance or repair combined with refuelling				944	18	
D. Inspection, maintenance or repair without refuelling				2		
E. Testing of plant systems or components				3	1	
H. Nuclear regulatory requirements					240	
J. Grid limitation, failure or grid unavailability						2
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
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.)						16
Z. Other					14	
Subtotal				1072	648	20
Total		**0**			**1740**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		24
14. Safety Systems		4
15. Reactor Cooling Systems		63
16. Steam generation systems		255
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		33
32. Feedwater and Main Steam System		14
33. Circulating Water System		5
34. Miscellaneous Systems		69
35. All other I&C Systems		0
41. Main Generator Systems		52
42. Electrical Power Supply Systems		48
Total		**604**

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2020 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	:	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]	:	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

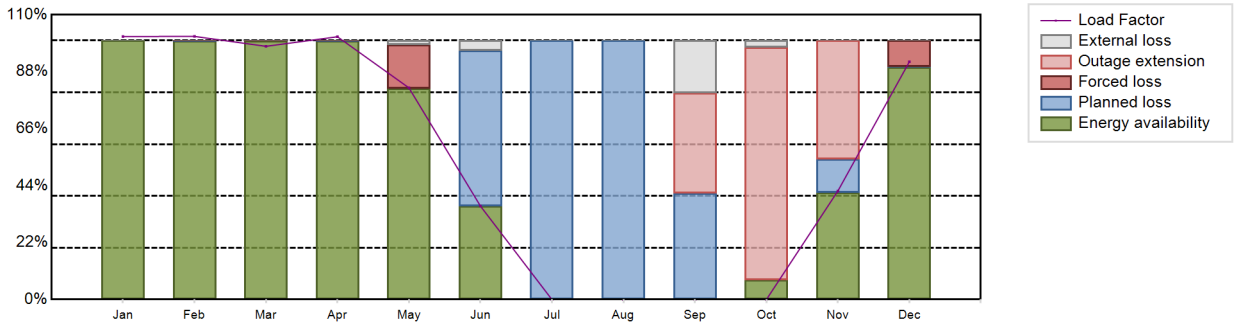
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4343.71 GW(e).h
Energy Availability Factor (EAF)	:	54.51 %
Unit Capability Factor (UCF)	:	56.83 %
Load Factor (LF)	:	54.34 %
Operating Factor (OF)	:	55.57 %

Forced Loss Rate (FLR)	:	3.9 %
Unplanned Capability Loss Factor (UCL)	:	16.86 %
Planned Unavailability Factor (PUF)	:	26.3 %
Externally cause unavailability (XUF)	:	2.32 %
Total off-line time	:	3903 hours

Annual Summary



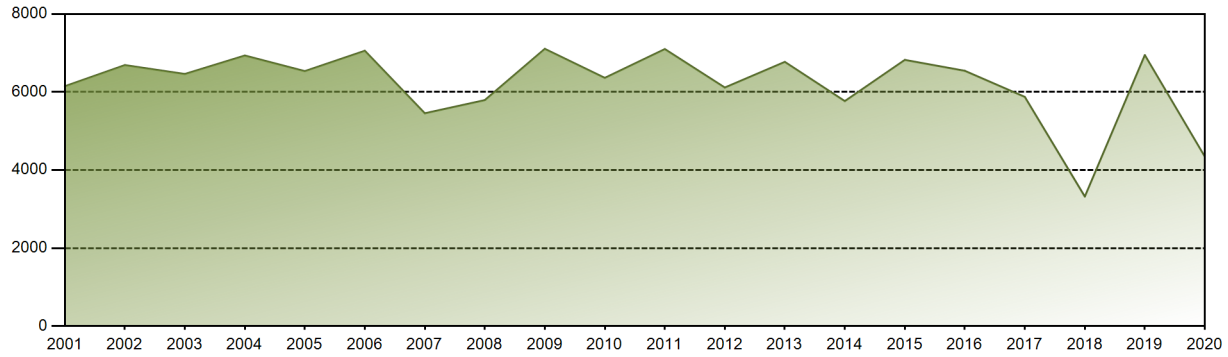
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	687.77	643.67	661.21	664.89	553.46	236.46	0.00	0.00	0.00	0.00	274.63	621.64	4343.71
EAF [%]	100.00	99.79	99.94	99.91	81.49	36.09	0.00	0.00	0.03	7.53	41.40	89.73	54.51
UCF [%]	100.00	99.79	99.94	99.91	83.03	39.90	0.00	0.00	20.26	10.08	41.40	89.73	56.83
LF [%]	101.58	101.63	97.79	101.48	81.75	36.09	0.00	0.00	0.00	0.00	41.92	91.82	54.34
OF [%]	100.00	100.00	100.00	100.00	83.60	40.14	0.00	0.00	0.00	0.00	54.31	90.86	55.57
FLR [%]	0.00	0.05	0.06	0.05	16.97	0.00	0.00	0.00	0.00	0.00	0.00	10.15	3.90
UCL [%]	0.00	0.05	0.06	0.05	16.97	0.00	0.00	0.00	38.82	89.92	45.72	10.13	16.86
PUF [%]	0.00	0.16	0.00	0.04	0.00	60.10	100.00	100.00	40.92	0.00	12.89	0.14	26.30
XUF [%]	0.00	0.00	0.00	0.00	1.53	3.81	0.00	0.00	20.23	2.55	0.00	0.00	2.32

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Historical Summary

Lifetime energy generation	:	214938.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.78 %
Cumulative Energy Availability Factor (EAF)	:	78.69 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.15 %
Cumulative Unit Capability Factor (UCF)	:	80.28 %	Cumulative Planned Unavailability Factor (PUF)	:	13.56 %
Cumulative Load Factor (LF)	:	76.28 %	Cumulative Externally cause unavailability (XUF)	:	1.6 %
Cumulative Operating Factor (OF)	:	80.44 %			

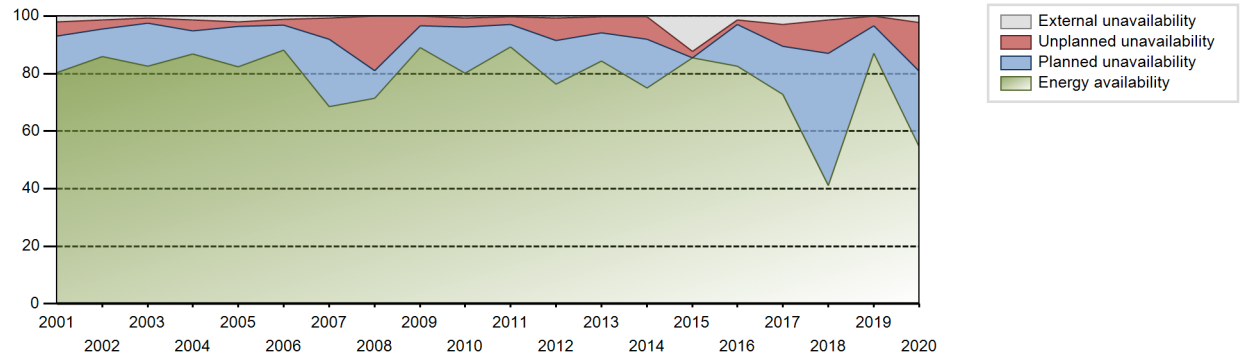
Electricity Production (net) [GWh]



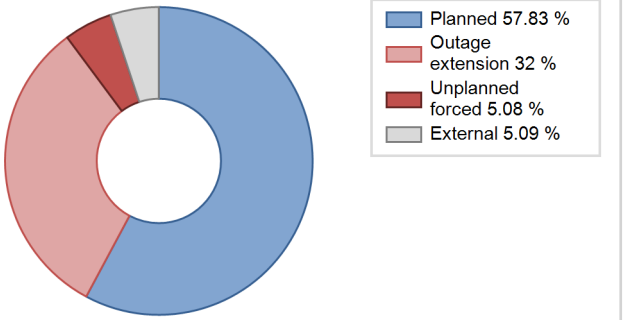
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	2337.10	3111	910	97.26	97.26	94.68	97.61	2.74	2.74	0.00	0.00
1986	5540.40	6677	910	75.88	76.32	69.50	76.22	3.96	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	4881	910	54.51	56.83	54.34	55.57	3.90	16.86	26.30	2.32

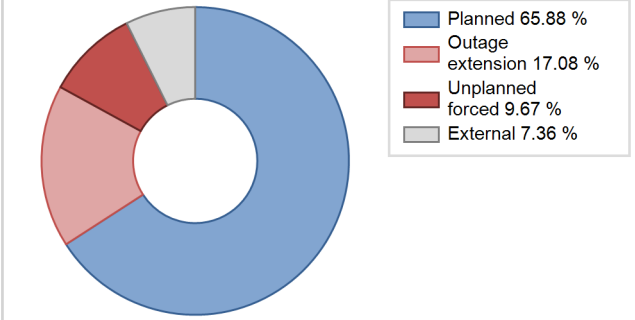
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					372	
B. Refuelling without maintenance				99		
C. Inspection, maintenance or repair combined with refuelling				953	21	
D. Inspection, maintenance or repair without refuelling					15	
E. Testing of plant systems or components				8		
H. Nuclear regulatory requirements					4	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						2
L. Human factor related					16	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.)					3	10
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						25
Z. Other					32	1
Subtotal				1060	463	40
Total		**0**			**1563**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		33
13. Reactor Auxiliary Systems		62
14. Safety Systems		13
15. Reactor Cooling Systems		24
16. Steam generation systems		5
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		58
32. Feedwater and Main Steam System		18
33. Circulating Water System		5
34. Miscellaneous Systems		95
35. All other I&C Systems		0
41. Main Generator Systems		15
42. Electrical Power Supply Systems		37
Total		**372**

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2020 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	:	33 years

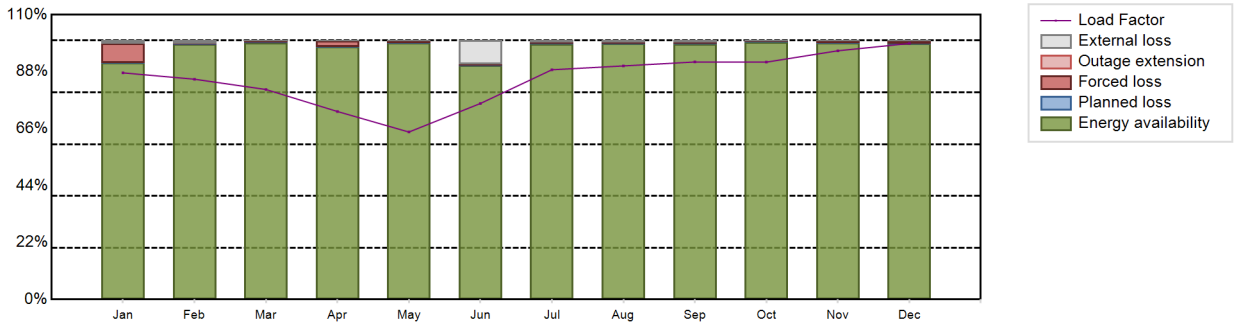
Design Characteristics

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]	:	17.5
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	:	none

Annual Production Results (2020)

Net Energy Production	:	9822.26 GW(e).h
Energy Availability Factor (EAF)	:	97.52 %
Unit Capability Factor (UCF)	:	98.71 %
Load Factor (LF)	:	85.36 %
Operating Factor (OF)	:	99 %
Forced Loss Rate (FLR)	:	1.24 %
Unplanned Capability Loss Factor (UCL)	:	1.24 %
Planned Unavailability Factor (PUF)	:	0.06 %
Externally cause unavailability (XUF)	:	1.19 %
Total off-line time	:	88 hours

Annual Summary



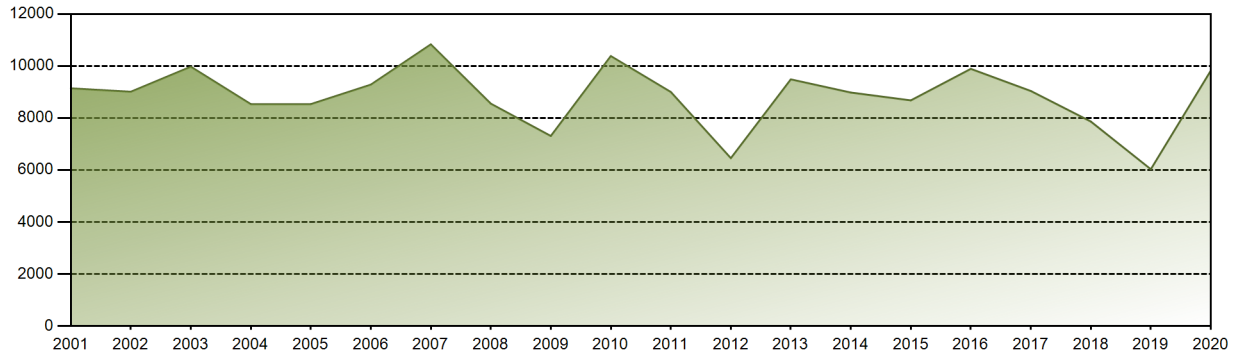
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	853.21	775.83	789.53	684.93	630.48	714.18	864.88	879.37	865.35	894.74	906.12	963.64	9822.26
EAF [%]	91.48	98.66	99.08	97.56	99.16	90.49	98.73	98.91	98.71	99.48	99.02	98.89	97.52
UCF [%]	92.65	99.67	99.18	97.75	99.41	99.56	99.30	99.59	99.41	99.69	99.27	99.10	98.71
LF [%]	87.54	85.09	81.12	72.62	64.69	75.72	88.74	90.23	91.75	91.68	96.07	98.87	85.36
OF [%]	96.10	100.00	100.00	98.89	100.00	93.06	100.00	100.00	100.00	99.87	100.00	100.00	99.00
FLR [%]	7.35	0.28	0.65	2.23	0.55	0.44	0.58	0.39	0.44	0.29	0.65	0.87	1.24
UCL [%]	7.35	0.28	0.65	2.23	0.55	0.44	0.58	0.39	0.44	0.29	0.65	0.87	1.24
PUF [%]	0.00	0.04	0.17	0.01	0.03	0.00	0.12	0.01	0.15	0.02	0.08	0.04	0.06
XUF [%]	1.17	1.01	0.10	0.19	0.25	9.07	0.57	0.68	0.71	0.21	0.25	0.20	1.19

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Historical Summary

Lifetime energy generation	:	274715.98 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.47 %
Cumulative Energy Availability Factor (EAF)	:	77.57 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.64 %
Cumulative Unit Capability Factor (UCF)	:	79.6 %	Cumulative Planned Unavailability Factor (PUF)	:	12.76 %
Cumulative Load Factor (LF)	:	72.39 %	Cumulative Externally cause unavailability (XUF)	:	2.03 %
Cumulative Operating Factor (OF)	:	79.74 %			

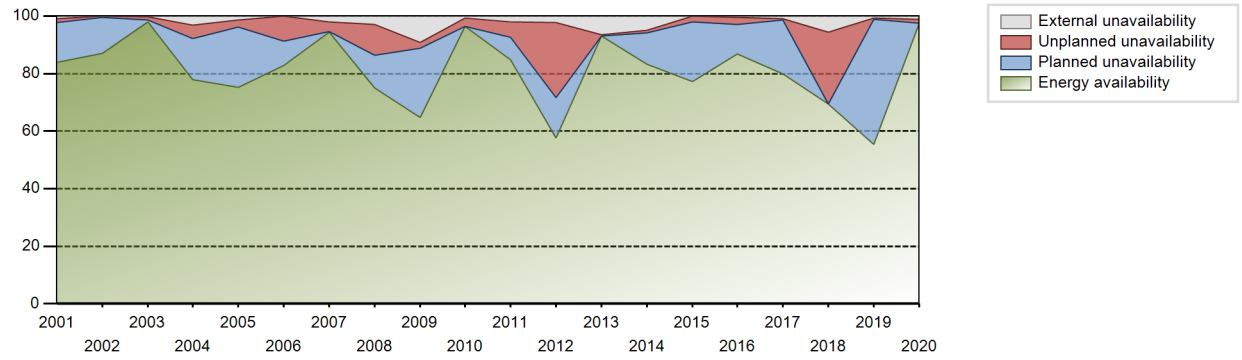
Electricity Production (net) [GWh]



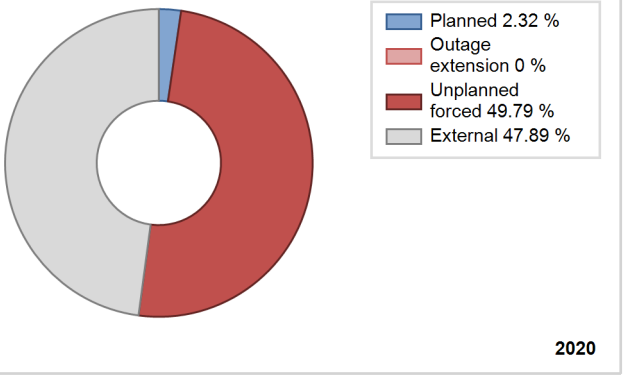
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	7715.00	7324	1310	86.78	87.76	63.93	81.77	12.24	12.24	0.00	0.98
1989	3172.66	2663	1310	28.26	30.25	27.65	30.40	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

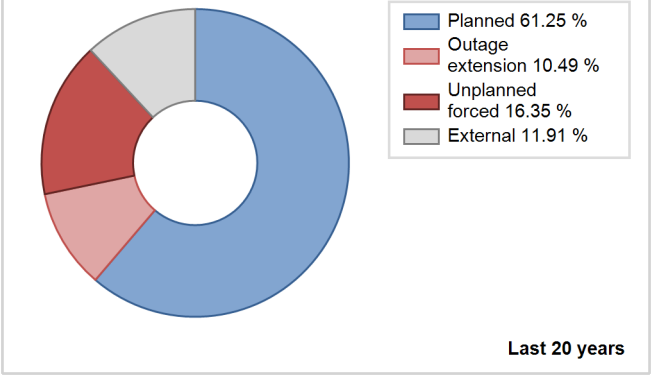
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					502	
B. Refuelling without maintenance				50		
C. Inspection, maintenance or repair combined with refuelling				970	1	
D. Inspection, maintenance or repair without refuelling				53		
E. Testing of plant systems or components				47		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					45	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.)						36
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						19
Z. Other					6	2
Subtotal				1120	564	61
Total		**0**			**1745**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1988 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		50
12. Reactor I&C Systems		95
13. Reactor Auxiliary Systems		1
14. Safety Systems		2
15. Reactor Cooling Systems		19
16. Steam generation systems		78
17. Safety I&C Systems (excluding reactor I&C)		10
21. Fuel Handling and Storage Facilities		6
31. Turbine and auxiliaries		47
32. Feedwater and Main Steam System		15
33. Circulating Water System		51
34. Miscellaneous Systems		22
35. All other I&C Systems		2
41. Main Generator Systems		83
42. Electrical Power Supply Systems		17
Total		**498**

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2020 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	:	32 years

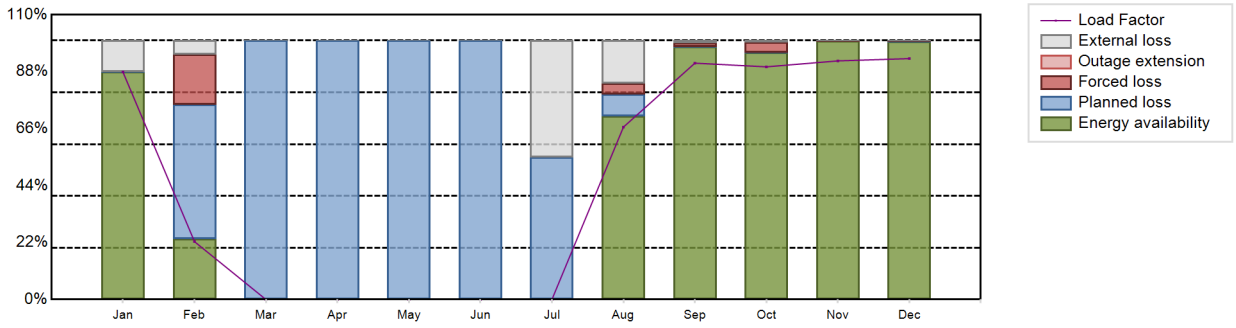
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
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]	:	17.5	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 (2020)

Net Energy Production	:	5223.23 GW(e).h	Forced Loss Rate (FLR)	:	4.12 %
Energy Availability Factor (EAF)	:	48 %	Unplanned Capability Loss Factor (UCL)	:	2.36 %
Unit Capability Factor (UCF)	:	54.82 %	Planned Unavailability Factor (PUF)	:	42.82 %
Load Factor (LF)	:	45.39 %	Externally cause unavailability (XUF)	:	6.82 %
Operating Factor (OF)	:	50.71 %	Total off-line time	:	4330 hours

Annual Summary



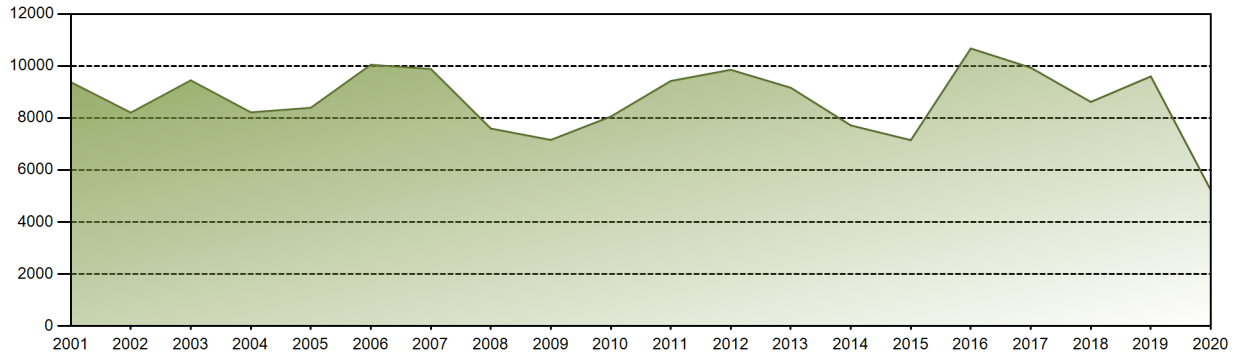
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	856.02	204.02	0.00	0.00	0.00	0.00	0.00	649.01	861.13	877.00	869.26	906.79	5223.23
EAF [%]	87.84	23.37	0.00	0.00	0.00	0.00	0.00	70.94	97.54	95.36	99.75	99.63	48.00
UCF [%]	100.00	28.76	0.00	0.00	0.00	0.00	45.03	87.47	98.37	95.96	99.90	99.88	54.82
LF [%]	87.83	22.38	0.00	0.00	0.00	0.00	0.00	66.59	91.30	89.86	92.16	93.04	45.39
OF [%]	100.00	28.16	0.00	0.00	0.00	0.00	0.00	83.47	99.17	95.97	100.00	100.00	50.71
FLR [%]	0.00	40.15	0.00	0.00	0.00	0.00	0.00	4.51	1.54	3.98	0.05	0.12	4.12
UCL [%]	0.00	19.30	0.00	0.00	0.00	0.00	0.00	4.13	1.54	3.98	0.05	0.12	2.36
PUF [%]	0.00	51.94	100.00	100.00	100.00	100.00	54.97	8.40	0.09	0.06	0.05	0.01	42.82
XUF [%]	12.16	5.39	0.00	0.00	0.00	0.00	45.02	16.53	0.83	0.60	0.15	0.25	6.82

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Historical Summary

Lifetime energy generation	:	272174.42 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.1 %
Cumulative Energy Availability Factor (EAF)	:	79.95 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.5 %
Cumulative Unit Capability Factor (UCF)	:	82.23 %	Cumulative Planned Unavailability Factor (PUF)	:	12.26 %
Cumulative Load Factor (LF)	:	74.4 %	Cumulative Externally cause unavailability (XUF)	:	2.29 %
Cumulative Operating Factor (OF)	:	80.83 %			

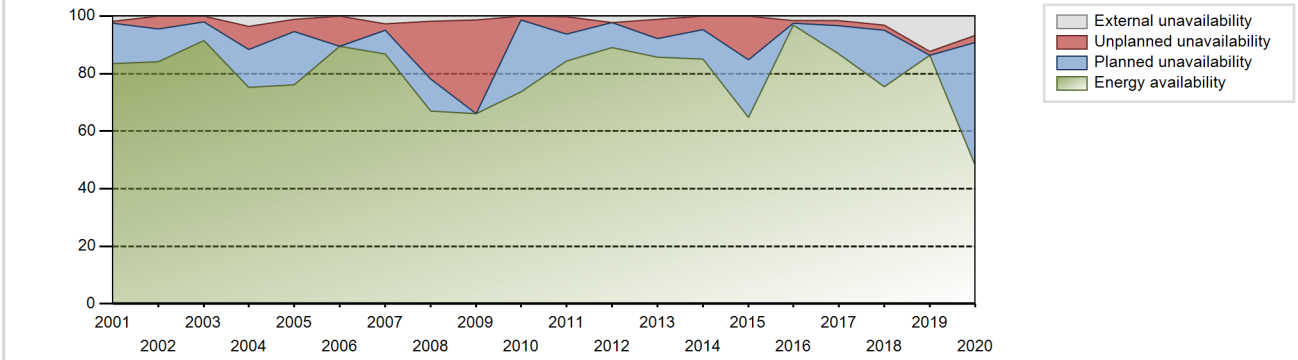
Electricity Production (net) [GWh]



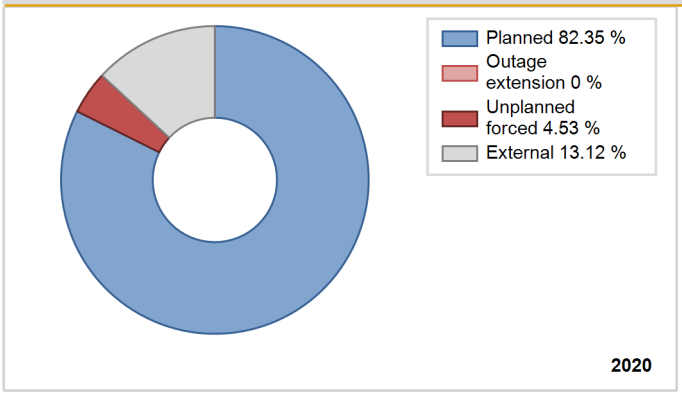
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	7470.05	6660	1310	78.93	78.94	72.84	80.67	21.06	21.05	0.01	0.01
1990	7532.95	6094	1310	68.29	69.37	65.64	69.57	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	4454	1310	48.00	54.82	45.39	50.71	4.12	2.36	42.82	6.82

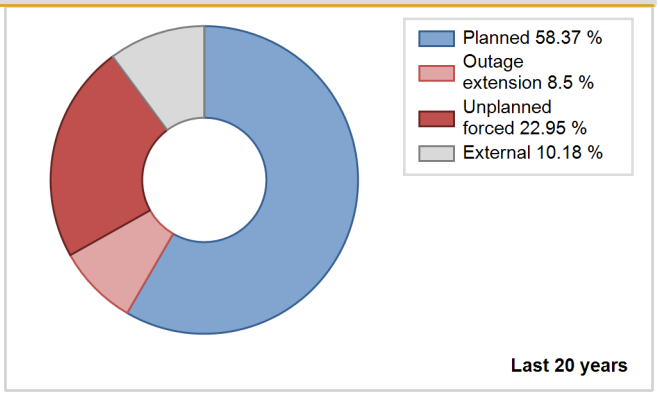
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					396	
B. Refuelling without maintenance				50		
C. Inspection, maintenance or repair combined with refuelling				822		
E. Testing of plant systems or components				25		
J. Grid limitation, failure or grid unavailability						2
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						31
L. Human factor related					8	
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.)						6
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						28
Z. Other					35	
Subtotal				897	439	70
Total	**0**			**1406**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		14
12. Reactor I&C Systems		28
13. Reactor Auxiliary Systems		9
14. Safety Systems		24
15. Reactor Cooling Systems		20
16. Steam generation systems		28
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		56
31. Turbine and auxiliaries		18
32. Feedwater and Main Steam System		7
33. Circulating Water System		27
34. Miscellaneous Systems		8
35. All other I&C Systems		10
41. Main Generator Systems		138
42. Electrical Power Supply Systems		5
Total		**392**

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2020 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	:	36 years

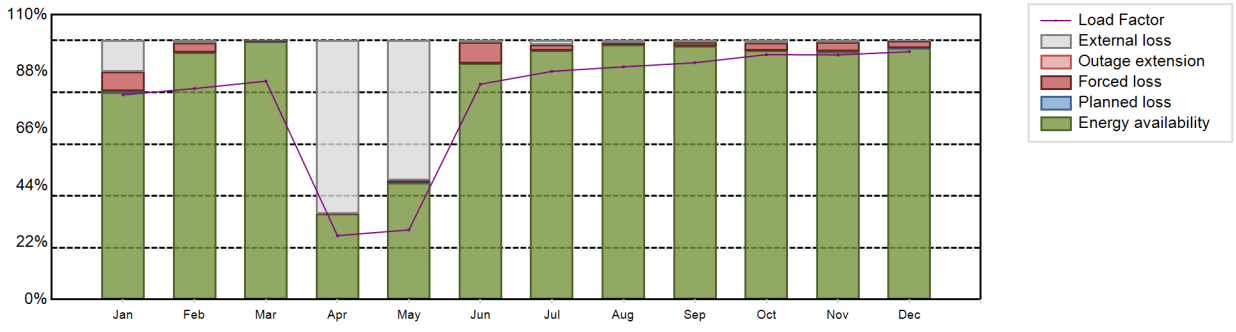
Design Characteristics

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]	:	15.5
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 (2020)

Net Energy Production	:	9093.82 GW(e).h
Energy Availability Factor (EAF)	:	85.47 %
Unit Capability Factor (UCF)	:	97.09 %
Load Factor (LF)	:	77.84 %
Operating Factor (OF)	:	87.8 %
Forced Loss Rate (FLR)	:	2.82 %
Unplanned Capability Loss Factor (UCL)	:	2.81 %
Planned Unavailability Factor (PUF)	:	0.09 %
Externally cause unavailability (XUF)	:	11.62 %
Total off-line time	:	1072 hours

Annual Summary



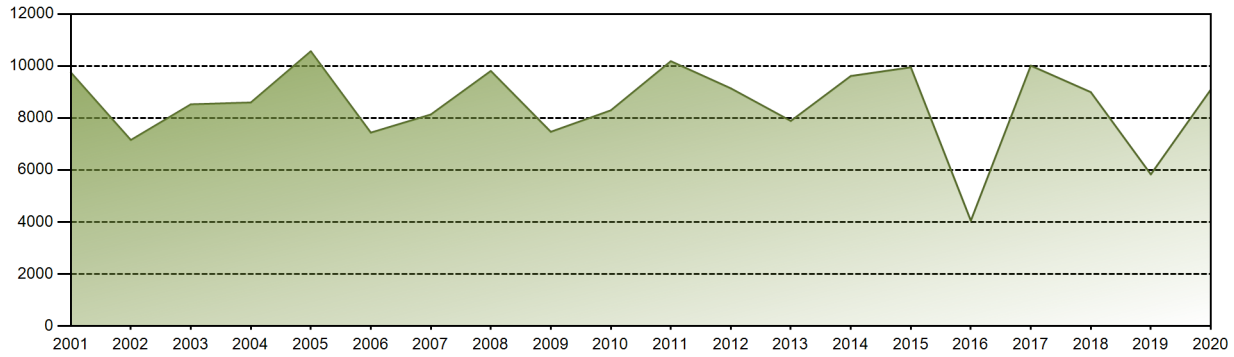
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	782.02	754.22	833.33	236.10	266.09	796.30	872.01	889.27	875.74	937.11	904.50	947.11	9093.82
EAF [%]	79.91	95.41	99.64	33.09	45.14	91.23	96.09	98.28	97.95	96.06	95.70	97.05	85.47
UCF [%]	91.85	96.31	99.64	99.95	99.22	91.93	97.63	99.16	98.64	97.01	96.44	97.23	97.09
LF [%]	79.03	81.48	84.33	24.66	26.89	83.16	88.12	89.87	91.45	94.58	94.45	95.71	77.84
OF [%]	83.47	95.98	100.00	33.33	46.24	94.44	100.00	100.00	100.00	99.87	100.00	100.00	87.80
FLR [%]	7.60	3.69	0.31	0.05	0.60	8.07	2.34	0.84	1.36	2.99	3.44	2.64	2.82
UCL [%]	7.55	3.69	0.31	0.05	0.60	8.07	2.34	0.84	1.36	2.99	3.43	2.64	2.81
PUF [%]	0.59	0.00	0.05	0.00	0.19	0.00	0.03	0.00	0.00	0.00	0.13	0.12	0.09
XUF [%]	11.94	0.90	0.00	66.86	54.08	0.70	1.54	0.88	0.69	0.95	0.74	0.18	11.62

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Historical Summary

Lifetime energy generation	:	295183.27 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.26 %
Cumulative Energy Availability Factor (EAF)	:	76.31 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.85 %
Cumulative Unit Capability Factor (UCF)	:	79 %	Cumulative Planned Unavailability Factor (PUF)	:	13.15 %
Cumulative Load Factor (LF)	:	70.96 %	Cumulative Externally cause unavailability (XUF)	:	2.69 %
Cumulative Operating Factor (OF)	:	78.03 %			

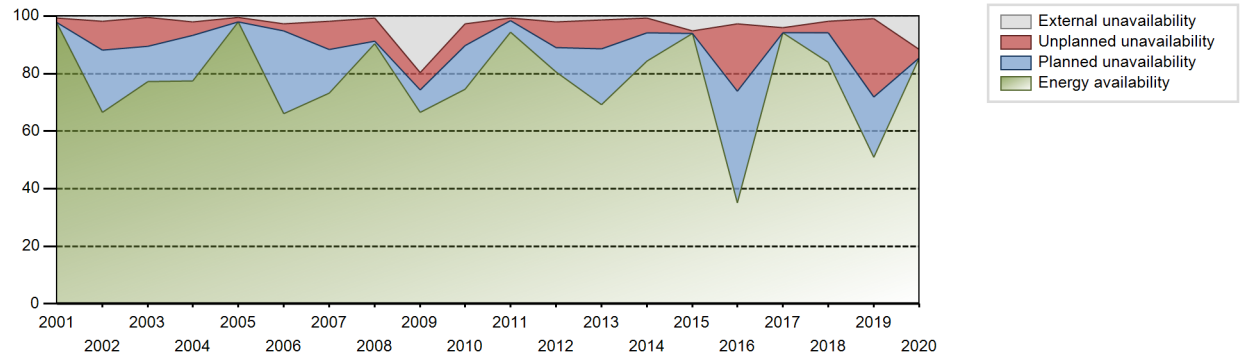
Electricity Production (net) [GWh]



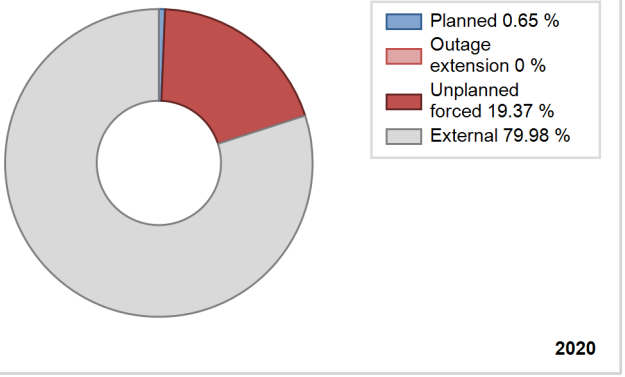
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	4685.80	4104	1290	94.92	94.92	98.72	98.25	5.08	5.08	0.00	0.00
1986	5169.70	4455	1290	50.23	52.32	45.75	50.86	26.61	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	85.47	97.09	77.84	87.80	2.82	2.81	0.09	11.62

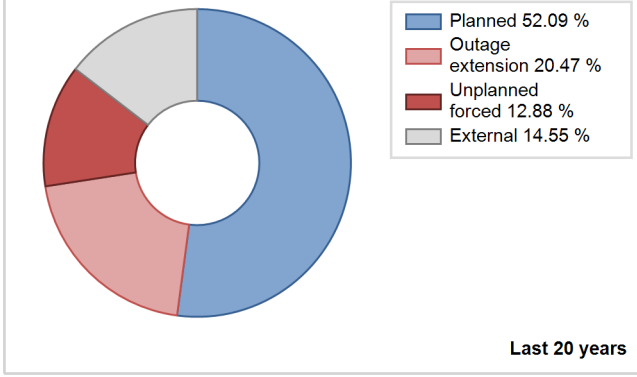
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					484	2
B. Refuelling without maintenance				65		
C. Inspection, maintenance or repair combined with refuelling				992	40	
D. Inspection, maintenance or repair without refuelling				103		
E. Testing of plant systems or components				19	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				10		
H. Nuclear regulatory requirements					11	
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					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.)						57
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						23
Z. Other					66	
Subtotal				1189	634	86
Total		**0**			**1909**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		38
13. Reactor Auxiliary Systems		27
14. Safety Systems		2
15. Reactor Cooling Systems		10
16. Steam generation systems		15
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		38
32. Feedwater and Main Steam System		27
33. Circulating Water System		14
34. Miscellaneous Systems		161
35. All other I&C Systems		2
41. Main Generator Systems		94
42. Electrical Power Supply Systems		15
Total		**469**

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2020 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	:	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

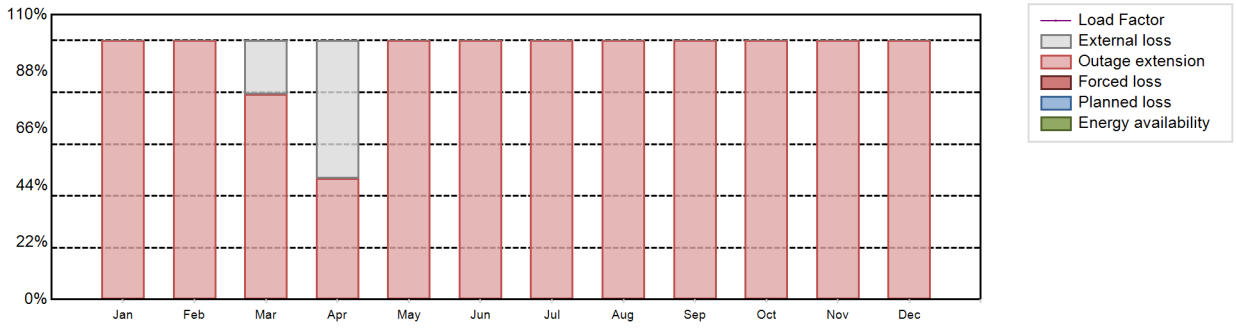
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	328.7
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.2
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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 (2020)

Net Energy Production	:	0 GW(e).h
Energy Availability Factor (EAF)	:	0.06 %
Unit Capability Factor (UCF)	:	6.19 %
Load Factor (LF)	:	0 %
Operating Factor (OF)	:	0 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	93.81 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	6.13 %
Total off-line time	:	8784 hours

Annual Summary



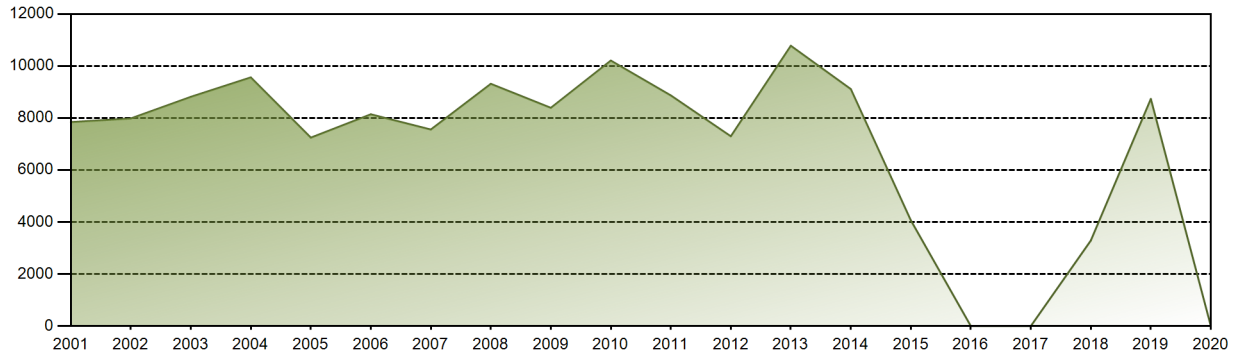
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.06	0.05	0.07	0.06	0.06	0.03	0.04	0.06	0.07	0.06	0.06	0.07	0.06
UCF [%]	0.06	0.05	20.91	53.35	0.06	0.03	0.04	0.06	0.07	0.06	0.06	0.07	6.19
LF [%]	0.00	0.00	0.00	0.00	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 [%]	99.94	99.95	79.09	46.65	99.94	99.97	99.96	99.94	99.93	99.94	99.94	99.93	93.81
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	20.84	53.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.13

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Historical Summary

Lifetime energy generation	:	260010.28 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.04 %
Cumulative Energy Availability Factor (EAF)	:	66.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	17.62 %
Cumulative Unit Capability Factor (UCF)	:	68.89 %	Cumulative Planned Unavailability Factor (PUF)	:	13.49 %
Cumulative Load Factor (LF)	:	62.27 %	Cumulative Externally cause unavailability (XUF)	:	1.96 %
Cumulative Operating Factor (OF)	:	69 %			

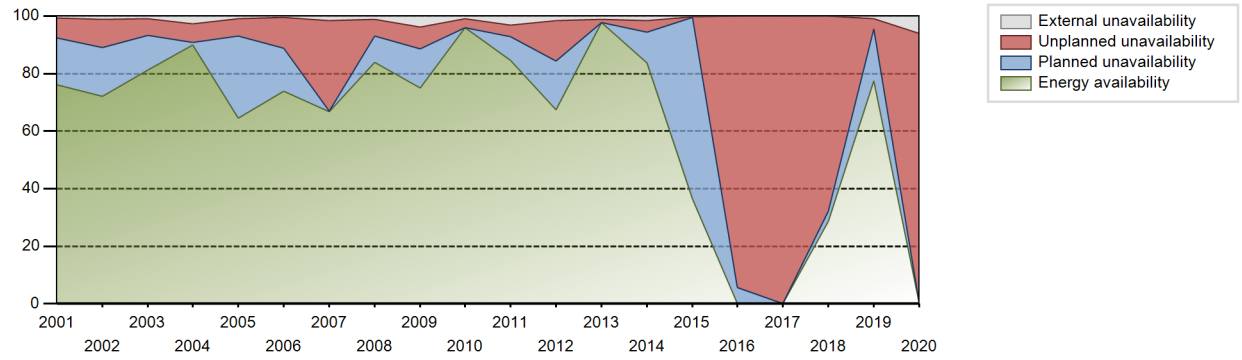
Electricity Production (net) [GWh]



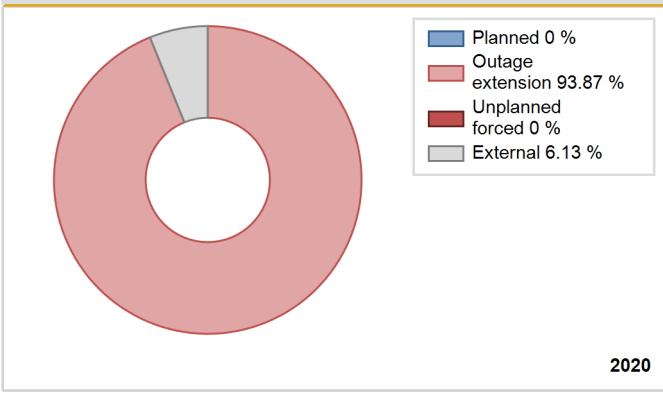
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	5997.80	5548	1290	99.64	99.64	103.20	100.00	0.36	0.36	0.00	0.00
1986	6040.90	4804	1290	52.22	52.33	53.46	54.84	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

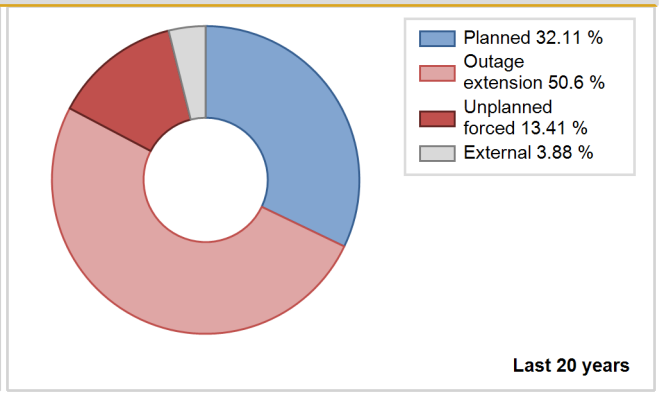
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					1149	2
B. Refuelling without maintenance				134		
C. Inspection, maintenance or repair combined with refuelling				742	83	
D. Inspection, maintenance or repair without refuelling				33	7	
E. Testing of plant systems or components				14	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				172		
H. Nuclear regulatory requirements					7	
J. Grid limitation, failure or grid unavailability						4
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						2
L. Human factor related					9	
P. Fire					48	
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					32	1
Subtotal				1095	1336	14
Total	**0**			**2445**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		15
12. Reactor I&C Systems		76
13. Reactor Auxiliary Systems		10
14. Safety Systems		21
15. Reactor Cooling Systems		56
16. Steam generation systems		581
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		39
32. Feedwater and Main Steam System		30
33. Circulating Water System		44
34. Miscellaneous Systems		47
35. All other I&C Systems		2
41. Main Generator Systems		162
42. Electrical Power Supply Systems		27
Total		**1116**

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2020 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

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	:	1979-02-01
Grid Date	:	1985-09-30
Commercial Date	:	1986-02-01
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]	:	17.2
Number of control rod assemblies	:	53
Number of external reactor coolant loops	:	4
Coolant type	:	H2O

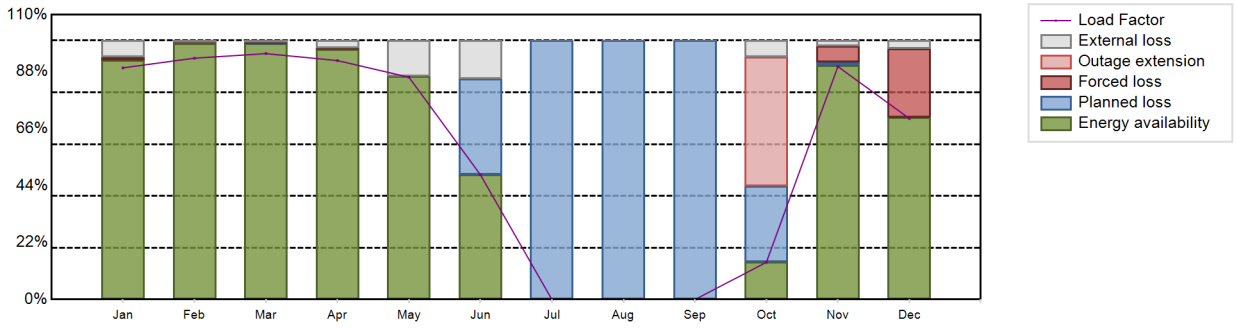
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	328.7
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.2
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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 (2020)

Net Energy Production	:	6577.17 GW(e).h
Energy Availability Factor (EAF)	:	57.82 %
Unit Capability Factor (UCF)	:	62.09 %
Load Factor (LF)	:	56.3 %
Operating Factor (OF)	:	62.4 %

Forced Loss Rate (FLR)	:	4.53 %
Unplanned Capability Loss Factor (UCL)	:	7.18 %
Planned Unavailability Factor (PUF)	:	30.73 %
Externally cause unavailability (XUF)	:	4.26 %
Total off-line time	:	3303 hours

Annual Summary



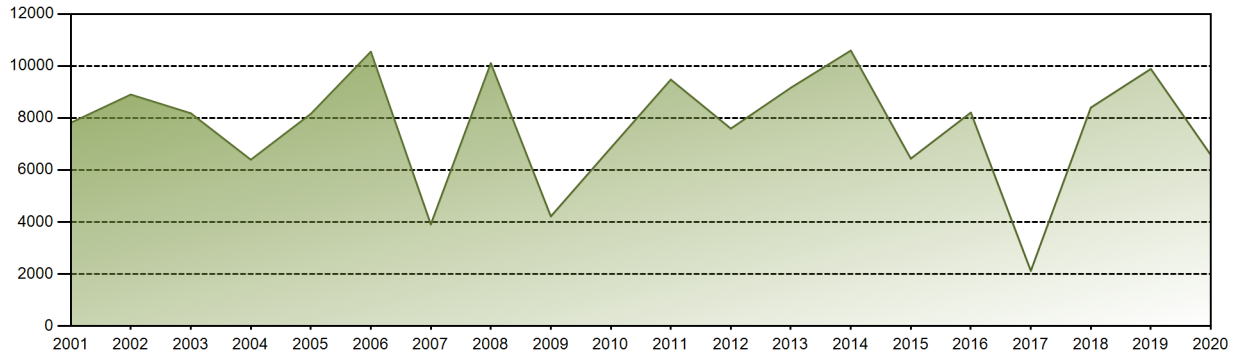
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	885.45	862.85	938.52	883.71	849.58	461.32	0.00	0.00	0.00	142.29	861.70	691.74	6577.17
EAF [%]	92.40	98.99	98.79	96.68	86.18	48.19	0.05	0.06	0.05	14.43	90.50	70.43	57.82
UCF [%]	98.82	99.63	99.47	99.63	100.00	63.03	0.05	0.06	0.05	20.73	92.65	73.66	62.09
LF [%]	89.48	93.21	94.97	92.28	85.86	48.17	0.00	0.00	0.00	14.36	89.99	69.91	56.30
OF [%]	100.00	100.00	100.00	100.00	100.00	63.33	0.00	0.00	0.00	20.40	94.44	73.39	62.40
FLR [%]	1.18	0.34	0.51	0.38	0.00	0.00	0.00	0.00	0.00	0.00	6.31	26.34	4.53
UCL [%]	1.18	0.34	0.51	0.38	0.00	0.00	0.00	0.00	0.00	49.97	6.24	26.34	7.18
PUF [%]	0.00	0.03	0.02	0.00	0.00	36.97	99.95	99.94	99.95	29.30	1.10	0.00	30.73
XUF [%]	6.42	0.64	0.68	2.94	13.82	14.84	0.00	0.00	0.00	6.30	2.15	3.22	4.26

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Historical Summary

Lifetime energy generation	:	274760.35 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	10.6 %
Cumulative Energy Availability Factor (EAF)	:	71.62 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	12.33 %
Cumulative Unit Capability Factor (UCF)	:	74.14 %	Cumulative Planned Unavailability Factor (PUF)	:	13.54 %
Cumulative Load Factor (LF)	:	67.09 %	Cumulative Externally cause unavailability (XUF)	:	2.52 %
Cumulative Operating Factor (OF)	:	73.44 %			

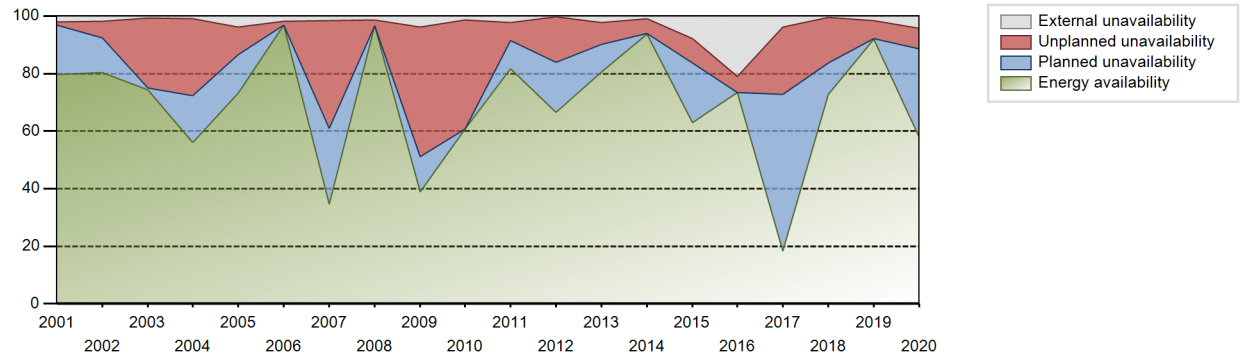
Electricity Production (net) [GWh]



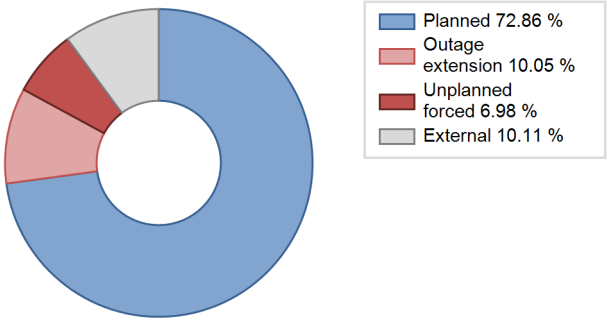
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	8321.70	6503	1290	72.10	72.10	71.52	71.84	7.84	6.13	21.77	0.00
1987	7716.60	6104	1290	78.31	78.35	68.29	69.68	15.09	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

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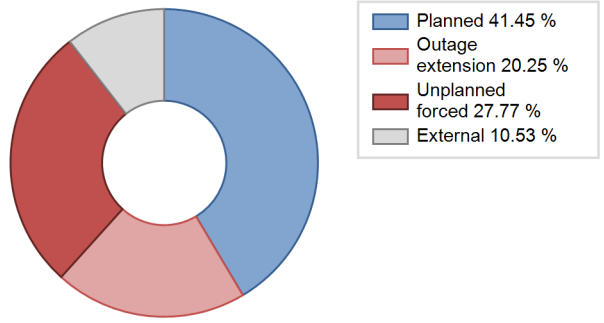
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					912	
B. Refuelling without maintenance				97		
C. Inspection, maintenance or repair combined with refuelling				916	28	
D. Inspection, maintenance or repair without refuelling				29		
E. Testing of plant systems or components				25	8	
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					8	
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.)					1	30
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						67
Z. Other					24	
Subtotal				1067	984	104
Total		**0**			**2155**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		37
12. Reactor I&C Systems		69
13. Reactor Auxiliary Systems		40
14. Safety Systems		32
15. Reactor Cooling Systems		125
16. Steam generation systems		7
17. Safety I&C Systems (excluding reactor I&C)		2
21. Fuel Handling and Storage Facilities		11
31. Turbine and auxiliaries		39
32. Feedwater and Main Steam System		56
33. Circulating Water System		37
34. Miscellaneous Systems		128
35. All other I&C Systems		0
41. Main Generator Systems		263
42. Electrical Power Supply Systems		67
Total		**913**

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2020 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	:	34 years

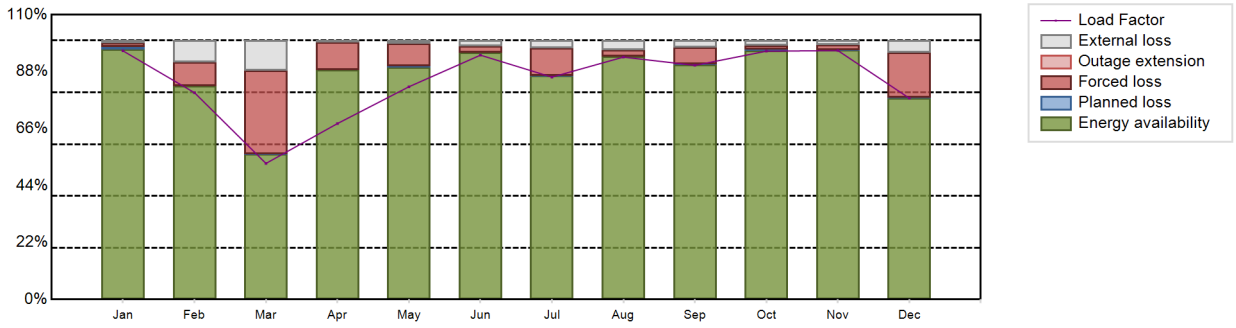
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
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]	:	4.2
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	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	17.2	Number of main condensate pumps	:	-
Number of control rod assemblies	:	36	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 (2020)

Net Energy Production	:	9859.6 GW(e).h	Forced Loss Rate (FLR)	:	8.84 %
Energy Availability Factor (EAF)	:	87.5 %	Unplanned Capability Loss Factor (UCL)	:	8.82 %
Unit Capability Factor (UCF)	:	90.96 %	Planned Unavailability Factor (PUF)	:	0.23 %
Load Factor (LF)	:	84.39 %	Externally cause unavailability (XUF)	:	3.46 %
Operating Factor (OF)	:	91.46 %	Total off-line time	:	750 hours

Annual Summary



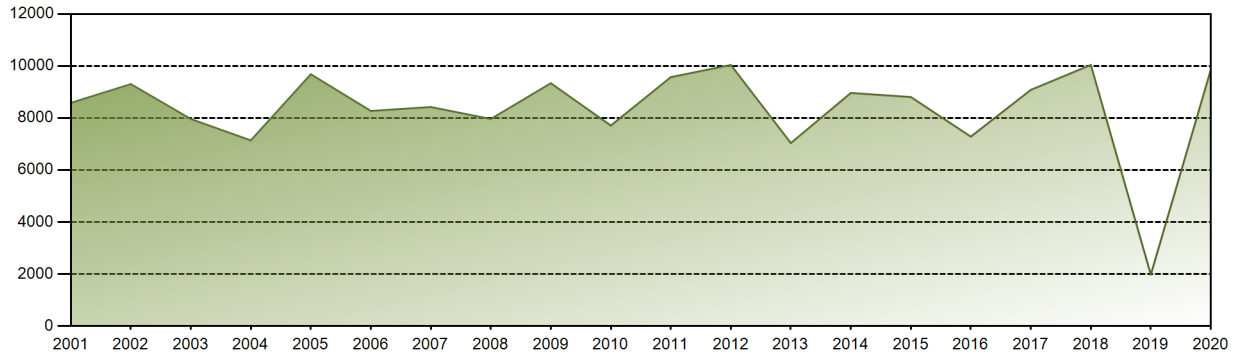
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	950.26	739.42	519.40	650.77	813.15	903.78	849.94	926.40	866.00	950.37	920.76	769.36	9859.60
EAF [%]	96.76	82.51	56.16	88.69	89.78	95.33	86.35	93.92	90.59	96.07	96.27	77.88	87.50
UCF [%]	97.70	90.83	67.70	89.24	90.94	97.33	89.17	97.55	93.09	98.04	97.82	82.48	90.96
LF [%]	96.03	79.88	52.56	67.96	82.18	94.38	85.89	93.62	90.43	95.91	96.15	77.75	84.39
OF [%]	100.00	85.92	57.34	90.42	93.15	100.00	90.99	100.00	99.17	99.87	100.00	81.05	91.46
FLR [%]	1.36	9.17	32.27	10.76	8.62	2.67	10.79	2.45	6.70	1.28	1.99	17.47	8.84
UCL [%]	1.34	9.17	32.26	10.76	8.58	2.67	10.79	2.45	6.69	1.27	1.99	17.46	8.82
PUF [%]	0.96	0.00	0.03	0.00	0.48	0.00	0.04	0.00	0.22	0.68	0.19	0.06	0.23
XUF [%]	0.94	8.32	11.54	0.55	1.16	2.01	2.83	3.63	2.50	1.98	1.55	4.61	3.46

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Historical Summary

Lifetime energy generation	:	285130.87 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.54 %
Cumulative Energy Availability Factor (EAF)	:	76.24 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.65 %
Cumulative Unit Capability Factor (UCF)	:	78.39 %	Cumulative Planned Unavailability Factor (PUF)	:	12.96 %
Cumulative Load Factor (LF)	:	70.57 %	Cumulative Externally cause unavailability (XUF)	:	2.15 %
Cumulative Operating Factor (OF)	:	78.52 %			

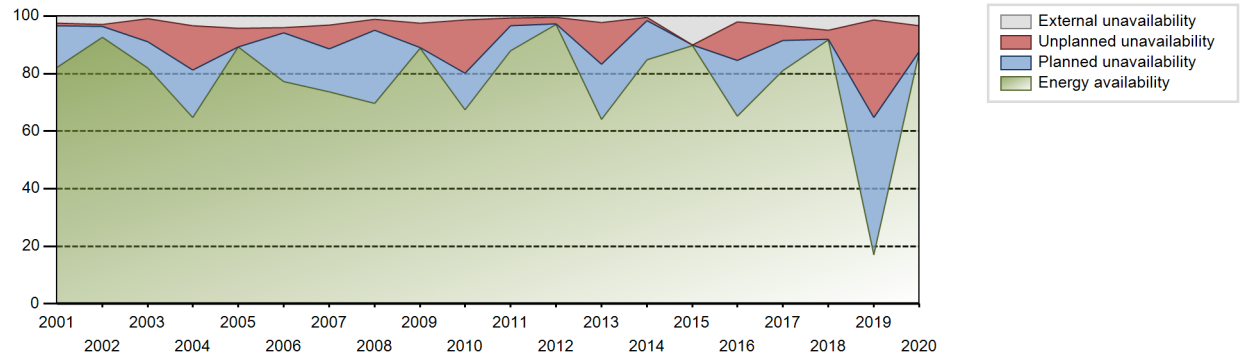
Electricity Production (net) [GWh]



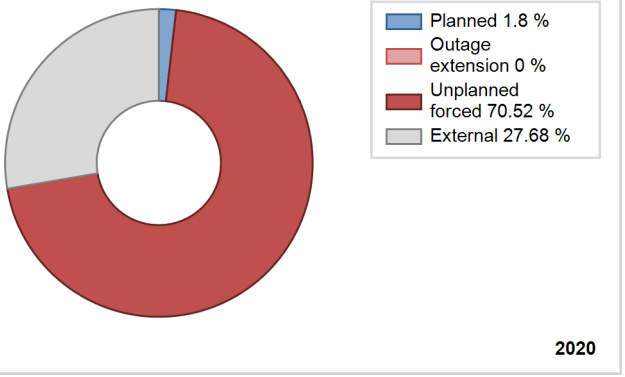
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	6118.60	5343	1300	85.21	85.69	78.04	83.67	14.30	14.30	0.02	0.48
1987	8014.60	6289	1290	69.74	69.84	70.92	71.79	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	8034	1330	87.50	90.96	84.39	91.46	8.84	8.82	0.23	3.46

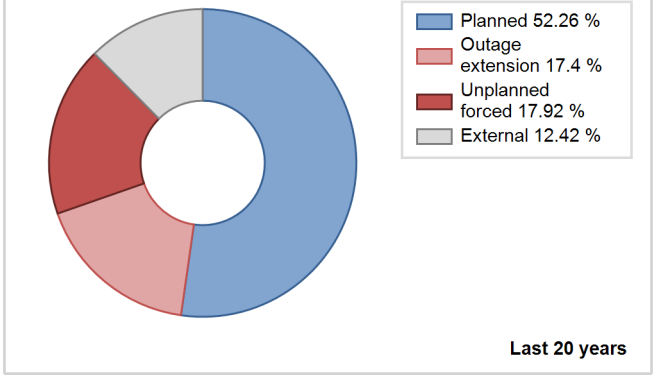
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					566	1
B. Refuelling without maintenance				115		
C. Inspection, maintenance or repair combined with refuelling				909	9	
D. Inspection, maintenance or repair without refuelling				26		
E. Testing of plant systems or components				14	0	
H. Nuclear regulatory requirements					3	
J. Grid limitation, failure or grid unavailability						4
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						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.)						3
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.)					11	10
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						30
Z. Other					59	2
Subtotal				1064	665	59
Total		**0**			**1788**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		100
12. Reactor I&C Systems		29
13. Reactor Auxiliary Systems		7
14. Safety Systems		11
15. Reactor Cooling Systems		25
16. Steam generation systems		49
21. Fuel Handling and Storage Facilities		11
31. Turbine and auxiliaries		47
32. Feedwater and Main Steam System		21
33. Circulating Water System		1
34. Miscellaneous Systems		142
41. Main Generator Systems		97
42. Electrical Power Supply Systems		25
Total		**565**

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2020 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	:	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]	:	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

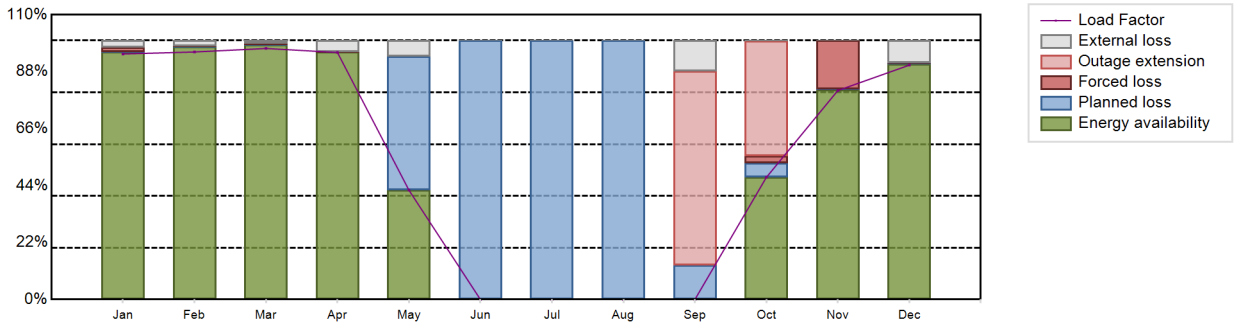
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	328.7
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	4.1
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6249.27 GW(e).h
Energy Availability Factor (EAF)	:	53.91 %
Unit Capability Factor (UCF)	:	56.99 %
Load Factor (LF)	:	53.49 %
Operating Factor (OF)	:	58.29 %

Forced Loss Rate (FLR)	:	3.42 %
Unplanned Capability Loss Factor (UCL)	:	11.92 %
Planned Unavailability Factor (PUF)	:	31.09 %
Externally cause unavailability (XUF)	:	3.08 %
Total off-line time	:	3664 hours

Annual Summary



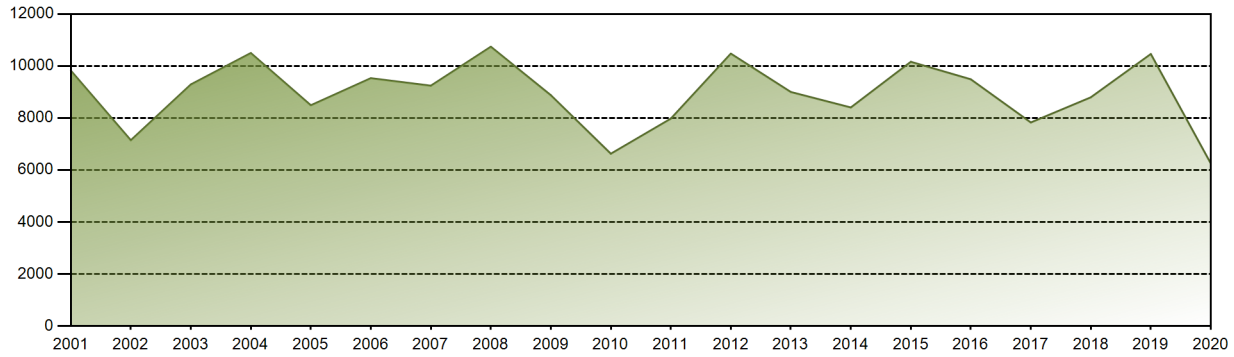
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	938.30	885.05	958.16	913.51	417.94	0.00	0.00	0.00	0.00	467.61	773.00	895.70	6249.27
EAF [%]	95.54	97.54	98.39	95.52	42.24	0.00	0.00	0.01	0.01	47.31	80.99	90.93	53.91
UCF [%]	98.18	99.65	99.57	99.89	48.41	0.00	0.00	0.01	11.87	47.38	80.99	99.58	56.99
LF [%]	94.82	95.61	96.96	95.40	42.24	0.00	0.00	0.00	0.00	47.19	80.72	90.52	53.49
OF [%]	99.19	100.00	100.00	100.00	48.66	0.00	0.00	0.00	0.00	53.29	100.00	100.00	58.29
FLR [%]	1.75	0.28	0.37	0.10	0.00	0.00	0.00	0.00	0.00	5.68	18.89	0.27	3.42
UCL [%]	1.74	0.28	0.37	0.10	0.00	0.00	0.00	0.00	74.78	47.29	18.86	0.27	11.92
PUF [%]	0.08	0.06	0.06	0.01	51.59	100.00	100.00	99.99	13.35	5.33	0.15	0.15	31.09
XUF [%]	2.64	2.11	1.18	4.37	6.17	0.00	0.00	0.00	11.86	0.06	0.00	8.65	3.08

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Historical Summary

Lifetime energy generation	:	267311.82 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.66 %
Cumulative Energy Availability Factor (EAF)	:	80.71 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.43 %
Cumulative Unit Capability Factor (UCF)	:	82.09 %	Cumulative Planned Unavailability Factor (PUF)	:	12.49 %
Cumulative Load Factor (LF)	:	75.72 %	Cumulative Externally cause unavailability (XUF)	:	1.37 %
Cumulative Operating Factor (OF)	:	82.3 %			

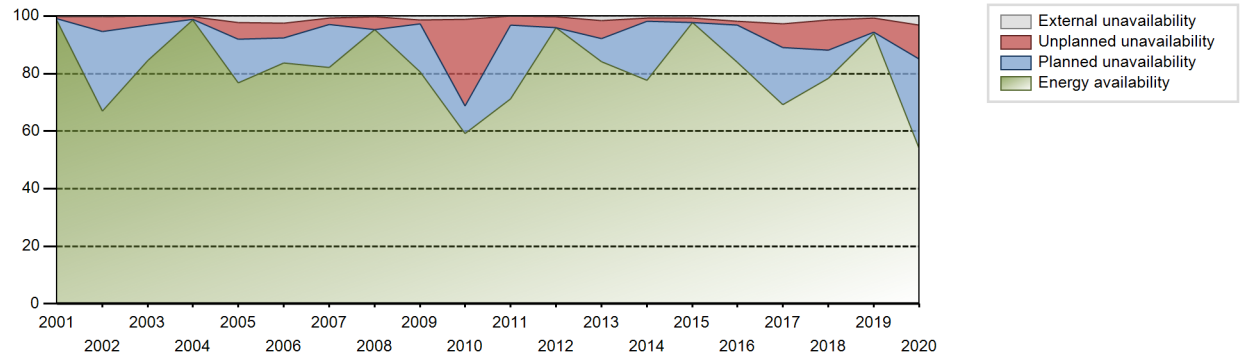
Electricity Production (net) [GWh]



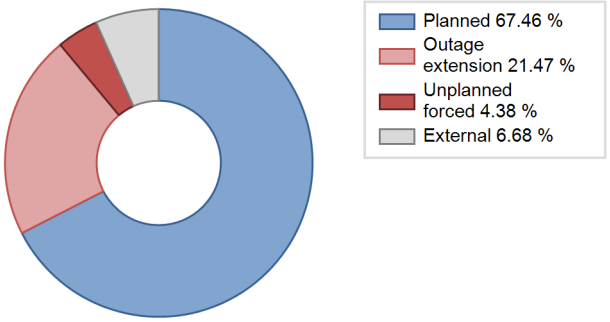
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	2887.12	3100	1330	98.94	98.94	98.15	99.19	0.96	0.96	0.10	0.00
1991	8436.71	6645	1330	74.23	74.27	72.41	75.86	10.99	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

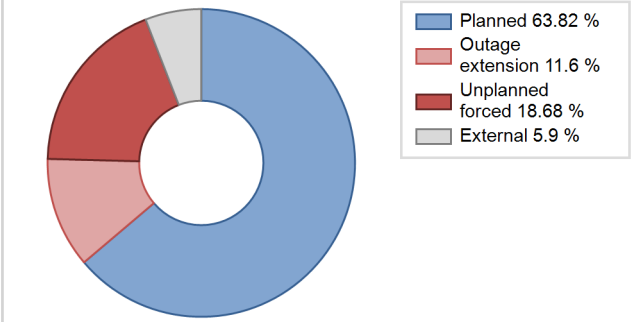
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1990 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					374	0
B. Refuelling without maintenance				112		
C. Inspection, maintenance or repair combined with refuelling				754	1	
D. Inspection, maintenance or repair without refuelling				129		
E. Testing of plant systems or components				14		0
H. Nuclear regulatory requirements					2	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						1
L. Human factor related					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.)						8
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						1
Z. Other					5	
Subtotal				1009	385	10
Total		**0**			**1404**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1990 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		27
12. Reactor I&C Systems		22
13. Reactor Auxiliary Systems		26
14. Safety Systems		10
15. Reactor Cooling Systems		31
16. Steam generation systems		29
17. Safety I&C Systems (excluding reactor I&C)		3
21. Fuel Handling and Storage Facilities		3
31. Turbine and auxiliaries		33
32. Feedwater and Main Steam System		24
33. Circulating Water System		2
34. Miscellaneous Systems		68
35. All other I&C Systems		1
41. Main Generator Systems		88
42. Electrical Power Supply Systems		7
Total		**374**

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2020 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	:	28 years

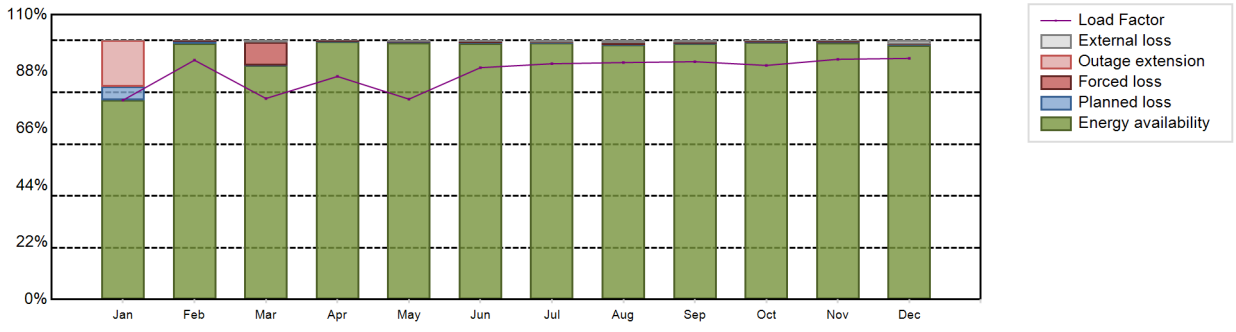
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	10224.76 GW(e).h
Energy Availability Factor (EAF)	:	96.37 %
Unit Capability Factor (UCF)	:	96.77 %
Load Factor (LF)	:	87.52 %
Operating Factor (OF)	:	97.76 %
Forced Loss Rate (FLR)	:	1.16 %
Unplanned Capability Loss Factor (UCL)	:	2.64 %
Planned Unavailability Factor (PUF)	:	0.59 %
Externally cause unavailability (XUF)	:	0.4 %
Total off-line time	:	197 hours

Annual Summary



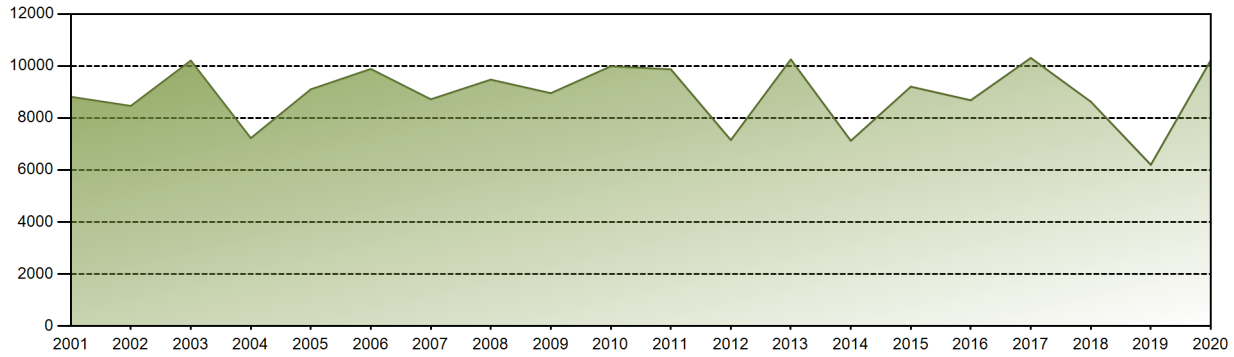
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	761.66	855.64	767.15	825.02	765.79	857.47	901.13	905.56	879.53	895.82	888.50	921.47	10224.76
EAF [%]	76.98	98.89	90.44	99.55	99.24	98.89	99.07	98.42	98.86	99.38	99.02	98.20	96.37
UCF [%]	76.98	98.89	91.09	99.55	99.53	99.29	99.59	99.24	99.37	99.58	99.02	99.53	96.77
LF [%]	76.97	92.43	77.63	86.16	77.39	89.54	91.07	91.52	91.85	90.41	92.78	93.12	87.52
OF [%]	82.26	100.00	91.39	100.00	100.00	100.00	100.00	100.00	100.00	99.87	100.00	100.00	97.76
FLR [%]	0.00	0.45	8.84	0.34	0.41	0.55	0.36	0.70	0.54	0.37	0.58	0.42	1.16
UCL [%]	17.73	0.45	8.84	0.34	0.41	0.55	0.36	0.70	0.54	0.37	0.58	0.42	2.64
PUF [%]	5.29	0.66	0.07	0.11	0.06	0.16	0.05	0.06	0.09	0.05	0.40	0.05	0.59
XUF [%]	0.00	0.00	0.65	0.00	0.29	0.40	0.52	0.83	0.52	0.20	0.00	1.33	0.40

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Historical Summary

Lifetime energy generation	:	254001.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.85 %
Cumulative Energy Availability Factor (EAF)	:	82.26 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.16 %
Cumulative Unit Capability Factor (UCF)	:	83.62 %	Cumulative Planned Unavailability Factor (PUF)	:	11.23 %
Cumulative Load Factor (LF)	:	76.41 %	Cumulative Externally cause unavailability (XUF)	:	1.36 %
Cumulative Operating Factor (OF)	:	84.01 %			

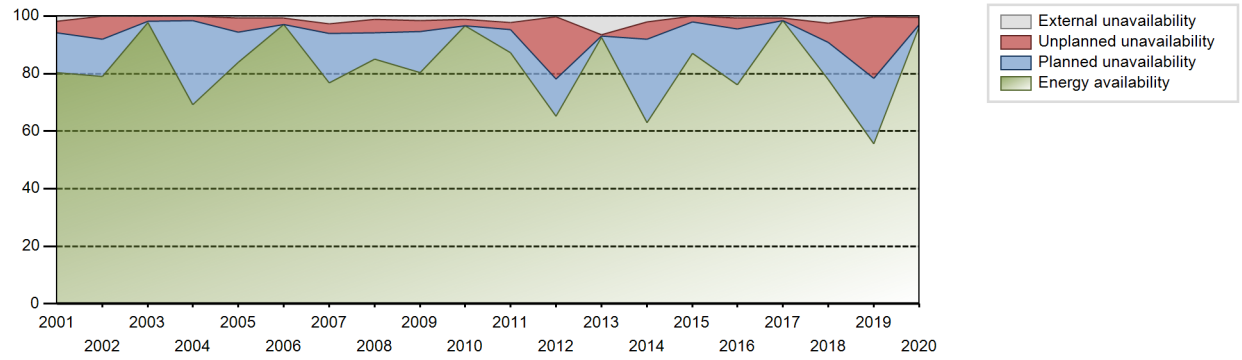
Electricity Production (net) [GWh]



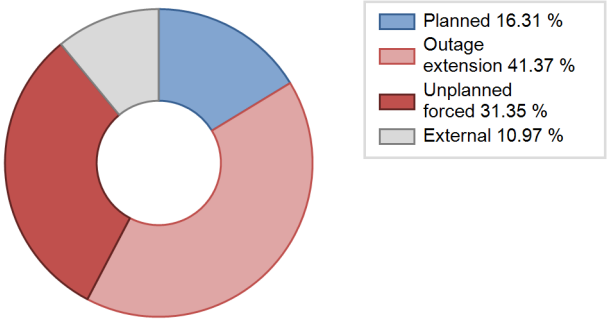
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1992	5149.77	4796	1330	99.98	99.98	101.22	100.00	0.00	0.00	0.02	0.00
1993	8611.76	6658	1330	74.40	75.16	73.92	76.00	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	8587	1330	96.37	96.77	87.52	97.76	1.16	2.64	0.59	0.40

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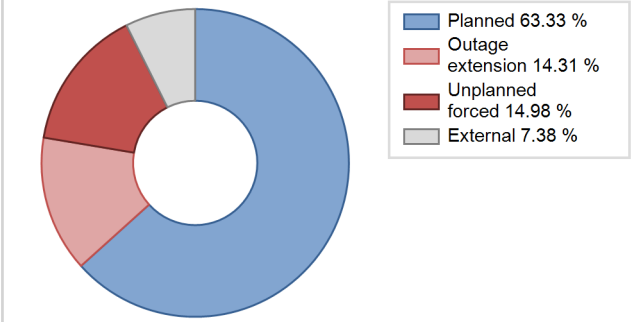
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1992 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					471	
B. Refuelling without maintenance				122		
C. Inspection, maintenance or repair combined with refuelling				797		
E. Testing of plant systems or components				30		
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)						1
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
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	4
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						12
Z. Other					2	
Subtotal				949	489	25
Total		**0**			**1463**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1992 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		25
12. Reactor I&C Systems		17
13. Reactor Auxiliary Systems		17
14. Safety Systems		22
15. Reactor Cooling Systems		77
16. Steam generation systems		11
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System		17
33. Circulating Water System		2
34. Miscellaneous Systems		111
35. All other I&C Systems		1
41. Main Generator Systems		6
42. Electrical Power Supply Systems		110
Total		**460**

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2020 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	:	35 years

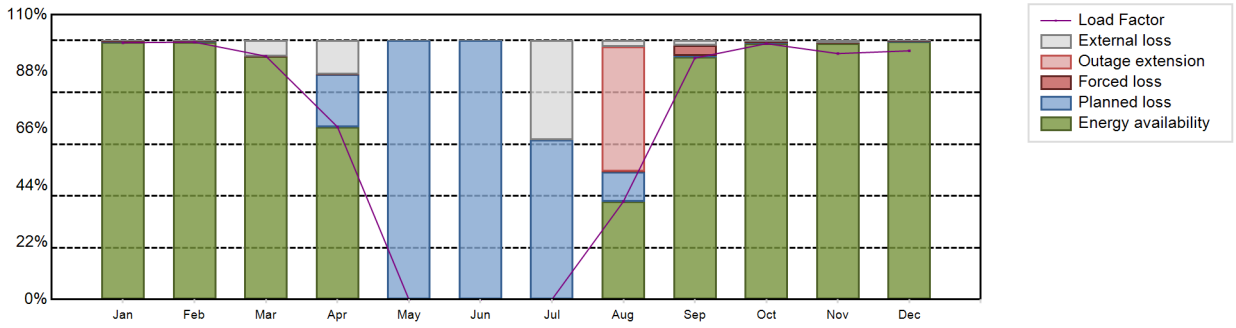
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	328.3
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	:	-	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 (2020)

Net Energy Production	:	7603.38 GW(e).h	Forced Loss Rate (FLR)	:	0.63 %
Energy Availability Factor (EAF)	:	65.52 %	Unplanned Capability Loss Factor (UCL)	:	4.53 %
Unit Capability Factor (UCF)	:	70.87 %	Planned Unavailability Factor (PUF)	:	24.6 %
Load Factor (LF)	:	64.84 %	Externally cause unavailability (XUF)	:	5.36 %
Operating Factor (OF)	:	68.69 %	Total off-line time	:	2750 hours

Annual Summary



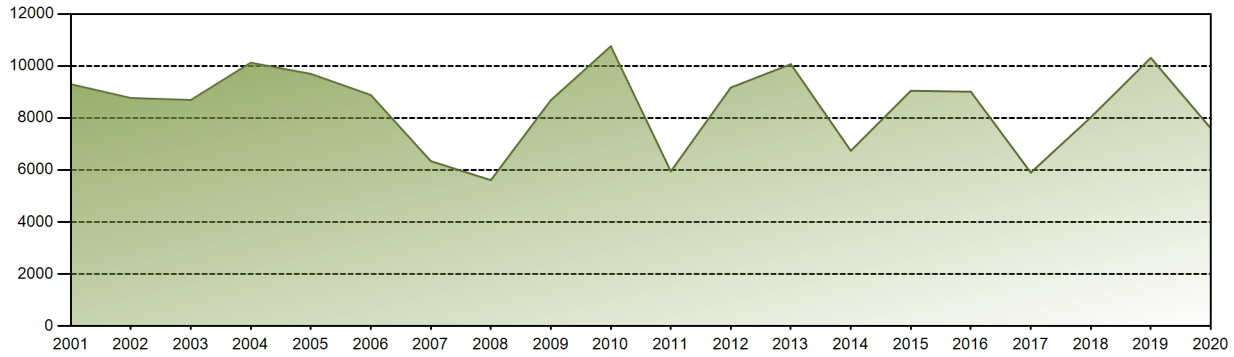
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	984.95	923.58	932.06	640.81	0.00	0.00	0.00	375.89	896.25	982.76	913.00	954.09	7603.38
EAF [%]	99.25	99.47	93.98	66.68	0.00	0.00	0.01	37.85	93.55	98.95	98.98	99.59	65.52
UCF [%]	99.50	99.69	99.97	79.63	0.00	0.00	38.40	40.32	95.39	99.45	99.90	99.81	70.87
LF [%]	99.17	99.40	93.97	66.67	0.00	0.00	0.00	37.85	93.24	98.81	94.99	96.06	64.84
OF [%]	100.00	100.00	100.00	80.28	0.00	0.00	0.00	49.33	96.94	99.87	100.00	100.00	68.69
FLR [%]	0.37	0.21	0.03	0.00	0.00	0.00	0.00	0.25	4.10	0.42	0.10	0.14	0.63
UCL [%]	0.37	0.21	0.03	0.00	0.00	0.00	0.00	48.23	4.08	0.42	0.10	0.14	4.53
PUF [%]	0.13	0.10	0.00	20.36	100.00	100.00	61.60	11.45	0.53	0.13	0.00	0.05	24.60
XUF [%]	0.26	0.22	5.99	12.95	0.00	0.00	38.39	2.46	1.84	0.49	0.92	0.22	5.36

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Historical Summary

Lifetime energy generation	:	278552.2 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.17 %
Cumulative Energy Availability Factor (EAF)	:	74.73 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.09 %
Cumulative Unit Capability Factor (UCF)	:	77.06 %	Cumulative Planned Unavailability Factor (PUF)	:	13.85 %
Cumulative Load Factor (LF)	:	67.82 %	Cumulative Externally cause unavailability (XUF)	:	2.33 %
Cumulative Operating Factor (OF)	:	74.74 %			

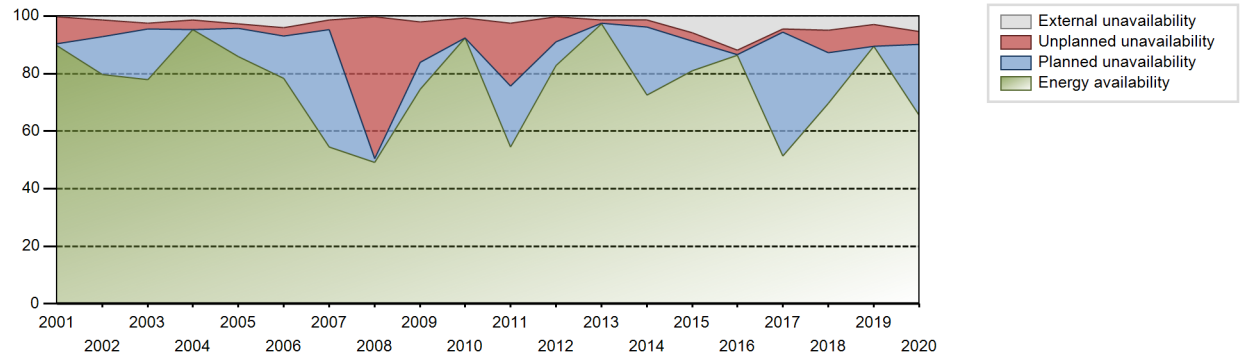
Electricity Production (net) [GWh]



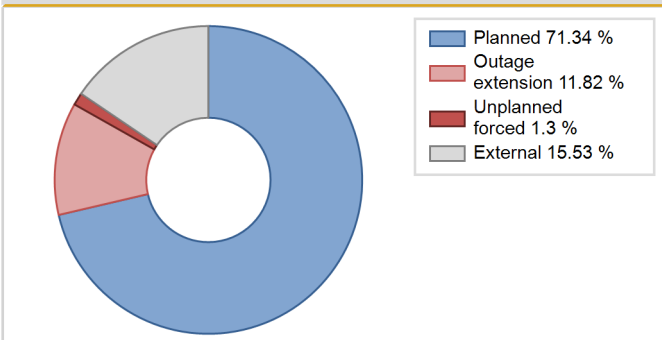
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	6722.90	5449	1300	66.38	67.62	51.14	54.11	17.05	13.90	18.48	1.24
1987	6101.60	4944	1300	56.16	56.61	53.58	56.44	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	6034	1335	65.52	70.87	64.84	68.69	0.63	4.53	24.60	5.36

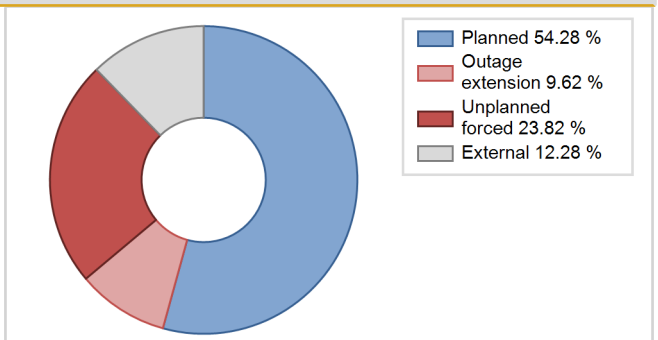
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					644	
B. Refuelling without maintenance				125		
C. Inspection, maintenance or repair combined with refuelling				927	7	
D. Inspection, maintenance or repair without refuelling				47	0	
E. Testing of plant systems or components				25		
H. Nuclear regulatory requirements					41	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						19
L. Human factor related					5	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						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.)					8	7
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					0	39
Z. Other					14	0
Subtotal				1124	719	79
Total	**0**			**1922**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		42
12. Reactor I&C Systems		26
13. Reactor Auxiliary Systems		19
14. Safety Systems		12
15. Reactor Cooling Systems		81
16. Steam generation systems		5
21. Fuel Handling and Storage Facilities		10
31. Turbine and auxiliaries		115
32. Feedwater and Main Steam System		56
33. Circulating Water System		2
34. Miscellaneous Systems		61
35. All other I&C Systems		2
41. Main Generator Systems		163
42. Electrical Power Supply Systems		45
Total		**639**

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2020 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	:	34 years

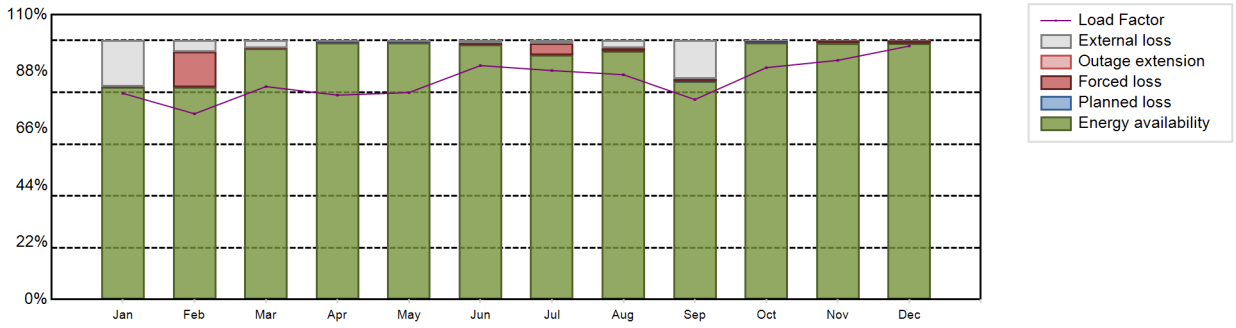
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	328.3
Fuel material	:	UO2	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	-
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	:	-	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 (2020)

Net Energy Production	:	9928.37 GW(e).h	Forced Loss Rate (FLR)	:	2 %
Energy Availability Factor (EAF)	:	94.16 %	Unplanned Capability Loss Factor (UCL)	:	2 %
Unit Capability Factor (UCF)	:	97.94 %	Planned Unavailability Factor (PUF)	:	0.06 %
Load Factor (LF)	:	84.67 %	Externally cause unavailability (XUF)	:	3.78 %
Operating Factor (OF)	:	98.46 %	Total off-line time	:	135 hours

Annual Summary



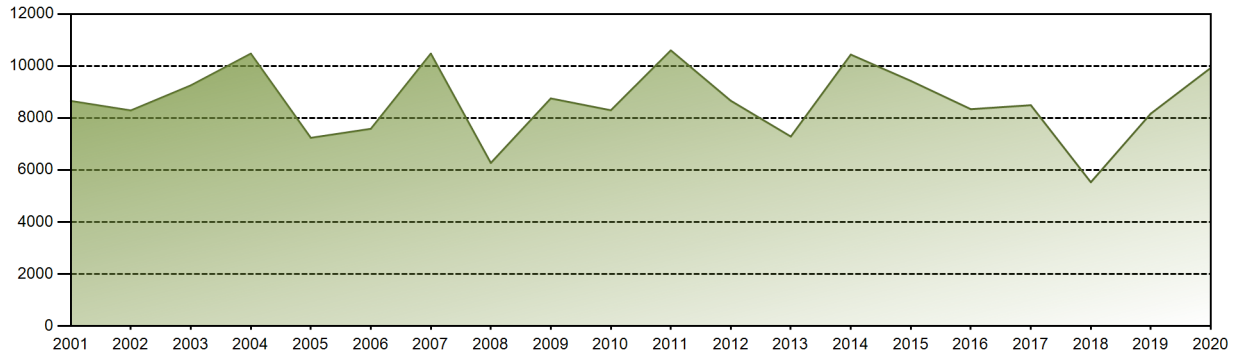
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	790.82	666.52	815.72	758.75	793.89	868.53	878.27	862.46	742.32	890.70	887.93	972.45	9928.37
EAF [%]	81.93	82.06	96.91	99.23	99.18	98.44	94.48	95.95	84.14	99.09	98.98	98.92	94.16
UCF [%]	99.61	86.42	99.67	99.67	99.57	99.43	95.52	98.90	98.93	99.10	98.98	98.92	97.94
LF [%]	79.62	71.73	82.24	78.94	79.93	90.36	88.42	86.83	77.23	89.56	92.38	97.91	84.67
OF [%]	100.00	87.50	100.00	96.67	100.00	100.00	96.91	100.00	100.00	99.87	100.00	100.00	98.46
FLR [%]	0.37	13.53	0.33	0.27	0.37	0.57	4.44	1.10	0.86	0.70	0.97	1.08	2.00
UCL [%]	0.37	13.53	0.33	0.27	0.37	0.57	4.44	1.10	0.86	0.70	0.97	1.08	2.00
PUF [%]	0.03	0.05	0.00	0.06	0.06	0.00	0.04	0.00	0.21	0.20	0.05	0.00	0.06
XUF [%]	17.68	4.36	2.77	0.44	0.39	0.98	1.05	2.95	14.79	0.02	0.00	0.00	3.78

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Historical Summary

Lifetime energy generation	:	273193.02 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	8.77 %
Cumulative Energy Availability Factor (EAF)	:	75.37 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.46 %
Cumulative Unit Capability Factor (UCF)	:	78.16 %	Cumulative Planned Unavailability Factor (PUF)	:	13.38 %
Cumulative Load Factor (LF)	:	68.51 %	Cumulative Externally cause unavailability (XUF)	:	2.79 %
Cumulative Operating Factor (OF)	:	76.87 %			

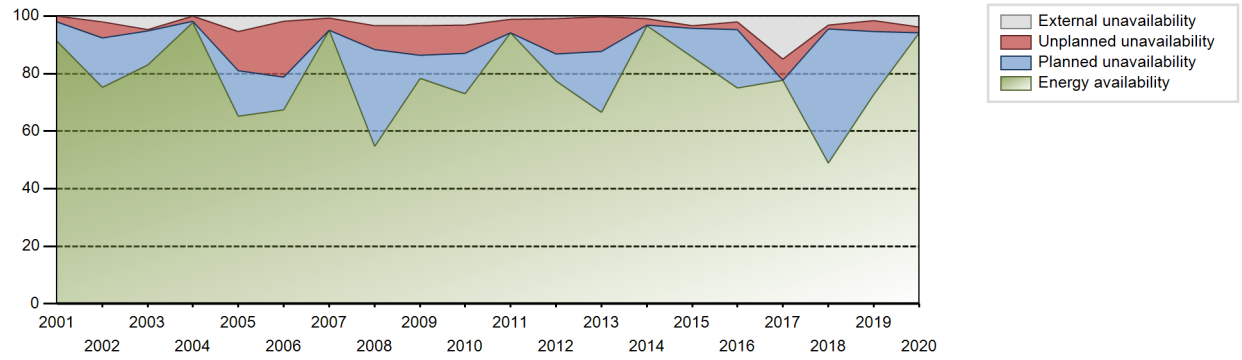
Electricity Production (net) [GWh]



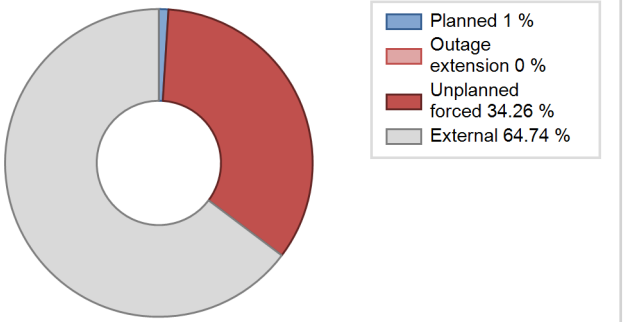
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	6952.20	6094	1300	79.01	79.06	59.07	68.27	20.94	20.94	0.00	0.05
1988	5185.00	4308	1335	46.48	47.29	44.22	49.04	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

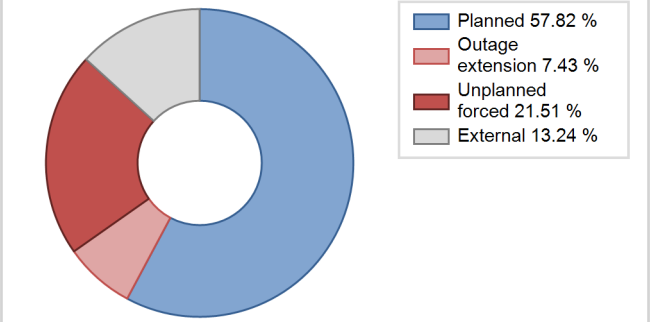
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					631	
B. Refuelling without maintenance				65		
C. Inspection, maintenance or repair combined with refuelling				977	20	
D. Inspection, maintenance or repair without refuelling				58		
E. Testing of plant systems or components				43	1	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						5
L. Human factor related					20	0
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						24
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	16
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						33
Z. Other					10	0
Subtotal				1143	683	78
Total		**0**			**1904**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		41
12. Reactor I&C Systems		63
13. Reactor Auxiliary Systems		11
14. Safety Systems		16
15. Reactor Cooling Systems		36
16. Steam generation systems		82
17. Safety I&C Systems (excluding reactor I&C)		2
21. Fuel Handling and Storage Facilities		20
31. Turbine and auxiliaries		101
32. Feedwater and Main Steam System		50
33. Circulating Water System		1
34. Miscellaneous Systems		53
35. All other I&C Systems		4
41. Main Generator Systems		114
42. Electrical Power Supply Systems		30
Total		**624**

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2020 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

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	:	1976-05-01
Grid Date	:	1981-01-21
Commercial Date	:	1983-08-01
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

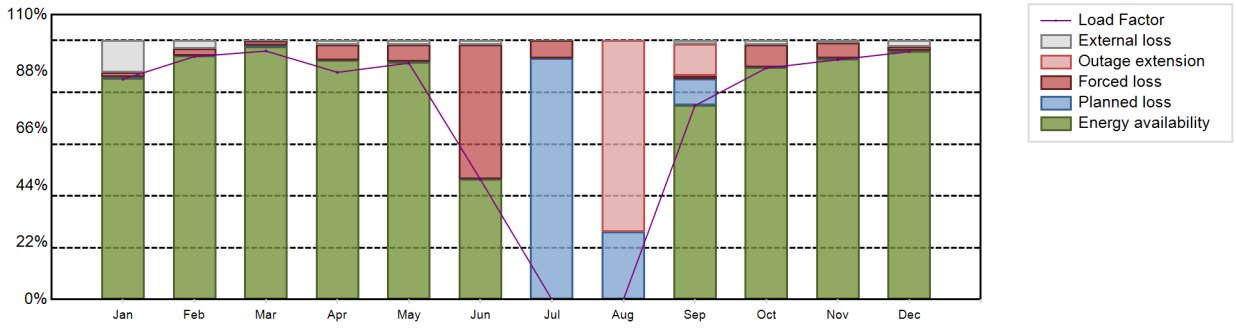
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	5698.35 GW(e).h
Energy Availability Factor (EAF)	:	71.59 %
Unit Capability Factor (UCF)	:	73.83 %
Load Factor (LF)	:	70.9 %
Operating Factor (OF)	:	77.3 %

Forced Loss Rate (FLR)	:	9.56 %
Unplanned Capability Loss Factor (UCL)	:	15.06 %
Planned Unavailability Factor (PUF)	:	11.12 %
Externally cause unavailability (XUF)	:	2.24 %
Total off-line time	:	1994 hours

Annual Summary



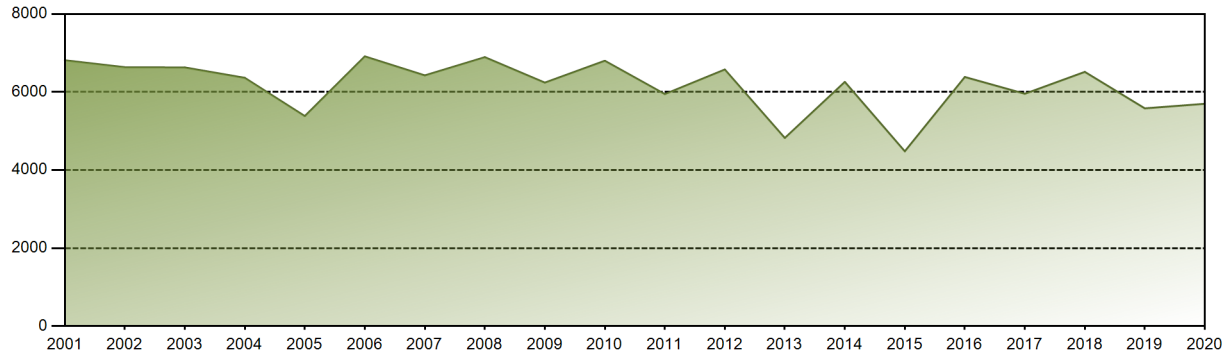
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	579.19	597.52	652.41	578.08	621.51	305.37	0.00	0.00	493.19	609.45	609.99	651.66	5698.35
EAF [%]	85.58	94.04	97.64	92.40	91.75	46.40	0.03	0.01	74.99	89.60	92.80	95.95	71.59
UCF [%]	97.86	97.22	97.90	93.98	93.39	48.03	0.03	0.01	76.44	91.15	93.71	98.26	73.83
LF [%]	85.08	93.83	95.96	87.75	91.30	46.35	0.00	0.00	74.86	89.40	92.59	95.73	70.90
OF [%]	100.00	100.00	100.00	100.00	100.00	48.89	0.00	0.00	87.92	93.15	100.00	100.00	77.30
FLR [%]	1.67	2.67	1.61	5.93	6.49	51.92	99.55	0.00	1.43	8.74	6.03	1.63	9.56
UCL [%]	1.66	2.66	1.60	5.92	6.48	51.86	6.72	73.92	13.22	8.72	6.02	1.63	15.06
PUF [%]	0.49	0.11	0.51	0.10	0.13	0.11	93.25	26.07	10.34	0.13	0.27	0.11	11.12
XUF [%]	12.27	3.18	0.26	1.58	1.64	1.63	0.00	0.00	1.45	1.55	0.91	2.31	2.24

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Historical Summary

Lifetime energy generation	:	219938.53 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.64 %
Cumulative Energy Availability Factor (EAF)	:	75.87 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.15 %
Cumulative Unit Capability Factor (UCF)	:	78.1 %	Cumulative Planned Unavailability Factor (PUF)	:	13.74 %
Cumulative Load Factor (LF)	:	73 %	Cumulative Externally cause unavailability (XUF)	:	2.23 %
Cumulative Operating Factor (OF)	:	78.38 %			

Electricity Production (net) [GWh]

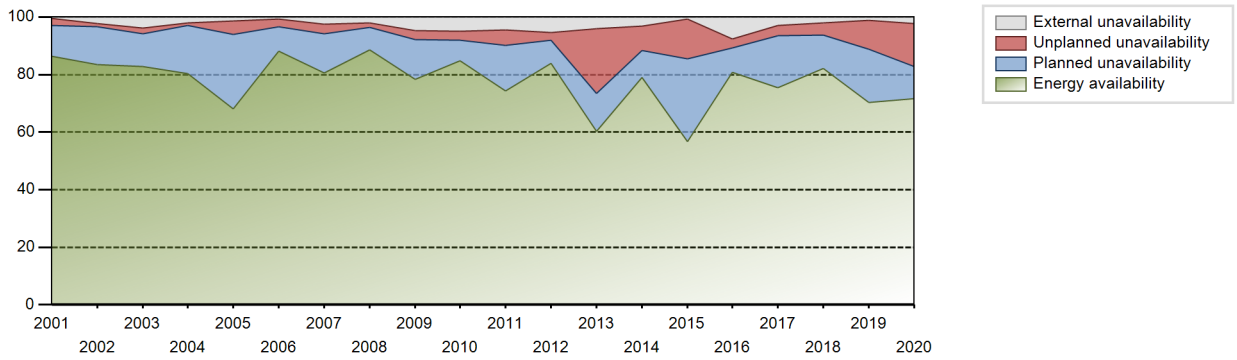


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	3670.00	4382	880	91.99	91.99	91.89	93.85	8.01	8.01	0.00	0.00
1984	4401.00	5042	880	55.95	55.95	56.93	57.40	22.37	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

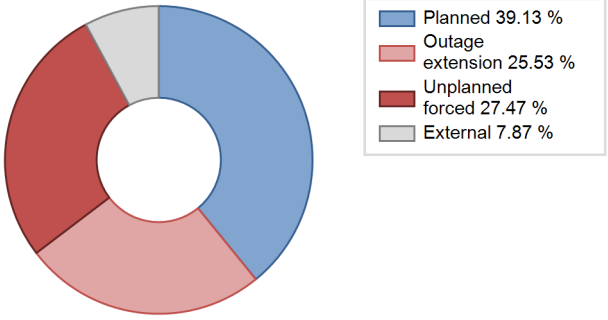
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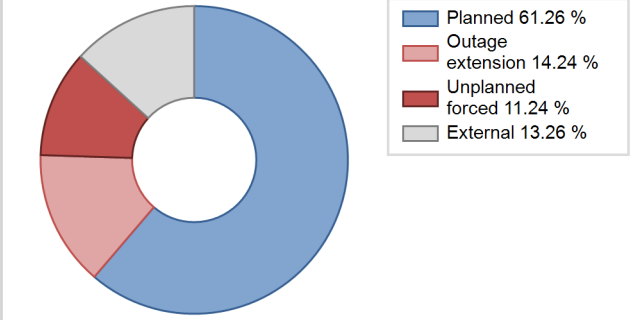
2020	5698.35	6790	915	71.59	73.83	70.90	77.30	9.56	15.06	11.12	2.24

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1983 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					516	
B.	Refuelling without maintenance				112		
C.	Inspection, maintenance or repair combined with refuelling				1116	15	
E.	Testing of plant systems or components				8	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)						7
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.)					24	40
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					239	1
Z.	Other					7	1
Subtotal					1236	809	49
Total			**0**			**2094**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		11
12. Reactor I&C Systems		30
13. Reactor Auxiliary Systems		16
14. Safety Systems		30
15. Reactor Cooling Systems		9
16. Steam generation systems		77
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		52
32. Feedwater and Main Steam System		15
33. Circulating Water System		2
34. Miscellaneous Systems		138
35. All other I&C Systems		4
41. Main Generator Systems		117
42. Electrical Power Supply Systems		9
Total		**519**

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2020 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

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	:	1976-07-01
Grid Date	:	1981-06-01
Commercial Date	:	1983-08-01
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

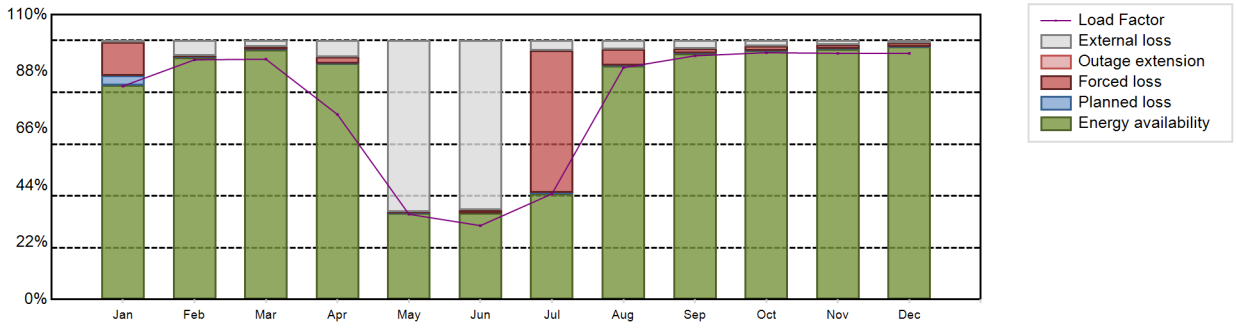
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	6094.77 GW(e).h
Energy Availability Factor (EAF)	:	78.83 %
Unit Capability Factor (UCF)	:	92.29 %
Load Factor (LF)	:	75.83 %
Operating Factor (OF)	:	88.87 %

Forced Loss Rate (FLR)	:	7.26 %
Unplanned Capability Loss Factor (UCL)	:	7.23 %
Planned Unavailability Factor (PUF)	:	0.48 %
Externally cause unavailability (XUF)	:	13.46 %
Total off-line time	:	978 hours

Annual Summary



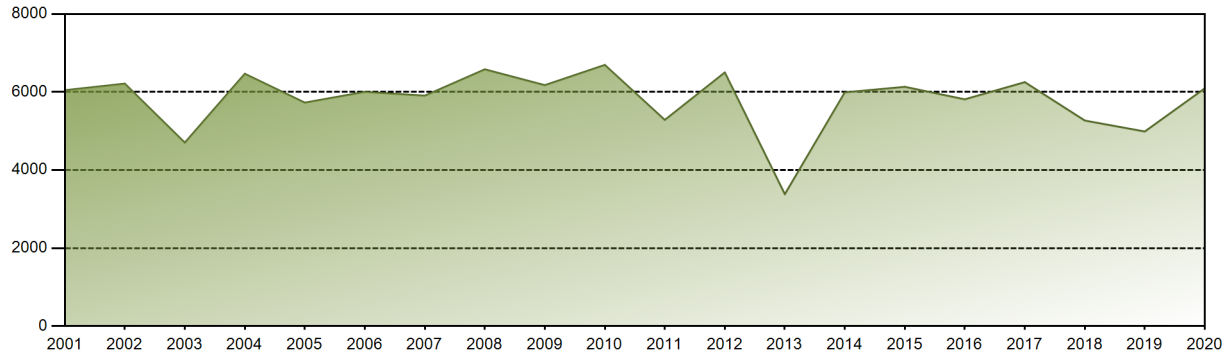
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	561.05	589.55	630.86	470.75	224.12	188.00	277.61	609.42	620.04	649.85	626.39	647.14	6094.77
EAF [%]	82.83	93.41	96.43	91.09	33.39	33.46	40.82	90.18	94.95	96.08	96.60	97.67	78.83
UCF [%]	83.39	99.33	98.81	97.44	99.42	98.97	44.78	93.61	97.98	98.31	98.12	98.57	92.29
LF [%]	82.42	92.57	92.79	71.46	32.92	28.54	40.78	89.52	94.12	95.33	95.08	95.06	75.83
OF [%]	97.45	100.00	100.00	95.28	36.56	37.22	100.00	100.00	100.00	99.87	100.00	100.00	88.87
FLR [%]	13.36	0.51	1.11	2.46	0.53	1.03	54.97	6.08	1.91	1.59	1.56	1.35	7.26
UCL [%]	12.86	0.51	1.11	2.46	0.53	1.03	54.66	6.06	1.91	1.59	1.55	1.35	7.23
PUF [%]	3.75	0.16	0.09	0.09	0.05	0.00	0.56	0.34	0.11	0.10	0.33	0.08	0.48
XUF [%]	0.56	5.92	2.37	6.35	66.03	65.50	3.96	3.43	3.03	2.22	1.52	0.90	13.46

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Historical Summary

Lifetime energy generation	:	216763.24 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.28 %
Cumulative Energy Availability Factor (EAF)	:	75.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.64 %
Cumulative Unit Capability Factor (UCF)	:	77.72 %	Cumulative Planned Unavailability Factor (PUF)	:	13.64 %
Cumulative Load Factor (LF)	:	70.9 %	Cumulative Externally cause unavailability (XUF)	:	2.38 %
Cumulative Operating Factor (OF)	:	78.02 %			

Electricity Production (net) [GWh]

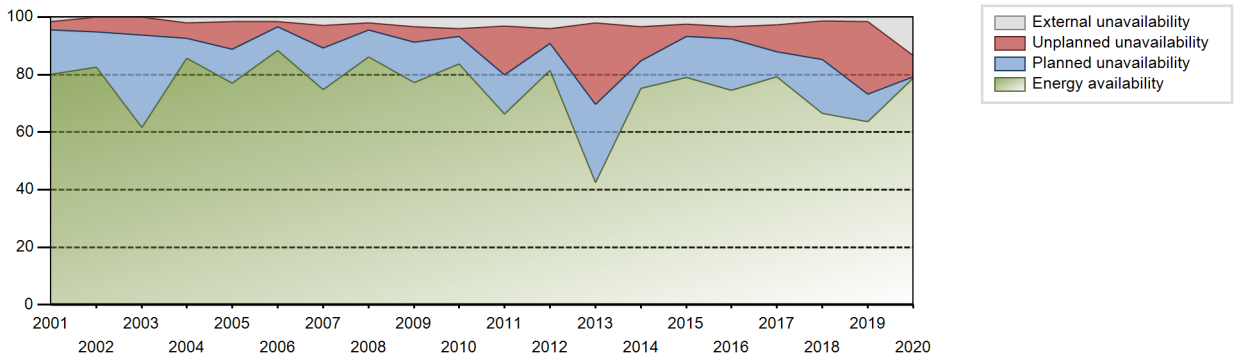


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	4123.00	4839	880	16.06	16.06	15.84	16.74	34.68	8.53	75.41	0.00
1984	5724.00	7237	880	88.88	88.88	74.05	82.39	11.08	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

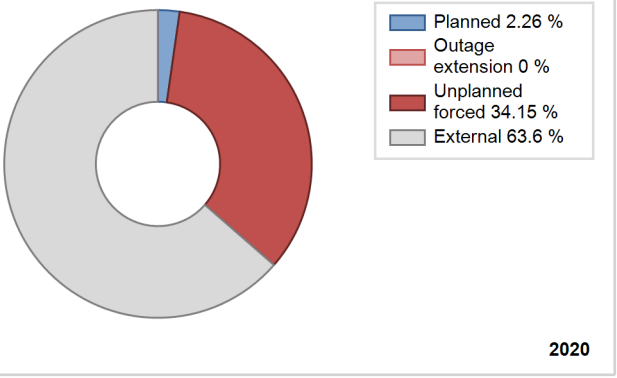
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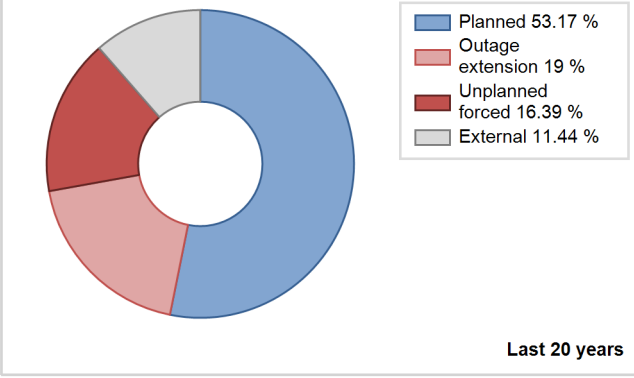
2020	6094.77	7806	915	78.83	92.29	75.83	88.87	7.26	7.23	0.48	13.46

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1983 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					697	
B. Refuelling without maintenance				95		
C. Inspection, maintenance or repair combined with refuelling				1024	11	
D. Inspection, maintenance or repair without refuelling				5		
E. Testing of plant systems or components				12	1	
H. Nuclear regulatory requirements					11	
J. Grid limitation, failure or grid unavailability						4
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						1
L. Human factor related					14	
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)					86	2
Z. Other					31	
Subtotal				1136	851	22
Total	**0**			**2009**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		16
14. Safety Systems		47
15. Reactor Cooling Systems		35
16. Steam generation systems		34
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		19
31. Turbine and auxiliaries		214
32. Feedwater and Main Steam System		24
33. Circulating Water System		5
34. Miscellaneous Systems		188
35. All other I&C Systems		2
41. Main Generator Systems		54
42. Electrical Power Supply Systems		16
Total		**683**

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2020 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	:	40 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

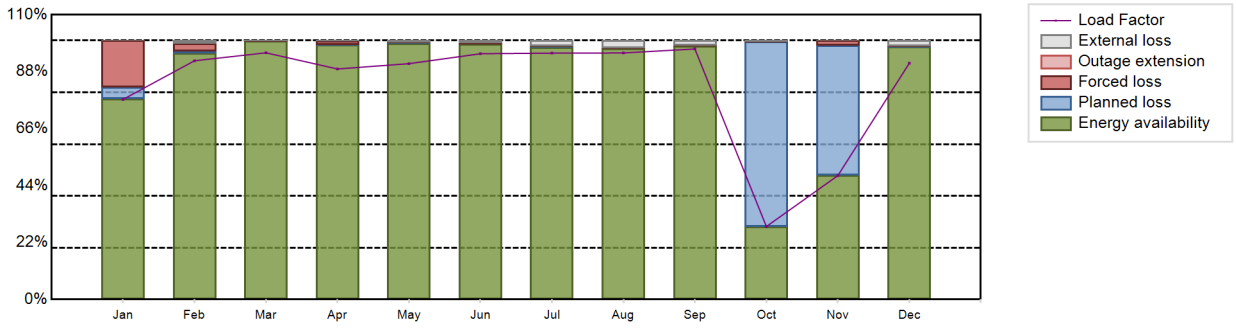
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6655.75 GW(e).h
Energy Availability Factor (EAF)	:	86.13 %
Unit Capability Factor (UCF)	:	87.16 %
Load Factor (LF)	:	82.81 %
Operating Factor (OF)	:	89.31 %

Forced Loss Rate (FLR)	:	2.43 %
Unplanned Capability Loss Factor (UCL)	:	2.17 %
Planned Unavailability Factor (PUF)	:	10.67 %
Externally cause unavailability (XUF)	:	1.03 %
Total off-line time	:	939 hours

Annual Summary



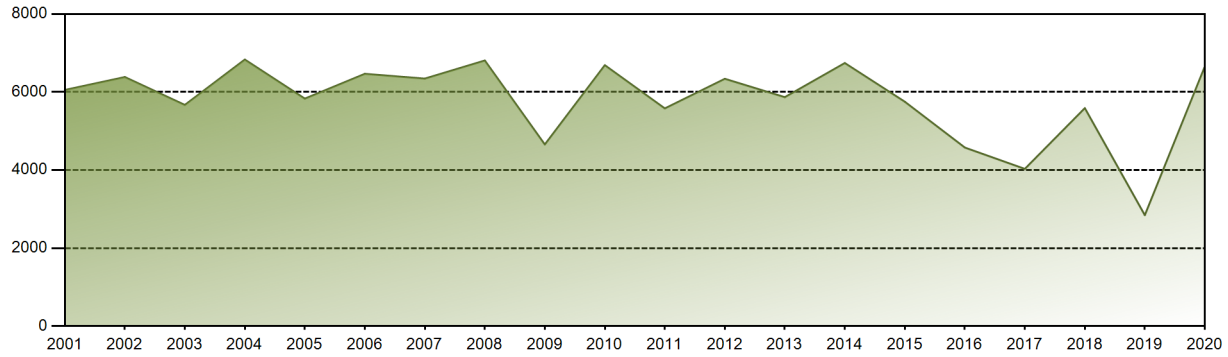
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	526.02	587.18	647.79	586.65	620.08	625.36	647.78	648.29	637.55	192.25	315.36	621.44	6655.75
EAF [%]	77.42	95.21	99.78	98.32	98.77	98.61	97.45	96.85	97.97	28.26	47.98	97.56	86.13
UCF [%]	77.42	96.40	99.87	98.45	99.28	99.57	99.63	99.72	99.89	28.66	47.98	99.70	87.16
LF [%]	77.27	92.20	95.29	89.05	91.09	94.92	95.16	95.23	96.77	28.20	47.87	91.29	82.81
OF [%]	89.38	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	28.72	54.31	100.00	89.31
FLR [%]	18.86	2.92	0.13	1.52	0.21	0.43	0.28	0.28	0.11	0.03	3.54	0.30	2.43
UCL [%]	18.00	2.90	0.13	1.52	0.21	0.43	0.28	0.28	0.11	0.01	1.76	0.30	2.17
PUF [%]	4.59	0.71	0.00	0.03	0.51	0.00	0.09	0.00	0.00	71.33	50.26	0.00	10.67
XUF [%]	0.00	1.19	0.09	0.13	0.51	0.96	2.18	2.87	1.92	0.40	0.00	2.13	1.03

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Historical Summary

Lifetime energy generation	:	231505.47 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.15 %
Cumulative Energy Availability Factor (EAF)	:	75.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.3 %
Cumulative Unit Capability Factor (UCF)	:	77.91 %	Cumulative Planned Unavailability Factor (PUF)	:	13.8 %
Cumulative Load Factor (LF)	:	71.41 %	Cumulative Externally cause unavailability (XUF)	:	2.82 %
Cumulative Operating Factor (OF)	:	78.74 %			

Electricity Production (net) [GWh]

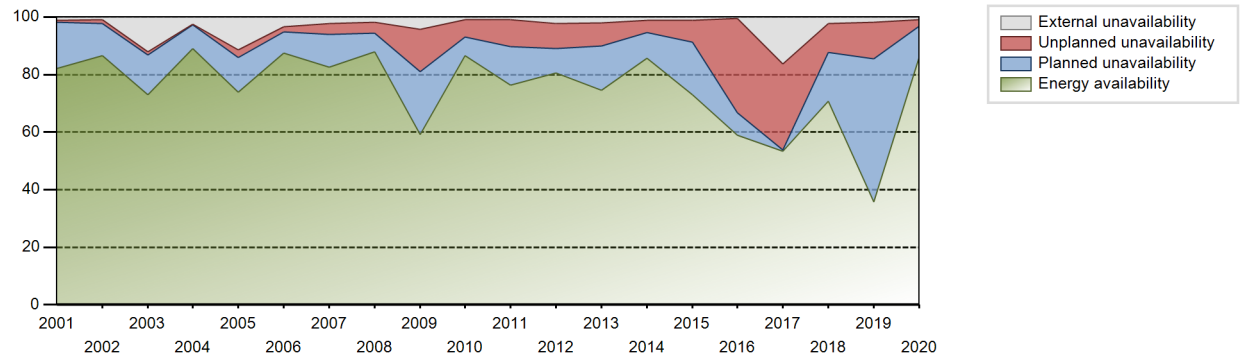


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	2468.00	3412	918	56.60	56.60	95.84	97.04	43.40	43.40	0.00	0.00
1981	4416.00	5176	920	56.33	56.33	54.79	59.09	20.34	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

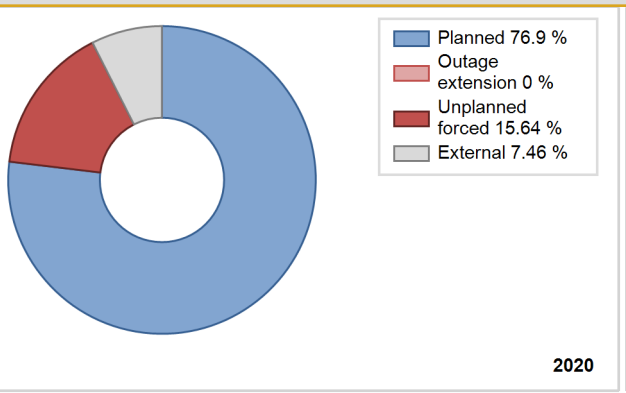
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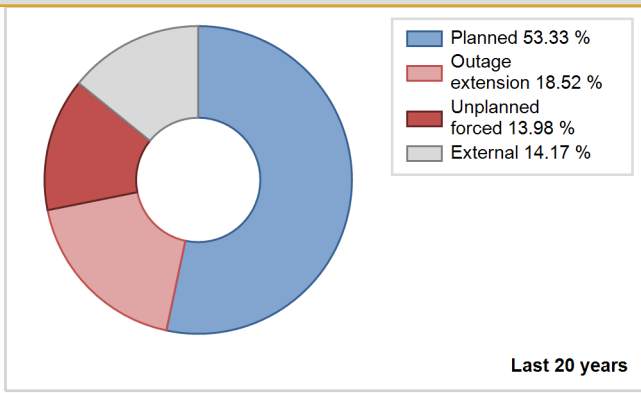
2017	4029.83	4975	915	53.33	69.61	50.28	56.79	29.14	29.98	0.40	16.28
2018	5586.73	6477	915	70.79	73.09	69.70	73.94	4.87	9.93	16.98	2.30
2019	2843.84	3231	915	35.70	37.49	35.48	36.88	16.76	12.76	49.75	1.79
2020	6655.75	7845	915	86.13	87.16	82.81	89.31	2.43	2.17	10.67	1.03

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					404	1
B. Refuelling without maintenance				79		
C. Inspection, maintenance or repair combined with refuelling				1050	8	
D. Inspection, maintenance or repair without refuelling				15	2	
E. Testing of plant systems or components				4	1	
H. Nuclear regulatory requirements					124	
J. Grid limitation, failure or grid unavailability						12
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						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.)					16	15
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						29
Z. Other					27	
Subtotal				1148	591	59
Total	**0**			**1798**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		72
12. Reactor I&C Systems		10
13. Reactor Auxiliary Systems		2
14. Safety Systems		65
15. Reactor Cooling Systems		19
16. Steam generation systems		92
21. Fuel Handling and Storage Facilities		8
31. Turbine and auxiliaries		45
32. Feedwater and Main Steam System		8
33. Circulating Water System		5
34. Miscellaneous Systems		92
35. All other I&C Systems		1
41. Main Generator Systems		67
42. Electrical Power Supply Systems		38
Total		**524**

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2020 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	:	40 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

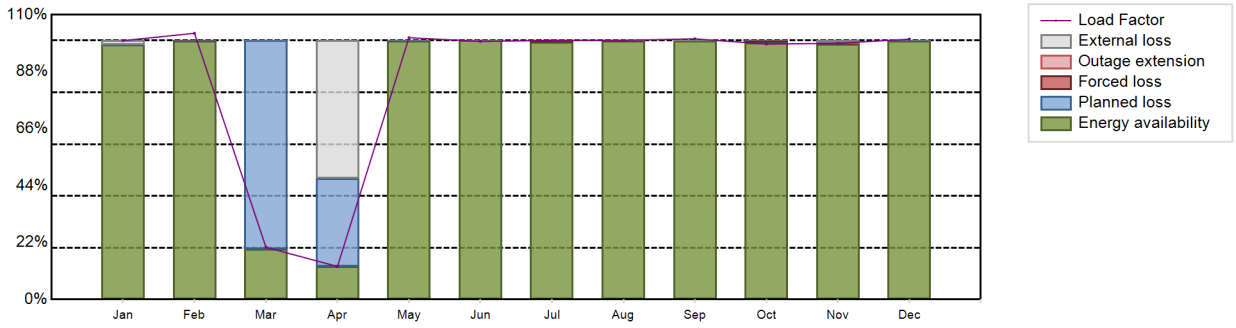
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	6937 GW(e).h
Energy Availability Factor (EAF)	:	85.66 %
Unit Capability Factor (UCF)	:	90.26 %
Load Factor (LF)	:	86.31 %
Operating Factor (OF)	:	86.42 %

Forced Loss Rate (FLR)	:	0.12 %
Unplanned Capability Loss Factor (UCL)	:	0.11 %
Planned Unavailability Factor (PUF)	:	9.63 %
Externally cause unavailability (XUF)	:	4.61 %
Total off-line time	:	1193 hours

Annual Summary



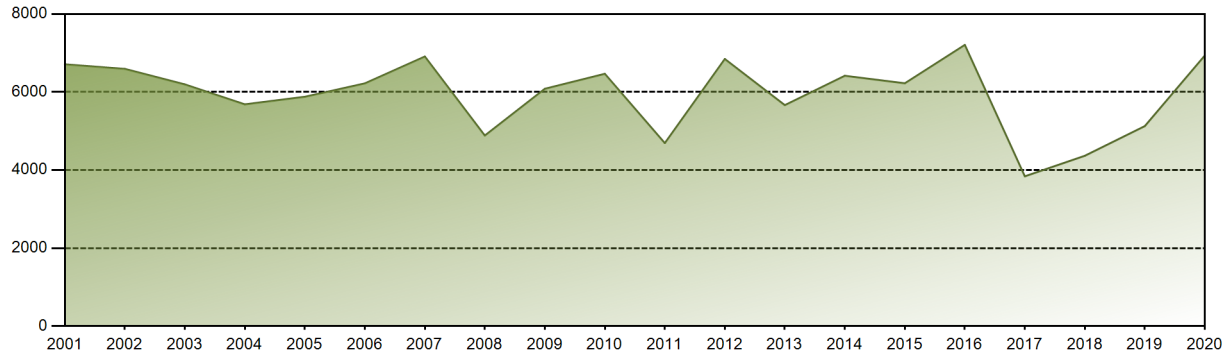
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	680.65	654.90	137.13	84.13	688.45	656.75	681.24	681.36	663.28	672.58	651.96	684.55	6937.00
EAF [%]	98.44	99.90	19.55	12.74	99.92	100.00	99.48	99.81	99.98	99.19	98.74	99.95	85.66
UCF [%]	99.99	99.90	19.55	65.99	99.92	100.00	99.49	99.89	99.98	99.19	99.99	99.95	90.26
LF [%]	99.98	102.84	20.17	12.77	101.13	99.69	100.07	100.09	100.68	98.67	98.96	100.56	86.31
OF [%]	100.00	100.00	19.78	17.22	100.00	100.00	100.00	100.00	100.00	99.87	100.00	100.00	86.42
FLR [%]	0.00	0.02	0.00	0.00	0.00	0.00	0.51	0.02	0.02	0.72	0.01	0.00	0.12
UCL [%]	0.00	0.02	0.00	0.00	0.00	0.00	0.51	0.02	0.02	0.72	0.01	0.00	0.11
PUF [%]	0.01	0.08	80.45	34.01	0.08	0.00	0.00	0.09	0.00	0.09	0.00	0.05	9.63
XUF [%]	1.55	0.00	0.00	53.26	0.00	0.00	0.02	0.07	0.01	0.00	1.25	0.00	4.61

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Historical Summary

Lifetime energy generation	:	233097.73 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.42 %
Cumulative Energy Availability Factor (EAF)	:	75.56 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.4 %
Cumulative Unit Capability Factor (UCF)	:	79.06 %	Cumulative Planned Unavailability Factor (PUF)	:	13.54 %
Cumulative Load Factor (LF)	:	72.18 %	Cumulative Externally cause unavailability (XUF)	:	3.5 %
Cumulative Operating Factor (OF)	:	78.72 %			

Electricity Production (net) [GWh]

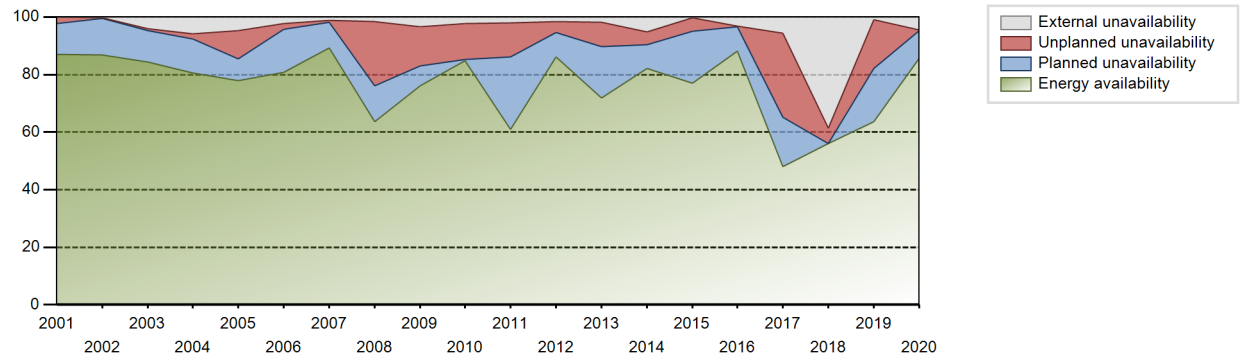


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	1614.00	2559	917	68.70	68.70	68.08	76.34	9.91	7.56	23.74	0.00
1981	6155.10	7819	920	82.33	82.33	76.37	89.26	4.42	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

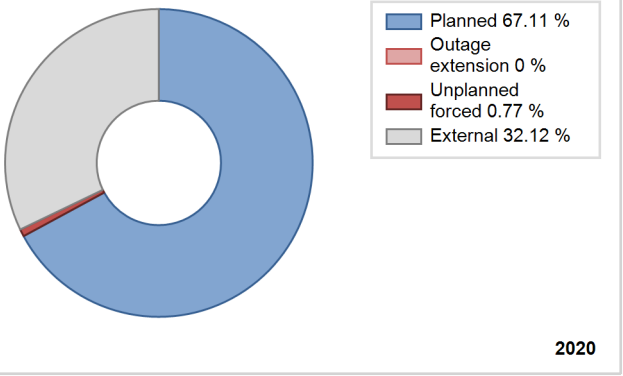
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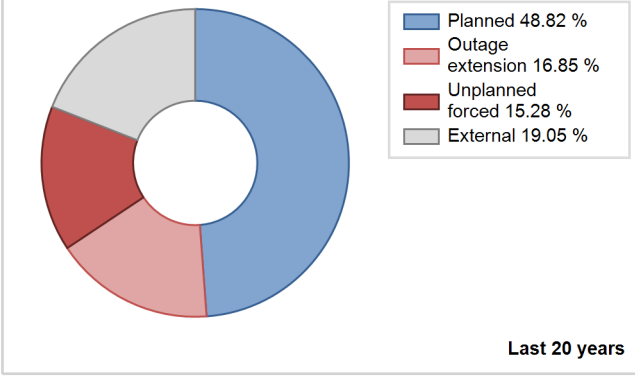
2017	3839.11	4529	915	47.96	53.48	47.90	51.70	32.46	29.21	17.30	5.52
2018	4365.93	5046	915	56.03	94.64	54.47	57.60	5.35	5.35	0.01	38.61
2019	5126.60	5725	915	63.55	64.50	63.96	65.35	3.01	16.84	18.66	0.95
2020	6937.00	7591	915	85.66	90.26	86.31	86.42	0.12	0.11	9.63	4.61

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					451	
B. Refuelling without maintenance				66		
C. Inspection, maintenance or repair combined with refuelling				1012	26	
D. Inspection, maintenance or repair without refuelling				26		
E. Testing of plant systems or components				4	1	
H. Nuclear regulatory requirements					39	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L. Human factor related					22	
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.)						46
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						83
Z. Other					29	
Subtotal				1108	568	139
Total	**0**			**1815**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		67
12. Reactor I&C Systems		30
13. Reactor Auxiliary Systems		6
14. Safety Systems		58
15. Reactor Cooling Systems		30
16. Steam generation systems		26
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries		64
32. Feedwater and Main Steam System		13
33. Circulating Water System		8
34. Miscellaneous Systems		127
41. Main Generator Systems		31
42. Electrical Power Supply Systems		32
Total		**496**

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2020 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	:	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]	:	-
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

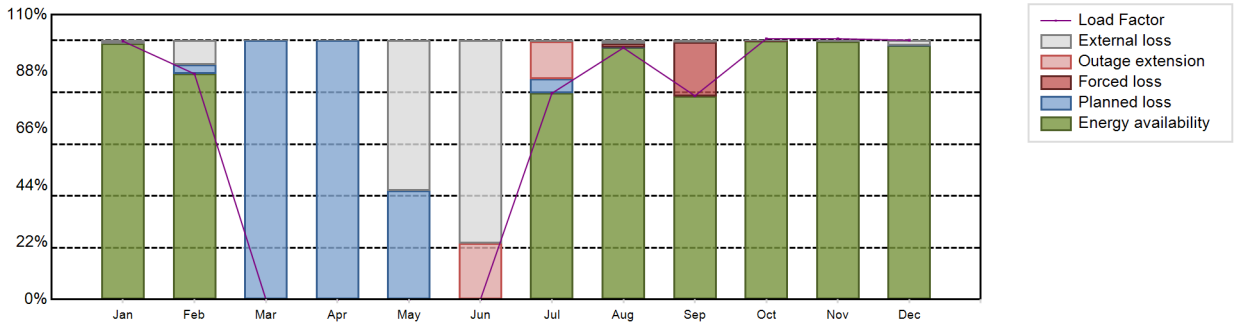
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4987.94 GW(e).h
Energy Availability Factor (EAF)	:	61.67 %
Unit Capability Factor (UCF)	:	74.21 %
Load Factor (LF)	:	62.06 %
Operating Factor (OF)	:	63.51 %

Forced Loss Rate (FLR)	:	2.4 %
Unplanned Capability Loss Factor (UCL)	:	4.82 %
Planned Unavailability Factor (PUF)	:	20.97 %
Externally cause unavailability (XUF)	:	12.54 %
Total off-line time	:	3205 hours

Annual Summary



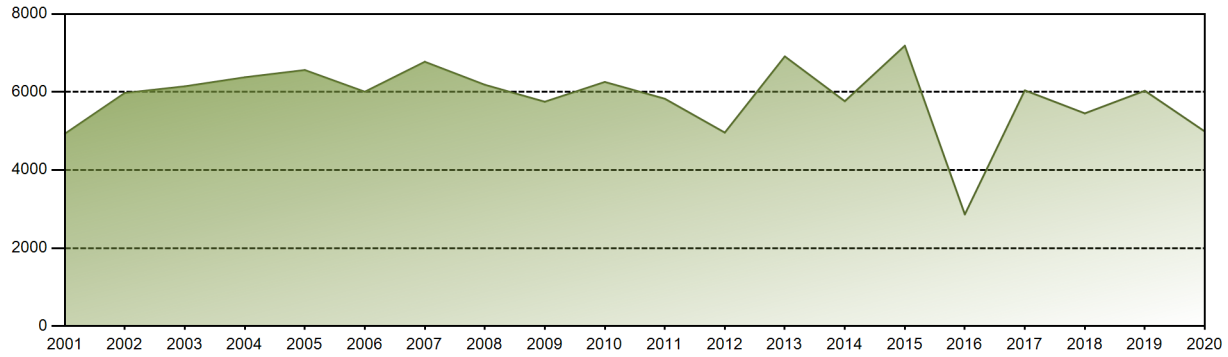
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	679.15	554.95	0.00	0.00	0.00	0.00	542.29	661.75	518.30	686.41	663.41	681.67	4987.94
EAF [%]	98.97	87.21	0.00	0.00	0.00	0.00	79.66	97.35	78.62	99.91	99.61	98.03	61.67
UCF [%]	100.00	96.46	0.00	0.00	58.02	78.39	80.09	98.42	79.32	99.95	100.00	99.95	74.21
LF [%]	99.76	87.14	0.00	0.00	0.00	0.00	79.66	97.21	78.67	100.69	100.70	100.13	62.06
OF [%]	100.00	96.70	0.00	0.00	0.00	0.00	85.62	100.00	79.58	99.87	100.00	100.00	63.51
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57	20.68	0.00	0.00	0.00	2.40
UCL [%]	0.00	0.00	0.00	0.00	0.00	21.61	14.38	1.57	20.68	0.00	0.00	0.00	4.82
PUF [%]	0.00	3.54	100.00	100.00	41.98	0.00	5.53	0.01	0.00	0.05	0.00	0.05	20.97
XUF [%]	1.03	9.26	0.00	0.00	58.01	78.39	0.42	1.07	0.70	0.04	0.39	1.92	12.54

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Historical Summary

Lifetime energy generation	:	236376.67 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.62 %
Cumulative Energy Availability Factor (EAF)	:	76.67 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.43 %
Cumulative Unit Capability Factor (UCF)	:	80.26 %	Cumulative Planned Unavailability Factor (PUF)	:	13.31 %
Cumulative Load Factor (LF)	:	74.03 %	Cumulative Externally cause unavailability (XUF)	:	3.59 %
Cumulative Operating Factor (OF)	:	79.48 %			

Electricity Production (net) [GWh]

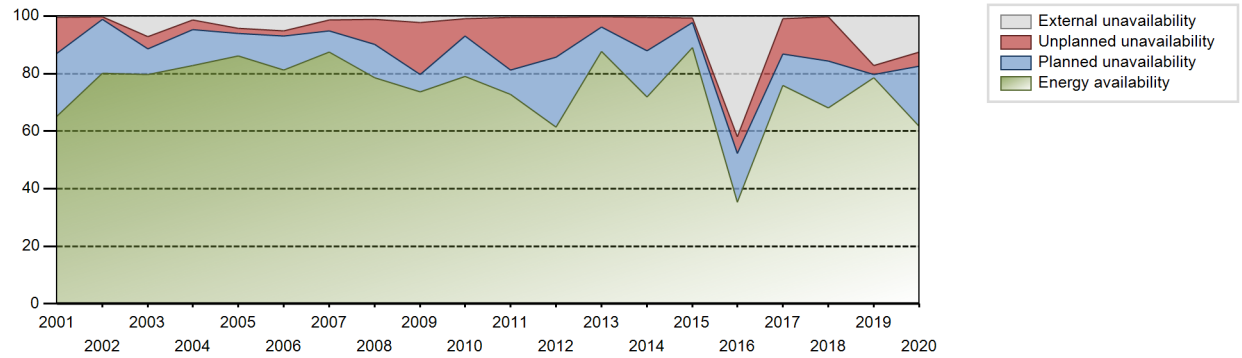


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	4917.60	6463	919	78.00	78.00	73.91	81.89	0.00	0.00	22.00	0.00
1982	5067.30	5966	915	65.83	65.83	63.22	68.11	7.17	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

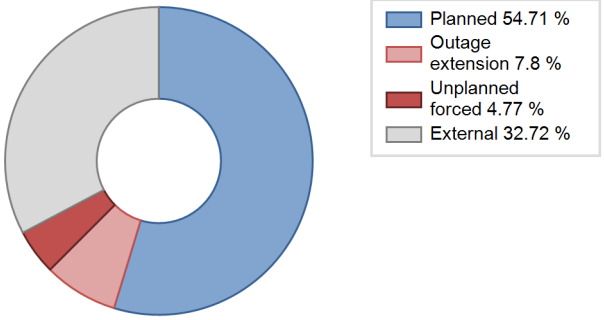
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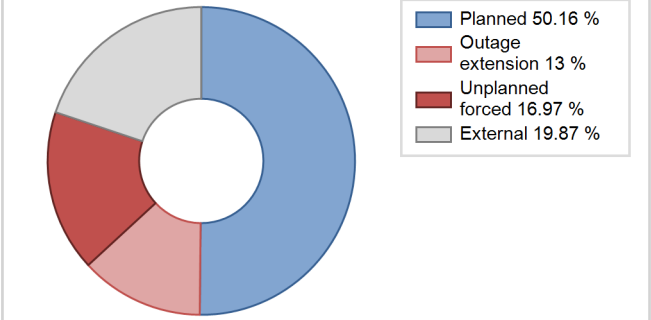
2018	5453.10	6019	915	68.17	68.32	68.03	68.71	18.45	15.46	16.21	0.16
2019	6032.36	7059	915	78.63	95.75	75.26	80.58	1.18	3.13	1.12	17.13
2020	4987.94	5579	915	61.67	74.21	62.06	63.51	2.40	4.82	20.97	12.54

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					408	
B. Refuelling without maintenance				89		
C. Inspection, maintenance or repair combined with refuelling				945	7	
D. Inspection, maintenance or repair without refuelling				24		
E. Testing of plant systems or components				4	1	
H. Nuclear regulatory requirements					24	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L. Human factor related					25	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						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.)					16	98
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						35
Z. Other					24	
Subtotal				1062	505	137
Total	**0**			**1704**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		31
13. Reactor Auxiliary Systems		19
14. Safety Systems		46
15. Reactor Cooling Systems		39
16. Steam generation systems		93
17. Safety I&C Systems (excluding reactor I&C)		3
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		96
32. Feedwater and Main Steam System		6
34. Miscellaneous Systems		70
35. All other I&C Systems		2
41. Main Generator Systems		88
42. Electrical Power Supply Systems		8
Total		**519**

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2020 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	:	39 years

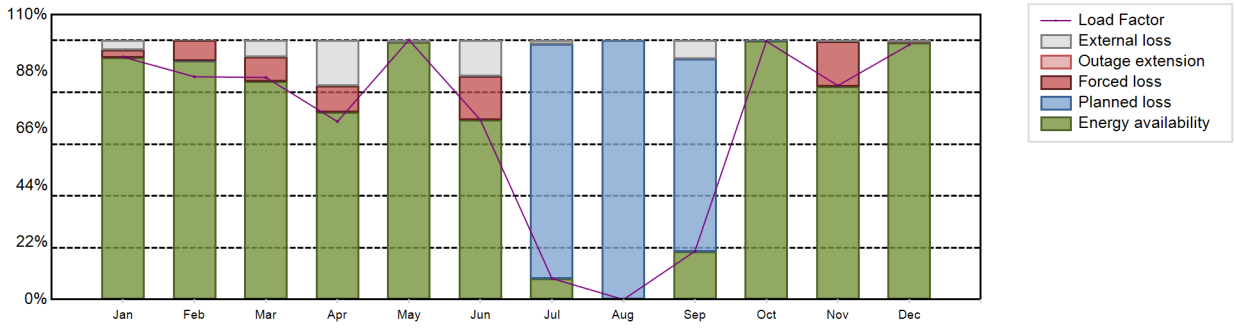
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	321
Fuel material	:	UO2/MOX	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 [%]	:	25	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	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	17.8	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 (2020)

Net Energy Production	:	5432.69 GW(e).h	Forced Loss Rate (FLR)	:	6.78 %
Energy Availability Factor (EAF)	:	68.21 %	Unplanned Capability Loss Factor (UCL)	:	5.27 %
Unit Capability Factor (UCF)	:	72.47 %	Planned Unavailability Factor (PUF)	:	22.26 %
Load Factor (LF)	:	67.59 %	Externally cause unavailability (XUF)	:	4.27 %
Operating Factor (OF)	:	70.75 %	Total off-line time	:	2569 hours

Annual Summary



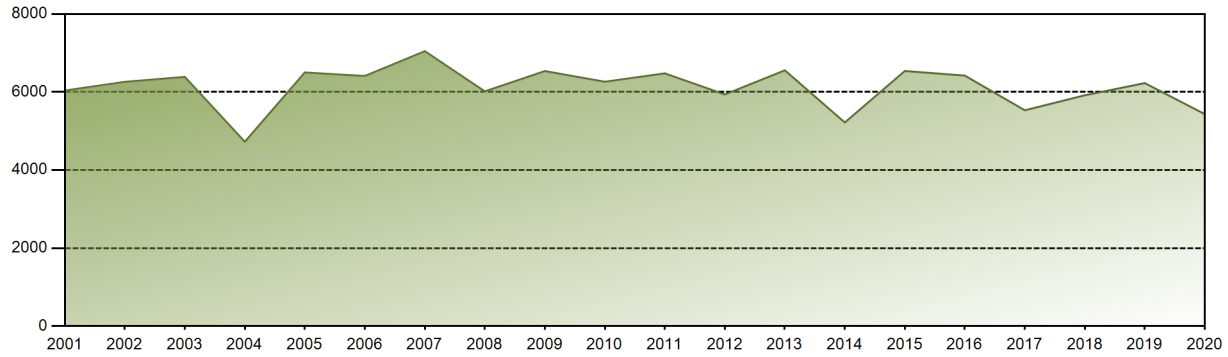
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	637.66	547.87	583.02	452.73	682.33	456.87	55.34	0.00	122.81	679.99	544.27	669.81	5432.69
EAF [%]	93.41	92.20	84.23	72.34	99.47	69.41	8.14	0.00	18.55	99.85	82.32	99.10	68.21
UCF [%]	97.11	92.20	90.55	89.96	100.00	83.25	9.64	0.00	25.55	99.85	82.73	99.80	72.47
LF [%]	93.67	86.03	85.76	68.72	100.23	69.35	8.13	0.00	18.64	99.75	82.62	98.39	67.59
OF [%]	100.00	92.82	85.06	71.67	100.00	83.19	9.81	0.00	24.17	99.87	83.19	100.00	70.75
FLR [%]	2.89	7.75	9.45	10.04	0.00	16.75	0.00	0.00	0.00	0.00	17.27	0.06	6.78
UCL [%]	2.89	7.74	9.45	10.04	0.00	16.75	0.00	0.00	0.00	0.00	17.27	0.06	5.27
PUF [%]	0.00	0.06	0.00	0.00	0.00	0.00	90.36	100.00	74.45	0.15	0.00	0.14	22.26
XUF [%]	3.70	0.00	6.32	17.62	0.53	13.84	1.50	0.00	7.00	0.00	0.41	0.70	4.27

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Historical Summary

Lifetime energy generation	:	234774.62 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.81 %
Cumulative Energy Availability Factor (EAF)	:	78.61 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.67 %
Cumulative Unit Capability Factor (UCF)	:	81.17 %	Cumulative Planned Unavailability Factor (PUF)	:	13.15 %
Cumulative Load Factor (LF)	:	74.39 %	Cumulative Externally cause unavailability (XUF)	:	2.57 %
Cumulative Operating Factor (OF)	:	80.99 %			

Electricity Production (net) [GWh]

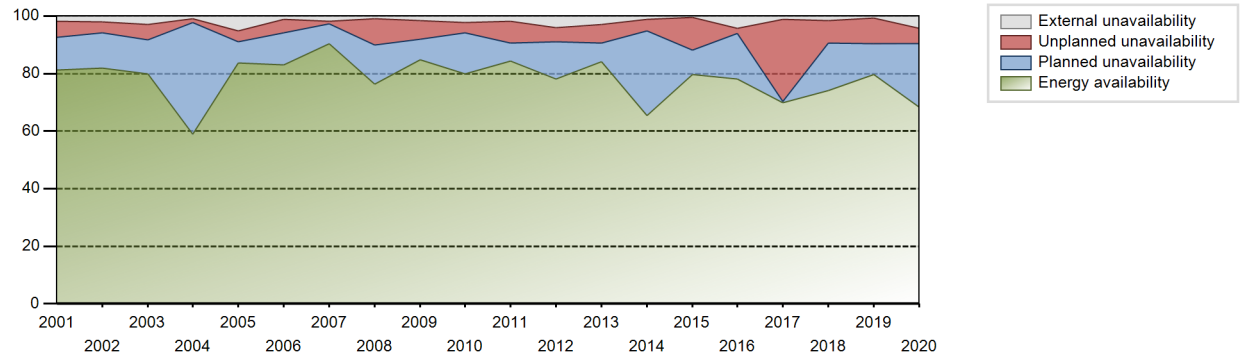


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	2480.00	3883	917	97.21	97.21	95.30	99.86	0.00	0.00	2.79	0.00
1982	5470.50	6311	915	69.85	69.85	68.25	72.04	5.62	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

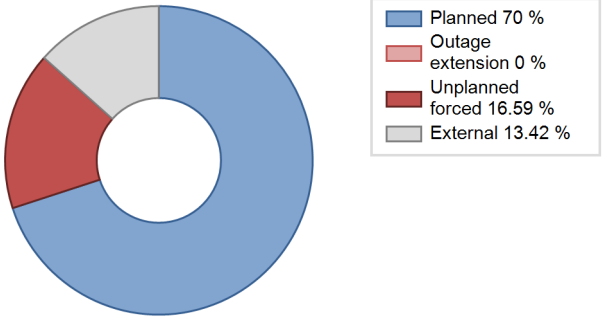
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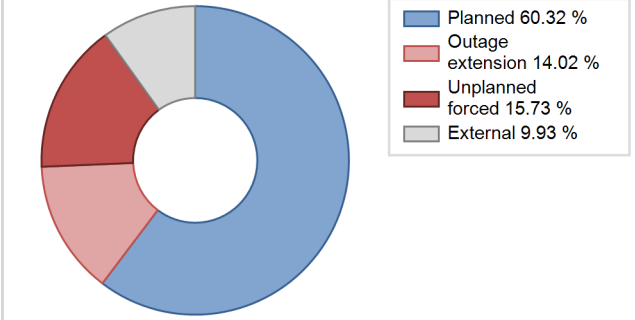
2018	5916.77	6699	915	74.10	75.71	73.82	76.47	3.43	7.69	16.60	1.61
2019	6228.37	7130	915	79.65	80.42	77.71	81.39	3.51	8.92	10.65	0.77
2020	5432.69	6215	915	68.21	72.47	67.59	70.75	6.78	5.27	22.26	4.27

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					297	1
B. Refuelling without maintenance				67		
C. Inspection, maintenance or repair combined with refuelling				966	8	
D. Inspection, maintenance or repair without refuelling				15		
E. Testing of plant systems or components				2		
H. Nuclear regulatory requirements					46	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						18
L. Human factor related					20	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						4
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.)					22	28
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						2
Z. Other					33	0
Subtotal				1050	426	53
Total		**0**			**1529**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		21
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		11
14. Safety Systems		75
15. Reactor Cooling Systems		15
16. Steam generation systems		32
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries		23
32. Feedwater and Main Steam System		11
33. Circulating Water System		1
34. Miscellaneous Systems		97
35. All other I&C Systems		0
41. Main Generator Systems		33
42. Electrical Power Supply Systems		15
Total		**353**

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2020 Operating Experience

DE-32 BROKDORF GERMANY

Status at end of year	:	**Operational**
Operator	:	PElektra (PreussenElektra GmbH)
Owner	:	PEL/VEN (1. (80%) PreussenElektra GmbH
Reactor Supplier	:	KWU (KRAFTWERK UNION, AG)
Turbine Supplier	:	KWU (KRAFTWERK UNION, AG)



Reactor Unit Details

Reactor type and model	:	PWR / PWR
Thermal power	:	3900 MWth
Gross electrical power	:	1480 MWe
Reference unit power (net)	:	1410 MWe

Key Dates

Construction Date	:	1976-01-01
Grid Date	:	1986-10-14
Commercial Date	:	1986-12-22
Age at end of year	:	34 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 [%]	:	71
Average discharge burnup [MWd/t]	:	34000
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]	:	20.8
Number of control rod assemblies	:	61
Number of external reactor coolant loops	:	4
Coolant type	:	H2O

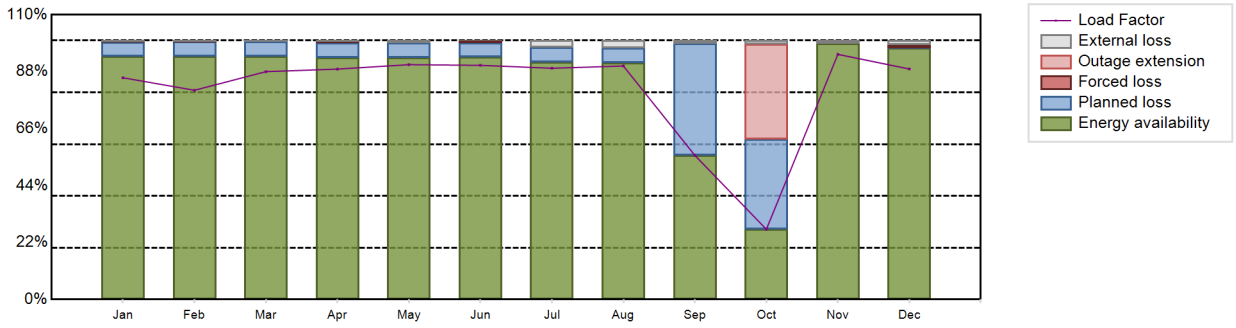
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	326
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	0.63
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	6.7
Output voltage [kV]	:	27
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 (2020)

Net Energy Production	:	10015.11 GW(e).h
Energy Availability Factor (EAF)	:	85.3 %
Unit Capability Factor (UCF)	:	86.38 %
Load Factor (LF)	:	80.86 %
Operating Factor (OF)	:	90.72 %

Forced Loss Rate (FLR)	:	0.29 %
Unplanned Capability Loss Factor (UCL)	:	3.38 %
Planned Unavailability Factor (PUF)	:	10.24 %
Externally cause unavailability (XUF)	:	1.08 %
Total off-line time	:	815 hours

Annual Summary



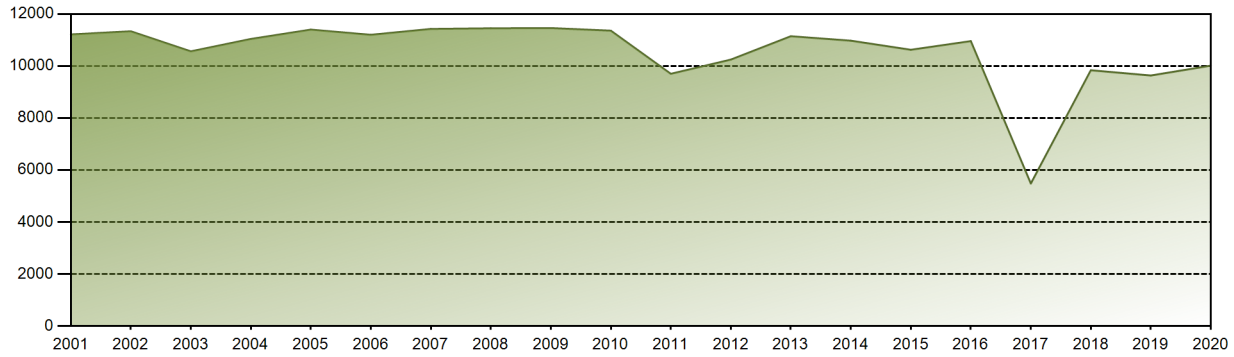
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	898.52	793.07	921.98	903.57	951.47	918.24	937.07	946.19	565.04	284.74	961.27	933.96	10015.11
EAF [%]	93.86	93.99	93.99	93.48	93.52	93.63	91.69	91.36	55.66	27.15	98.82	97.13	85.30
UCF [%]	94.14	94.30	94.28	93.80	94.33	93.63	94.31	94.30	56.87	28.45	100.00	98.74	86.38
LF [%]	85.65	80.81	88.01	89.00	90.70	90.45	89.33	90.20	55.66	27.11	94.69	89.03	80.86
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	60.83	28.46	100.00	100.00	90.72
FLR [%]	0.24	0.02	0.00	0.60	0.00	1.03	0.00	0.00	0.00	0.00	0.00	1.23	0.29
UCL [%]	0.23	0.02	0.00	0.56	0.00	0.98	0.00	0.00	0.00	36.83	0.00	1.23	3.38
PUF [%]	5.63	5.68	5.72	5.64	5.67	5.40	5.69	5.70	43.13	34.72	0.00	0.03	10.24
XUF [%]	0.28	0.31	0.28	0.31	0.81	0.00	2.62	2.93	1.21	1.30	1.18	1.61	1.08

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Historical Summary

Lifetime energy generation	:	352908.91 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.98 %
Cumulative Energy Availability Factor (EAF)	:	88.35 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.71 %
Cumulative Unit Capability Factor (UCF)	:	88.63 %	Cumulative Planned Unavailability Factor (PUF)	:	7.66 %
Cumulative Load Factor (LF)	:	86.09 %	Cumulative Externally cause unavailability (XUF)	:	0.27 %
Cumulative Operating Factor (OF)	:	89.42 %			

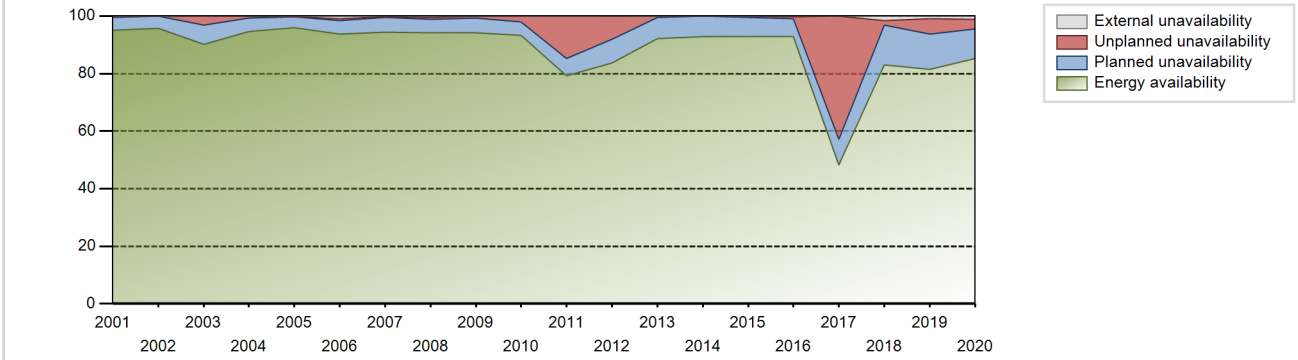
Electricity Production (net) [GWh]



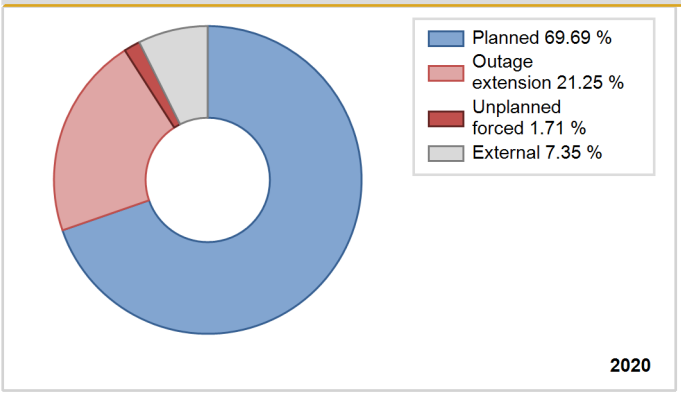
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	296.84	228	1307	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	9481.26	7477	1307	85.18	85.18	82.81	85.35	14.78	14.77	0.06	0.00
1988	8581.77	7014	1326	85.22	85.22	73.68	79.85	4.26	3.79	10.99	0.00
1989	8991.29	7134	1326	79.99	79.99	77.41	81.44	0.70	0.56	19.44	0.00
1990	8337.23	6447	1326	72.49	72.49	71.78	73.60	13.76	11.56	15.95	0.00
1991	9492.73	7542	1326	85.66	85.66	81.72	86.10	0.11	0.09	14.25	0.00
1992	10788.03	8461	1326	96.04	96.04	92.62	96.32	0.02	0.02	3.94	0.00
1993	9447.12	7441	1326	84.76	85.63	81.33	84.94	6.56	6.01	8.36	0.87
1994	10228.60	7793	1326	88.71	88.71	88.06	88.96	0.11	0.10	11.20	0.00
1995	9912.37	7833	1326	86.57	86.57	85.34	89.42	0.14	0.12	13.30	0.00
1996	10555.39	8212	1326	93.23	93.23	90.62	93.49	0.04	0.04	6.73	0.00
1997	11249.32	8328	1326	95.12	95.12	96.85	95.07	0.04	0.03	4.85	0.00
1998	10752.32	7966	1326	90.40	92.59	92.57	90.94	0.23	0.22	7.20	2.19
1999	11093.31	8177	1370	93.31	93.31	92.43	93.34	1.95	1.86	4.83	0.00
2000	11335.07	8397	1370	95.55	95.55	94.19	95.59	0.01	0.01	4.43	0.00
2001	11215.40	8331	1370	94.95	94.95	93.45	95.10	0.55	0.53	4.52	0.00
2002	11336.92	8405	1370	95.78	95.78	94.46	95.95	0.03	0.03	4.19	0.00
2003	10564.58	7903	1370	90.11	90.11	88.03	90.22	0.01	3.23	6.67	0.00
2004	11040.81	8327	1370	94.65	94.65	91.75	94.80	0.03	0.67	4.68	0.00
2005	11400.69	8433	1370	95.86	96.12	94.99	96.26	0.03	0.03	3.85	0.26
2006	11201.33	8307	1370	93.72	94.67	93.34	94.83	0.63	0.60	4.73	0.95
2007	11425.65	8293	1370	94.33	94.50	95.19	94.66	0.05	0.34	5.16	0.17
2008	11450.40	8320	1410	94.13	94.57	92.45	94.72	0.01	0.64	4.79	0.44
2009	11459.42	8260	1410	94.12	94.13	92.78	94.29	0.02	0.79	5.07	0.01
2010	11360.45	8201	1410	93.30	93.42	91.98	93.62	0.06	1.96	4.62	0.13
2011	9701.26	7382	1410	79.13	79.25	78.54	84.27	11.99	14.57	6.19	0.12
2012	10246.91	7369	1410	83.65	83.65	82.73	83.89	4.26	8.05	8.30	0.00
2013	11146.17	8108	1410	92.06	92.13	90.24	92.56	0.19	0.44	7.43	0.07
2014	10974.17	8136	1410	92.76	92.76	88.86	92.89	0.15	0.14	7.11	0.00
2015	10624.78	8210	1410	92.83	92.91	86.02	93.72	0.34	0.32	6.78	0.08
2016	10958.01	8194	1410	92.88	93.08	88.47	93.28	0.19	0.76	6.17	0.20
2017	5480.41	4527	1410	48.15	48.23	44.37	51.67	0.10	42.78	8.99	0.08
2018	9838.25	7937	1410	83.12	84.72	79.65	90.61	1.82	1.58	13.70	1.60
2019	9635.80	7682	1410	81.41	82.34	78.01	87.69	4.63	5.25	12.42	0.93
2020	10015.11	7969	1410	85.30	86.38	80.86	90.72	0.29	3.38	10.24	1.08

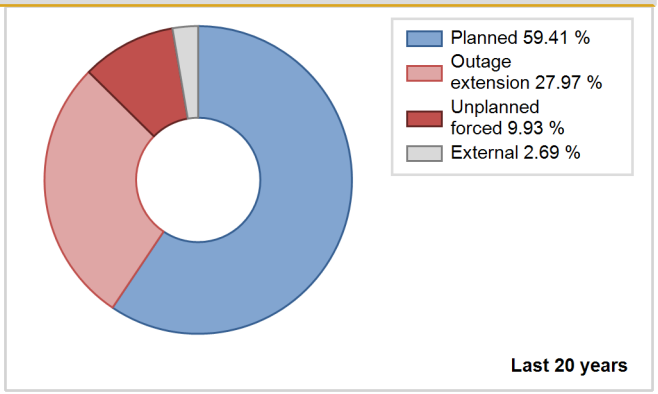
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		291			236	
C. Inspection, maintenance or repair combined with refuelling	541			577		
D. Inspection, maintenance or repair without refuelling				5	6	
E. Testing of plant systems or components				0		
H. Nuclear regulatory requirements		11			36	
L. Human factor related					18	
Z. Other					9	2
Subtotal	541	302		582	305	2
Total		**843**			**889**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	277	149
13. Reactor Auxiliary Systems		5
16. Steam generation systems		2
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		7
32. Feedwater and Main Steam System	14	1
33. Circulating Water System		4
41. Main Generator Systems		57
42. Electrical Power Supply Systems		16
Total	**291**	**246**

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2020 Operating Experience

DE-33 EMSLAND GERMANY

Status at end of year	:	**Operational**
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	:	32 years

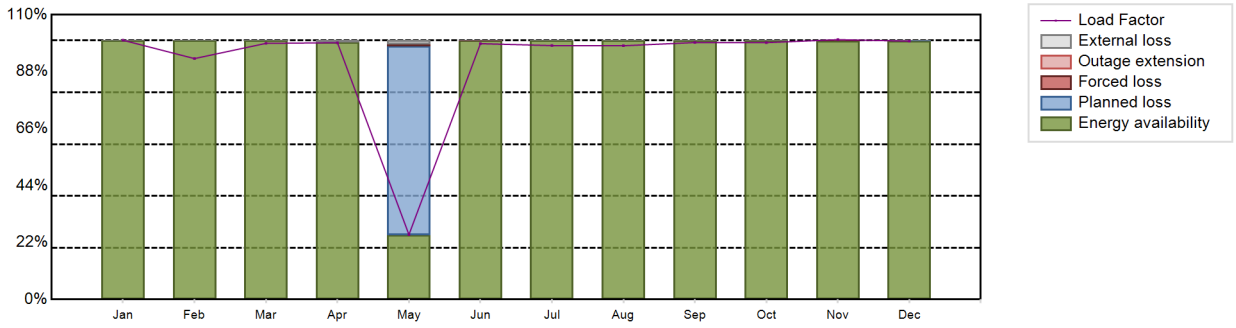
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	326
Fuel material	:	UO2	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	Double
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.62
Average fuel enrichment [% of U235]	:	3.2	**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]	:	32000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.6	HP cylinder inlet steam pressure [MPa]	:	6.05
Active core height/length [m]	:	3.9	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	River (once-through)
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 (2020)

Net Energy Production	:	10836.45 GW(e).h	Forced Loss Rate (FLR)	:	0.07 %
Energy Availability Factor (EAF)	:	93.59 %	Unplanned Capability Loss Factor (UCL)	:	0.07 %
Unit Capability Factor (UCF)	:	93.76 %	Planned Unavailability Factor (PUF)	:	6.18 %
Load Factor (LF)	:	92.41 %	Externally cause unavailability (XUF)	:	0.16 %
Operating Factor (OF)	:	93.83 %	Total off-line time	:	542 hours

Annual Summary



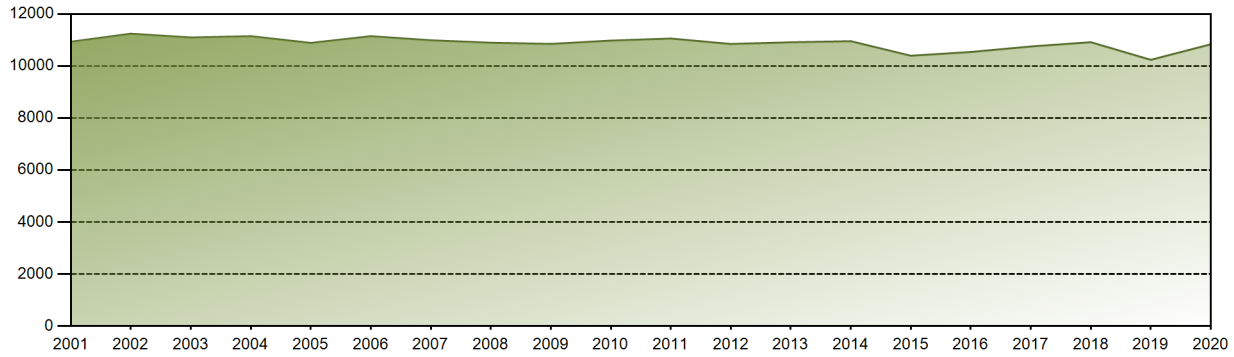
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	994.57	864.59	981.32	953.22	248.81	949.86	974.04	973.43	954.05	986.57	964.77	991.22	10836.45
EAF [%]	100.00	100.00	100.00	99.42	24.97	99.99	100.00	100.00	100.00	100.00	99.98	99.97	93.59
UCF [%]	100.00	100.00	100.00	100.00	26.34	99.99	100.00	100.00	100.00	100.00	99.98	99.97	93.76
LF [%]	100.13	93.05	98.93	99.17	25.05	98.82	98.07	98.01	99.26	99.20	100.37	99.80	92.41
OF [%]	100.00	100.00	100.00	100.00	27.15	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.83
FLR [%]	0.00	0.00	0.00	0.00	2.75	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.07
UCL [%]	0.00	0.00	0.00	0.00	0.74	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.07
PUF [%]	0.00	0.00	0.00	0.00	72.91	0.00	0.00	0.00	0.00	0.00	0.00	0.03	6.18
XUF [%]	0.00	0.00	0.00	0.58	1.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16

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Historical Summary

Lifetime energy generation	:	349989.54 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.36 %
Cumulative Energy Availability Factor (EAF)	:	93.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.6 %
Cumulative Unit Capability Factor (UCF)	:	93.49 %	Cumulative Planned Unavailability Factor (PUF)	:	5.92 %
Cumulative Load Factor (LF)	:	92.99 %	Cumulative Externally cause unavailability (XUF)	:	0.2 %
Cumulative Operating Factor (OF)	:	93.64 %			

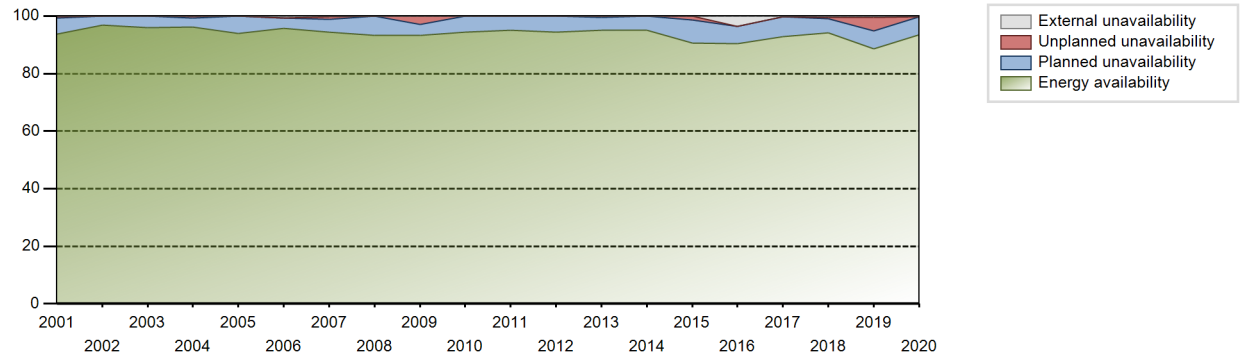
Electricity Production (net) [GWh]



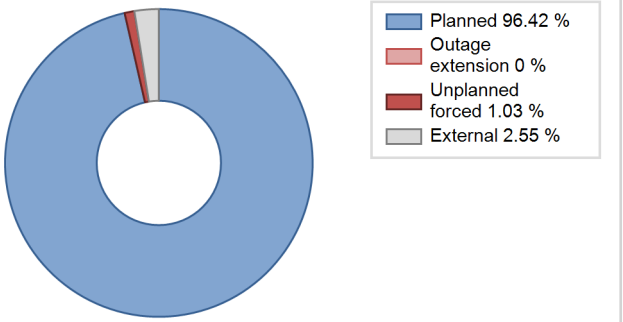
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	5694.91	4516	1262	96.27	96.27	98.06	96.54	3.68	3.68	0.05	0.00
1989	9857.21	7794	1242	88.65	88.65	90.60	88.97	1.23	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	93.59	93.76	92.41	93.83	0.07	0.07	6.18	0.16

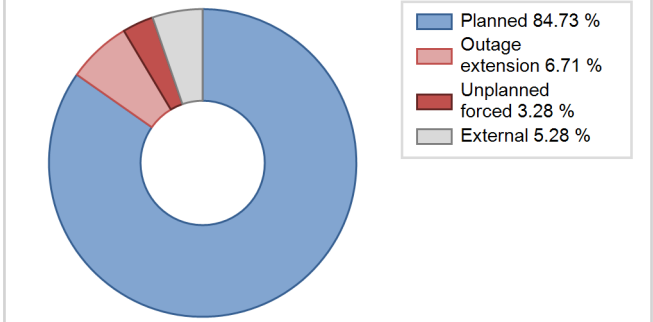
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		1			43	
C. Inspection, maintenance or repair combined with refuelling	540			480		
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	540	1		487	47	0
Total		**541**			**534**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		7
13. Reactor Auxiliary Systems		0
15. Reactor Cooling Systems		12
21. Fuel Handling and Storage Facilities		13
31. Turbine and auxiliaries	1	2
41. Main Generator Systems		8
42. Electrical Power Supply Systems		1
Total	**1**	**43**

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2020 Operating Experience

DE-27 GROHNDE GERMANY

Status at end of year	:	**Operational**
Operator	:	PElektra (PreussenElektra GmbH)
Owner	:	PEL/SBi (1. (83,3%) PreussenElektra GmbH
Reactor Supplier	:	KWU (KRAFTWERK UNION, AG)
Turbine Supplier	:	KWU (KRAFTWERK UNION, AG)



Reactor Unit Details

Reactor type and model	:	PWR / PWR
Thermal power	:	3900 MWth
Gross electrical power	:	1430 MWe
Reference unit power (net)	:	1360 MWe

Key Dates

Construction Date	:	1976-06-01
Grid Date	:	1984-09-05
Commercial Date	:	1985-02-01
Age at end of year	:	36 years

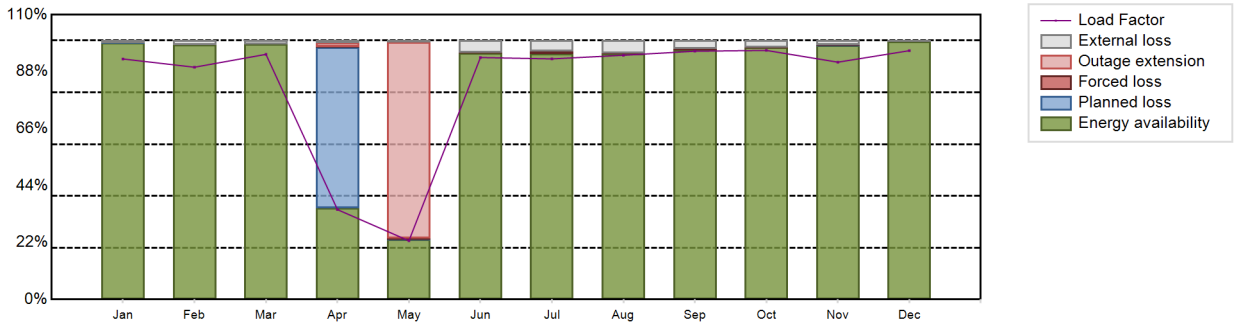
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	325.3
Fuel material	:	UO2/MOX	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	Double
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.53
Average fuel enrichment [% of U235]	:	3.2	**Secondary systems**		
Refuelling frequency [month]	:	12	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	75	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	34000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.6	HP cylinder inlet steam pressure [MPa]	:	6.59
Active core height/length [m]	:	3.9	Output voltage [kV]	:	27
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	21.2	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 (2020)

Net Energy Production	:	9909.6 GW(e).h	Forced Loss Rate (FLR)	:	0.24 %
Energy Availability Factor (EAF)	:	85.92 %	Unplanned Capability Loss Factor (UCL)	:	6.76 %
Unit Capability Factor (UCF)	:	88.14 %	Planned Unavailability Factor (PUF)	:	5.1 %
Load Factor (LF)	:	82.95 %	Externally cause unavailability (XUF)	:	2.22 %
Operating Factor (OF)	:	88.5 %	Total off-line time	:	1010 hours

Annual Summary



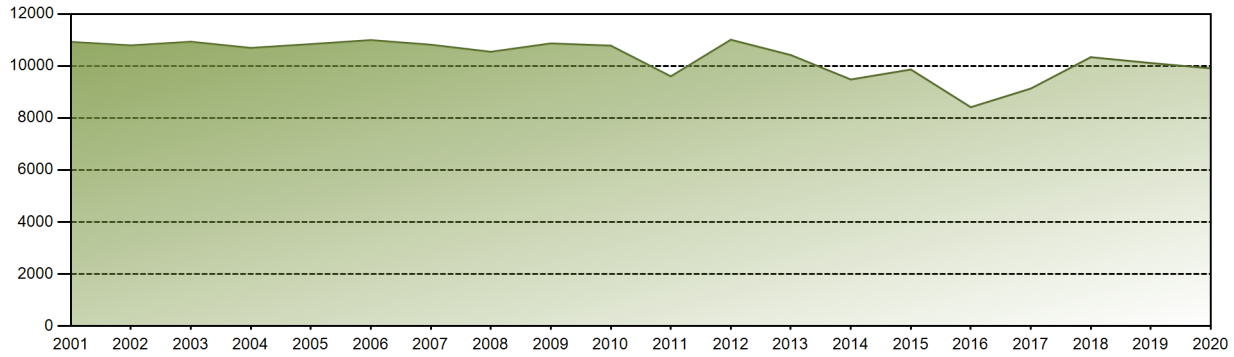
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	940.05	849.23	956.83	340.06	229.60	915.18	940.34	954.44	939.03	974.81	897.56	972.48	9909.60
EAF [%]	99.15	98.42	98.72	35.37	23.06	95.20	94.81	95.00	96.36	97.41	98.22	99.54	85.92
UCF [%]	99.97	100.00	100.00	36.17	23.75	99.71	98.98	99.92	99.56	99.97	99.91	100.00	88.14
LF [%]	92.90	89.72	94.69	34.73	22.69	93.46	92.93	94.33	95.90	96.21	91.66	96.11	82.95
OF [%]	100.00	100.00	100.00	36.94	25.27	100.00	100.00	100.00	100.00	100.00	100.00	100.00	88.50
FLR [%]	0.00	0.00	0.00	0.59	1.59	0.29	1.02	0.03	0.44	0.03	0.07	0.00	0.24
UCL [%]	0.00	0.00	0.00	1.88	76.12	0.29	1.02	0.03	0.44	0.03	0.07	0.00	6.76
PUF [%]	0.03	0.00	0.00	61.95	0.13	0.00	0.00	0.04	0.00	0.00	0.02	0.00	5.10
XUF [%]	0.82	1.58	1.28	0.81	0.69	4.51	4.17	4.92	3.19	2.56	1.69	0.46	2.22

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Historical Summary

Lifetime energy generation	:	376351.93 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.93 %
Cumulative Energy Availability Factor (EAF)	:	90.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.42 %
Cumulative Unit Capability Factor (UCF)	:	90.84 %	Cumulative Planned Unavailability Factor (PUF)	:	6.74 %
Cumulative Load Factor (LF)	:	88.43 %	Cumulative Externally cause unavailability (XUF)	:	0.56 %
Cumulative Operating Factor (OF)	:	91.6 %			

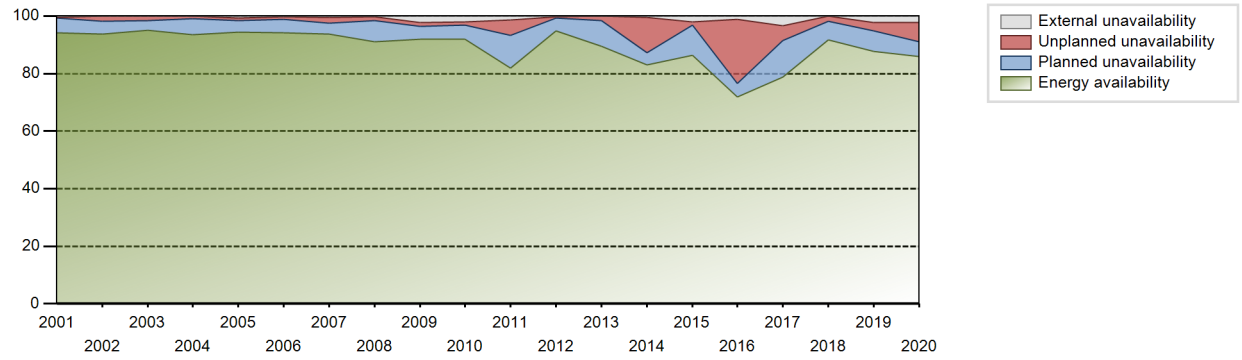
Electricity Production (net) [GWh]



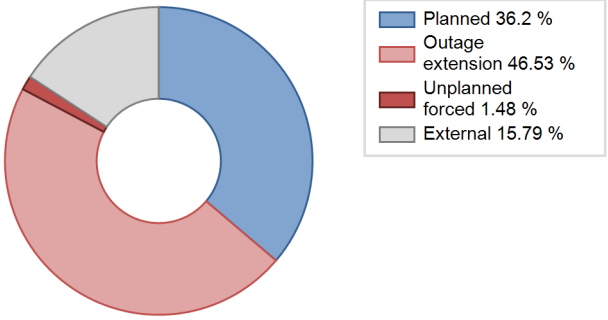
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	10871.05	8406	1300	95.17	95.17	94.97	95.58	4.60	4.59	0.24	0.00
1986	10205.37	8120	1300	89.70	89.70	89.62	92.69	0.47	0.43	9.87	0.00
1987	9648.48	7979	1300	86.44	86.44	84.72	91.08	0.51	0.44	13.12	0.00
1988	10208.28	8104	1300	90.83	90.83	89.40	92.26	0.63	0.57	8.60	0.00
1989	10279.44	8058	1300	90.32	90.32	90.27	91.99	0.94	0.86	8.82	0.00
1990	10123.56	7872	1314	88.13	88.13	87.91	89.86	0.02	0.02	11.85	0.00
1991	9957.76	7603	1325	86.43	86.43	85.79	86.79	6.52	6.03	7.54	0.00
1992	10424.29	7981	1325	89.96	89.96	89.56	90.86	0.14	0.13	9.91	0.00
1993	10680.11	8147	1325	92.84	92.84	92.01	93.00	0.01	0.01	7.15	0.00
1994	10266.46	8063	1325	91.91	91.91	88.45	92.04	0.01	0.01	8.09	0.00
1995	10771.16	7986	1349	91.10	91.10	91.12	91.16	0.08	0.07	8.83	0.00
1996	10589.85	7861	1360	88.87	88.87	88.65	89.49	1.23	1.10	10.02	0.00
1997	11864.65	8760	1360	99.96	99.96	99.59	100.00	0.01	0.01	0.03	0.00
1998	11146.31	8301	1360	94.52	94.52	93.56	94.76	0.81	0.77	4.71	0.00
1999	11212.15	8351	1360	95.28	95.28	94.11	95.33	0.00	0.00	4.72	0.00
2000	11055.88	8250	1360	93.72	93.72	92.55	93.92	0.12	0.11	6.17	0.00
2001	10926.65	8310	1360	94.18	94.72	91.72	94.86	0.06	0.06	5.22	0.54
2002	10791.89	8233	1360	93.82	93.82	90.58	93.98	1.90	1.81	4.37	0.00
2003	10933.04	8343	1360	95.00	95.00	91.77	95.24	0.09	1.65	3.35	0.00
2004	10695.42	8245	1360	93.59	93.59	89.53	93.86	0.97	0.92	5.49	0.00
2005	10840.95	8364	1360	94.49	95.15	91.00	95.48	0.50	0.98	3.87	0.66
2006	10995.69	8296	1360	94.24	94.55	92.30	94.70	0.01	0.88	4.57	0.31
2007	10818.40	8270	1360	93.63	94.07	90.80	94.40	0.20	2.03	3.91	0.43
2008	10545.95	8048	1360	91.05	91.32	88.28	91.62	0.11	1.23	7.45	0.27
2009	10867.47	8288	1360	92.00	94.36	91.22	94.61	0.06	1.14	4.50	2.36
2010	10782.44	8267	1360	91.99	94.08	90.51	94.37	0.17	1.12	4.79	2.10
2011	9603.19	7341	1360	81.91	83.40	80.61	83.80	0.98	5.25	11.36	1.49
2012	11008.61	8374	1360	94.92	95.11	92.15	95.33	0.10	0.49	4.40	0.19
2013	10420.06	7847	1360	89.39	89.39	87.46	89.58	0.03	1.62	9.00	0.00
2014	9481.18	7326	1360	82.96	83.43	79.58	83.63	1.28	12.37	4.19	0.47
2015	9864.56	7792	1360	86.32	88.43	82.80	88.95	0.05	1.04	10.53	2.12
2016	8415.91	6597	1360	71.96	73.08	70.45	75.10	7.85	22.31	4.61	1.12
2017	9133.02	7540	1360	78.68	82.15	76.66	86.07	3.74	5.08	12.77	3.47
2018	10339.24	8131	1360	91.61	91.61	86.79	92.82	0.38	1.92	6.47	0.00
2019	10113.33	7889	1360	87.65	89.82	84.89	90.06	0.10	3.01	7.16	2.18
2020	9909.60	7774	1360	85.92	88.14	82.95	88.50	0.24	6.76	5.10	2.22

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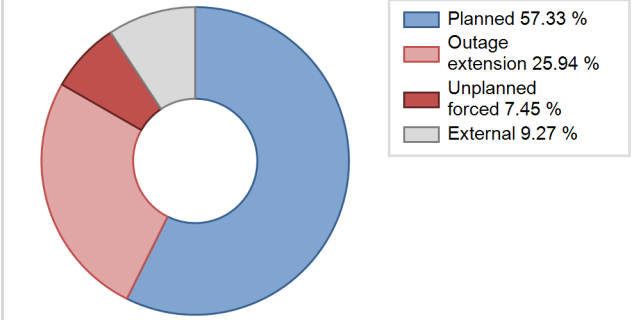
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		13			158	
C. Inspection, maintenance or repair combined with refuelling	447			491	3	
D. Inspection, maintenance or repair without refuelling				11		
L. Human factor related		582			19	
M. Governmental requirements or court decisions						1
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				10		
Z. Other					8	
Subtotal	447	595		512	188	1
Total	**1042**			**701**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems		41
15. Reactor Cooling Systems		35
21. Fuel Handling and Storage Facilities		8
31. Turbine and auxiliaries	13	3
32. Feedwater and Main Steam System		3
35. All other I&C Systems		1
41. Main Generator Systems		47
42. Electrical Power Supply Systems		4
Total	**13**	**158**

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2020 Operating Experience

DE-28 GUNDREMMINGEN-C GERMANY

Status at end of year	:	**Operational**
Operator	:	KGG (Kernkraftwerk Gundremmingen 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	:	BWR / BWR-72
Thermal power	:	3840 MWth
Gross electrical power	:	1344 MWe
Reference unit power (net)	:	1288 MWe

Key Dates

Construction Date	:	1976-07-20
Grid Date	:	1984-11-02
Commercial Date	:	1985-01-18
Age at end of year	:	36 years

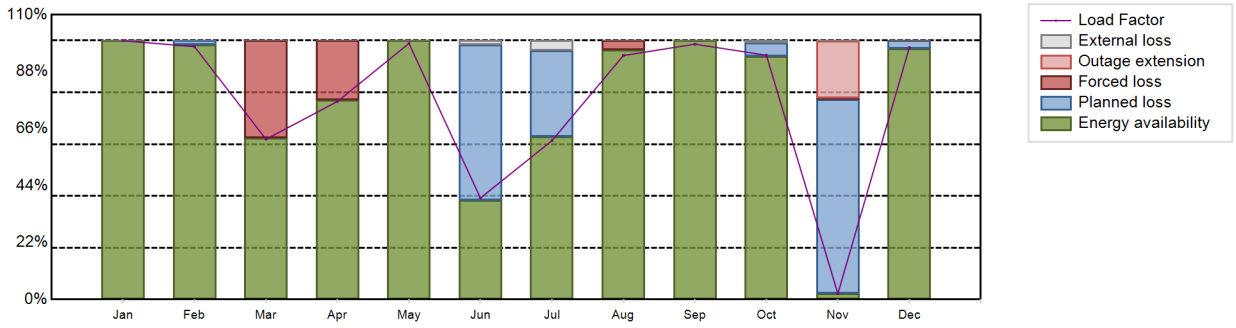
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	286
Fuel material	:	UO2/MOX	Number of SG	:	NA
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.42
Average fuel enrichment [% of U235]	:	2.8	**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]	:	27500	Number of LP cylinders per turbine	:	2
Active core diameter [m]	:	4.818	HP cylinder inlet steam pressure [MPa]	:	6.58
Active core height/length [m]	:	3.71	Output voltage [kV]	:	27
Number of fissile fuel assemblies/bundles	:	784	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	:	193	Number of FW pumps for full power operation	:	-
Number of external reactor coolant loops	:	NA	Number of on-site safety related diesel generators	:	-
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	8710.13 GW(e).h	Forced Loss Rate (FLR)	:	6.45 %
Energy Availability Factor (EAF)	:	77.53 %	Unplanned Capability Loss Factor (UCL)	:	7.2 %
Unit Capability Factor (UCF)	:	78.05 %	Planned Unavailability Factor (PUF)	:	14.75 %
Load Factor (LF)	:	76.99 %	Externally cause unavailability (XUF)	:	0.52 %
Operating Factor (OF)	:	79.37 %	Total off-line time	:	1812 hours

Annual Summary



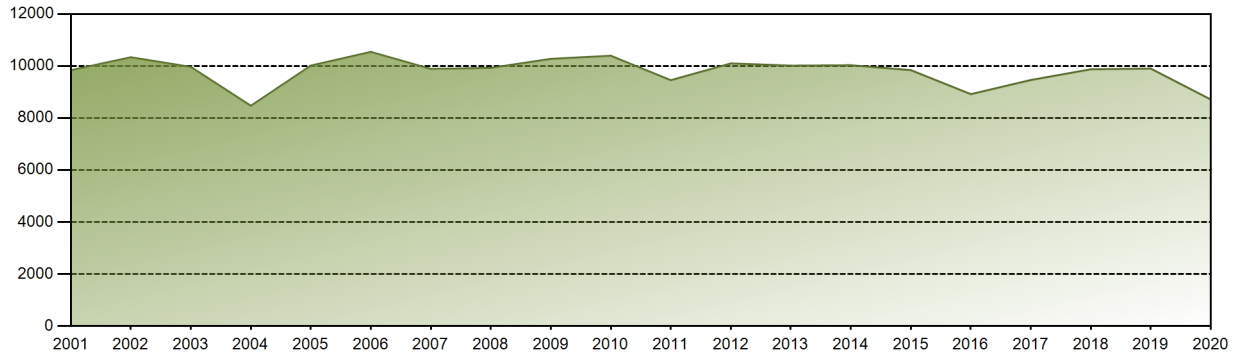
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	957.70	875.58	592.32	709.31	947.74	363.50	587.86	902.96	914.56	905.28	21.01	932.31	8710.13
EAF [%]	100.00	98.36	62.51	77.15	100.00	38.32	62.85	96.40	100.00	93.88	2.29	96.90	77.53
UCF [%]	100.00	98.36	62.51	77.15	100.00	39.84	66.61	96.40	100.00	94.75	2.33	96.90	78.05
LF [%]	99.94	97.67	61.89	76.49	98.90	39.20	61.35	94.23	98.62	94.34	2.27	97.29	76.99
OF [%]	100.00	100.00	63.12	81.94	100.00	40.69	66.40	99.73	100.00	95.30	4.03	99.60	79.37
FLR [%]	0.00	0.00	37.49	22.85	0.00	0.00	0.00	3.60	0.00	0.00	14.83	0.00	6.45
UCL [%]	0.00	0.00	37.49	22.85	0.00	0.00	0.00	3.60	0.00	0.00	22.62	0.00	7.20
PUF [%]	0.00	1.64	0.00	0.00	0.00	60.16	33.39	0.00	0.00	5.25	75.06	3.10	14.75
XUF [%]	0.00	0.00	0.00	0.00	0.00	1.52	3.76	0.00	0.00	0.87	0.03	0.00	0.52

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Historical Summary

Lifetime energy generation	:	333802.37 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.43 %
Cumulative Energy Availability Factor (EAF)	:	86.92 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.53 %
Cumulative Unit Capability Factor (UCF)	:	87.38 %	Cumulative Planned Unavailability Factor (PUF)	:	10.09 %
Cumulative Load Factor (LF)	:	82.52 %	Cumulative Externally cause unavailability (XUF)	:	0.46 %
Cumulative Operating Factor (OF)	:	88.99 %			

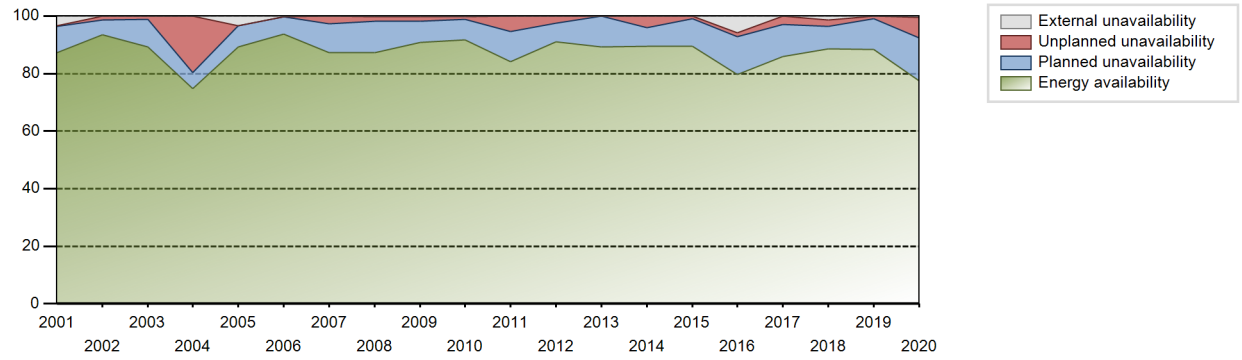
Electricity Production (net) [GWh]



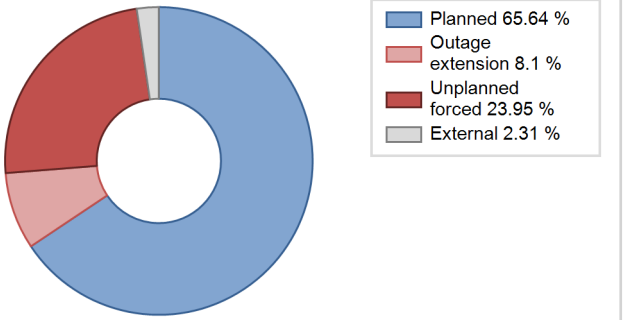
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	9149.56	7663	1244	91.07	91.07	89.78	93.25	8.02	7.94	0.99	0.00
1986	8018.53	7945	1244	84.68	84.68	73.58	90.70	0.38	0.32	15.00	0.00
1987	7333.18	7345	1248	74.68	74.68	67.08	83.85	7.43	5.99	19.33	0.00
1988	7456.14	7887	1248	88.28	88.28	68.02	89.79	0.65	0.58	11.14	0.00
1989	7884.50	7722	1248	84.21	84.21	72.12	88.15	0.14	0.12	15.66	0.00
1990	8264.75	7519	1248	80.23	80.23	75.60	85.83	2.02	1.65	18.12	0.00
1991	8341.34	7709	1248	85.88	85.88	76.30	88.00	1.39	1.21	12.91	0.00
1992	9381.03	8784	1248	98.92	98.92	85.57	100.00	0.19	0.19	0.89	0.00
1993	6689.16	7051	1248	79.10	79.10	61.19	80.49	0.12	0.09	20.80	0.00
1994	7501.99	7147	1248	80.67	81.11	68.62	81.59	0.23	0.19	18.70	0.44
1995	9376.72	7929	1288	89.31	89.31	83.11	90.51	0.20	0.18	10.51	0.00
1996	9508.99	8176	1288	91.66	91.66	84.05	93.08	0.54	0.49	7.85	0.00
1997	9013.63	7861	1288	88.68	89.10	79.89	89.74	0.74	0.67	10.23	0.42
1998	9629.47	8153	1288	91.53	91.53	85.35	93.07	0.80	0.74	7.73	0.00
1999	8187.60	6942	1288	77.04	77.04	72.57	79.25	15.76	14.42	8.55	0.00
2000	10176.83	8375	1288	94.57	94.57	89.95	95.34	0.09	0.08	5.35	0.00
2001	9838.39	8016	1288	87.21	90.66	87.20	91.51	0.19	0.17	9.17	3.45
2002	10335.84	8301	1288	93.43	93.43	91.61	94.76	1.50	1.43	5.14	0.00
2003	9965.59	7931	1288	89.16	89.16	88.32	90.54	1.29	1.17	9.67	0.00
2004	8470.48	6747	1288	74.87	74.87	74.87	76.81	20.75	19.60	5.52	0.00
2005	10015.64	8158	1288	89.22	92.56	88.77	93.13	0.04	0.04	7.40	3.34
2006	10542.96	8289	1288	93.74	93.94	93.44	94.62	0.18	0.17	5.89	0.19
2007	9888.31	7729	1288	87.36	87.40	87.64	88.23	2.95	2.66	9.94	0.04
2008	9928.98	7737	1288	87.34	87.49	87.76	88.08	0.14	1.60	10.91	0.15
2009	10275.18	8036	1288	90.88	91.13	91.07	91.74	0.34	1.46	7.41	0.26
2010	10394.76	8125	1288	91.74	92.10	92.13	92.75	0.15	0.73	7.17	0.35
2011	9454.97	7412	1288	84.08	84.08	83.80	84.61	4.24	5.38	10.54	0.00
2012	10099.09	8057	1288	91.07	91.07	89.26	91.72	2.55	2.38	6.55	0.00
2013	10015.72	7850	1288	89.19	89.19	88.77	89.61	0.07	0.06	10.74	0.00
2014	10031.13	7921	1288	89.44	89.44	88.91	90.42	3.34	4.06	6.49	0.00
2015	9841.63	7900	1288	89.49	89.49	87.23	90.18	0.46	0.99	9.52	0.00
2016	8918.29	7553	1288	79.61	85.46	78.83	85.99	0.05	1.41	13.14	5.84
2017	9462.05	7696	1288	85.93	85.93	83.86	87.85	2.36	2.90	11.18	0.00
2018	9874.20	7920	1288	88.56	89.85	87.51	90.41	0.00	2.26	7.89	1.29
2019	9900.24	7809	1288	88.41	88.54	87.75	89.14	0.87	0.77	10.69	0.13
2020	8710.13	6972	1288	77.53	78.05	76.99	79.37	6.45	7.20	14.75	0.52

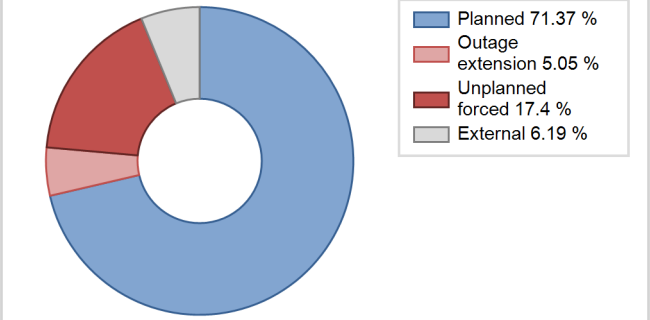
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		570			183	
B. Refuelling without maintenance				21		
C. Inspection, maintenance or repair combined with refuelling	1240			736		
D. Inspection, maintenance or repair without refuelling				14		
E. Testing of plant systems or components	0			1	1	
L. Human factor related					5	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				13		
Subtotal	1240	570		785	189	
Total	**1810**			**974**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	405	41
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems	6	0
14. Safety Systems		10
15. Reactor Cooling Systems		6
16. Steam generation systems		4
21. Fuel Handling and Storage Facilities	160	4
31. Turbine and auxiliaries		23
32. Feedwater and Main Steam System		0
41. Main Generator Systems		76
42. Electrical Power Supply Systems		4
Total	**571**	**184**

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2020 Operating Experience

DE-31 ISAR-2 GERMANY



Status at end of year	:	**Operational**
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	:	32 years

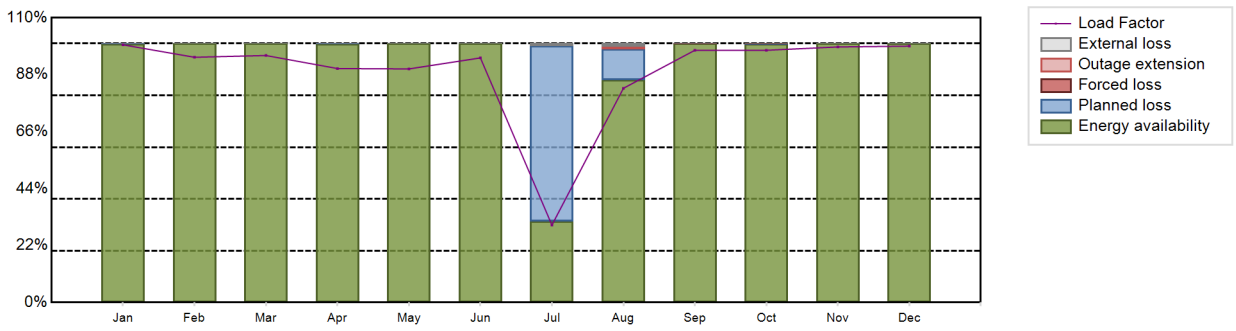
Design Characteristics

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 (2020)

Net Energy Production	:	11030.83 GW(e).h
Energy Availability Factor (EAF)	:	92.99 %
Unit Capability Factor (UCF)	:	93.15 %
Load Factor (LF)	:	89.06 %
Operating Factor (OF)	:	93.16 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0.09 %
Planned Unavailability Factor (PUF)	:	6.76 %
Externally cause unavailability (XUF)	:	0.16 %
Total off-line time	:	601 hours

Annual Summary



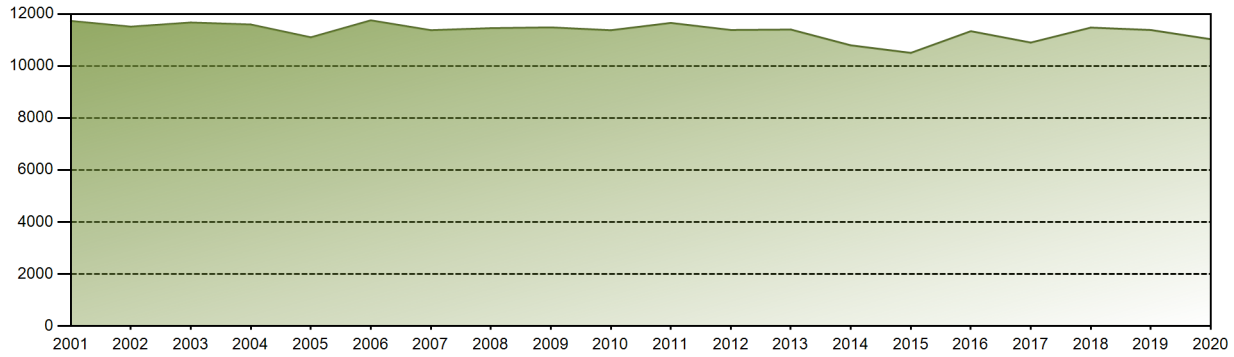
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	1044.01	929.51	999.38	917.41	946.50	959.05	313.81	867.95	989.15	1023.35	1002.05	1038.65	11030.83
EAF [%]	99.98	100.00	100.00	99.98	100.00	100.00	31.41	85.93	99.99	99.94	100.00	100.00	92.99
UCF [%]	99.98	100.00	100.00	99.98	100.00	100.00	32.26	87.00	99.99	99.94	100.00	100.00	93.15
LF [%]	99.52	94.72	95.39	90.37	90.23	94.47	29.91	82.74	97.43	97.42	98.70	99.01	89.06
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	32.26	86.96	100.00	100.00	100.00	100.00	93.16
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.00	0.00
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.01	0.04	0.00	0.00	0.09
PUF [%]	0.02	0.00	0.00	0.02	0.00	0.00	67.74	12.00	0.00	0.03	0.00	0.00	6.76
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.85	1.07	0.00	0.00	0.00	0.00	0.16

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Historical Summary

Lifetime energy generation	:	356826.05 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.89 %
Cumulative Energy Availability Factor (EAF)	:	92.31 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.31 %
Cumulative Unit Capability Factor (UCF)	:	92.63 %	Cumulative Planned Unavailability Factor (PUF)	:	6.05 %
Cumulative Load Factor (LF)	:	89.61 %	Cumulative Externally cause unavailability (XUF)	:	0.33 %
Cumulative Operating Factor (OF)	:	93.28 %			

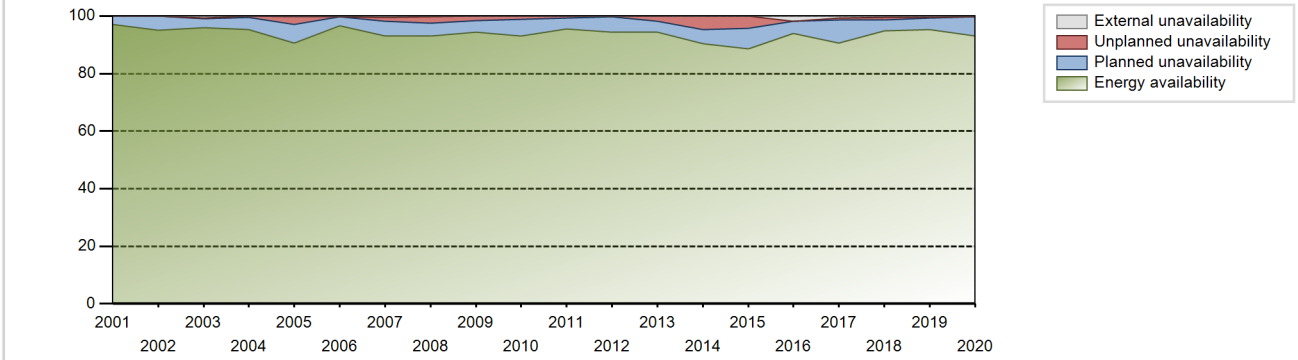
Electricity Production (net) [GWh]



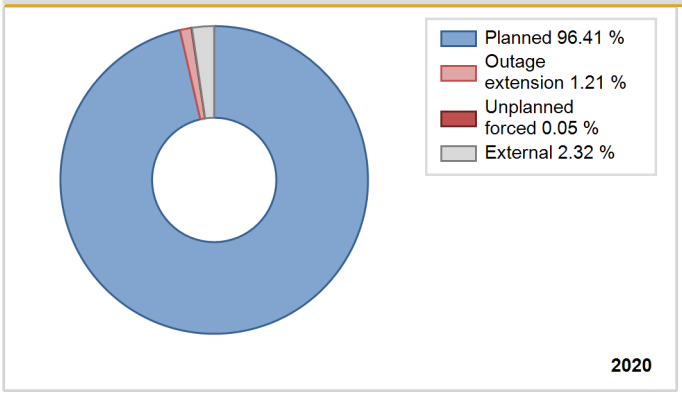
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	6023.00	6177	1323	95.09	95.09	69.65	93.58	4.81	4.81	0.11	0.00
1989	7728.92	6876	1310	73.41	73.41	67.35	78.49	12.96	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	93.15	89.06	93.16	0.00	0.09	6.76	0.16

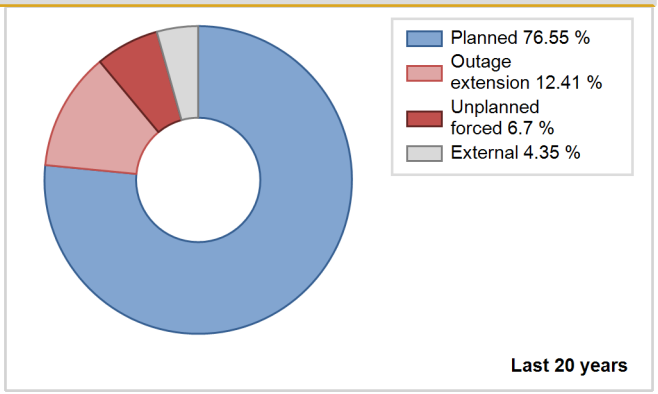
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1988 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		7			67	
B. Refuelling without maintenance				11		
C. Inspection, maintenance or repair combined with refuelling	593			475	7	
D. Inspection, maintenance or repair without refuelling				0		
E. Testing of plant systems or components				0	1	
L. Human factor related					8	
Z. Other					1	
Subtotal	593	7		486	84	
Total	**600**			**570**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1988 to 2020
	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	7	0
31. Turbine and auxiliaries		4
32. Feedwater and Main Steam System		12
41. Main Generator Systems		29
42. Electrical Power Supply Systems		0
Total	**7**	**66**

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2020 Operating Experience

DE-44 NECKARWESTHEIM-2 GERMANY

Status at end of year	:	**Operational**
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

Reactor type and model	:	PWR / Konvoi
Thermal power	:	3850 MWth
Gross electrical power	:	1400 MWe
Reference unit power (net)	:	1310 MWe

Key Dates

Construction Date	:	1982-11-09
Grid Date	:	1989-01-03
Commercial Date	:	1989-04-15
Age at end of year	:	31 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]	:	2.0
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	23
Average discharge burnup [MWd/t]	:	46000
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

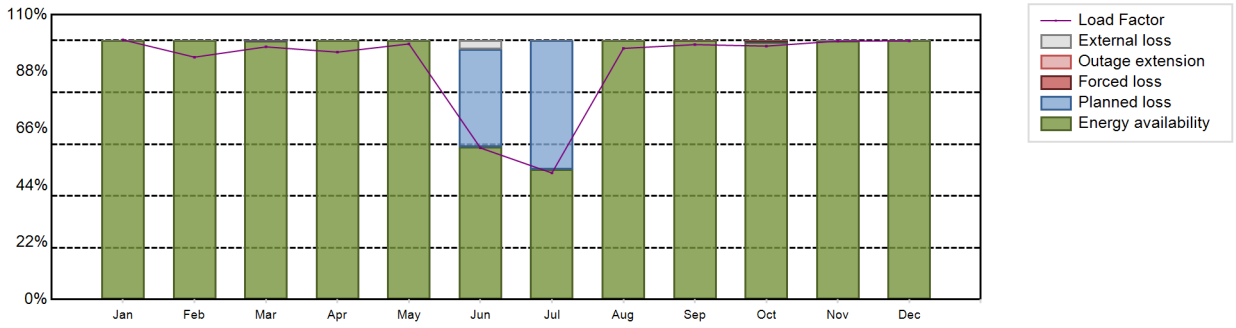
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	325.6
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	0.52
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.23
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 (2020)

Net Energy Production	:	10415.99 GW(e).h
Energy Availability Factor (EAF)	:	92.33 %
Unit Capability Factor (UCF)	:	92.61 %
Load Factor (LF)	:	90.52 %
Operating Factor (OF)	:	92.68 %

Forced Loss Rate (FLR)	:	0.06 %
Unplanned Capability Loss Factor (UCL)	:	0.05 %
Planned Unavailability Factor (PUF)	:	7.33 %
Externally cause unavailability (XUF)	:	0.28 %
Total off-line time	:	643 hours

Annual Summary



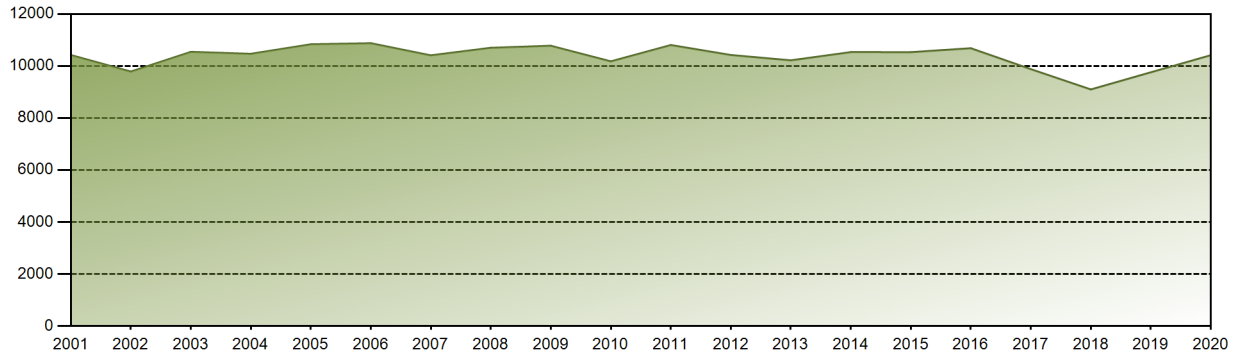
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	977.36	853.36	949.72	901.09	962.00	552.19	476.28	945.24	928.50	955.15	941.24	973.85	10415.99
EAF [%]	100.00	100.00	99.88	100.00	100.00	58.82	50.13	100.00	99.99	99.37	99.92	100.00	92.33
UCF [%]	100.00	100.00	99.88	100.00	100.00	62.19	50.13	100.00	99.99	99.37	100.00	100.00	92.61
LF [%]	100.28	93.60	97.57	95.54	98.70	58.54	48.87	96.98	98.44	97.87	99.79	99.92	90.52
OF [%]	100.00	100.00	100.00	100.00	100.00	62.22	50.13	100.00	100.00	100.00	100.00	100.00	92.68
FLR [%]	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.01	0.56	0.00	0.00	0.06
UCL [%]	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.01	0.56	0.00	0.00	0.05
PUF [%]	0.00	0.00	0.06	0.00	0.00	37.81	49.87	0.00	0.00	0.06	0.00	0.00	7.33
XUF [%]	0.00	0.00	0.00	0.00	0.00	3.37	0.00	0.00	0.00	0.00	0.08	0.00	0.28

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Historical Summary

Lifetime energy generation	:	328524.33 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.95 %
Cumulative Energy Availability Factor (EAF)	:	92.31 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.27 %
Cumulative Unit Capability Factor (UCF)	:	92.56 %	Cumulative Planned Unavailability Factor (PUF)	:	6.17 %
Cumulative Load Factor (LF)	:	91.26 %	Cumulative Externally cause unavailability (XUF)	:	0.25 %
Cumulative Operating Factor (OF)	:	92.81 %			

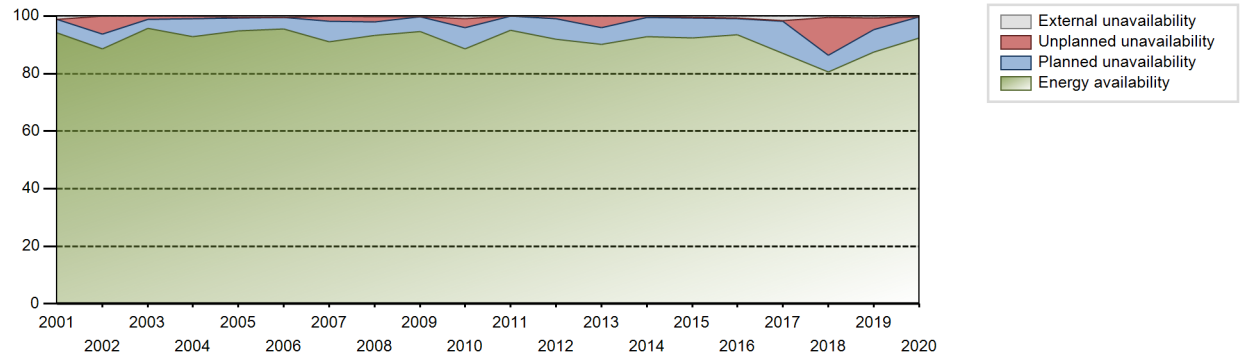
Electricity Production (net) [GWh]



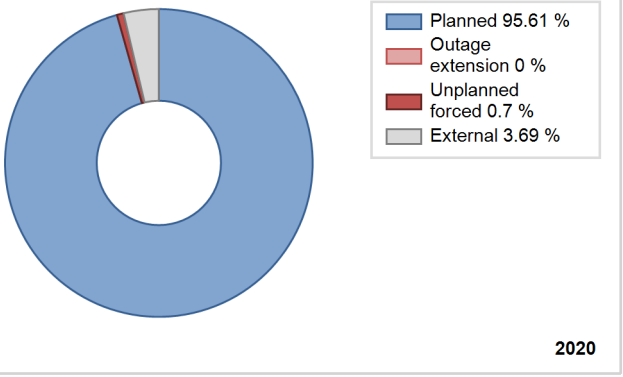
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	8673.22	8205	1225	99.76	99.76	84.22	94.74	0.00	0.00	0.24	0.00
1990	9693.91	7958	1225	90.21	90.21	90.34	90.84	0.27	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

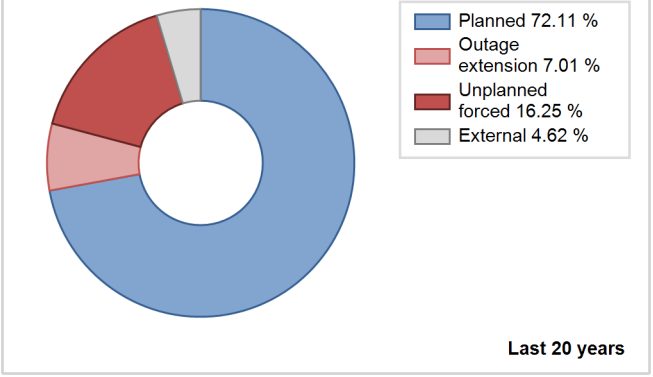
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					24	
C. Inspection, maintenance or repair combined with refuelling	643			519		
L. Human factor related					14	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					11	
Subtotal	643			519	49	
Total	**643**			**568**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		18
12. Reactor I&C Systems		3
21. Fuel Handling and Storage Facilities		11
32. Feedwater and Main Steam System		0
41. Main Generator Systems		2
Total		**34**

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2020 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	:	500 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	:	38 years

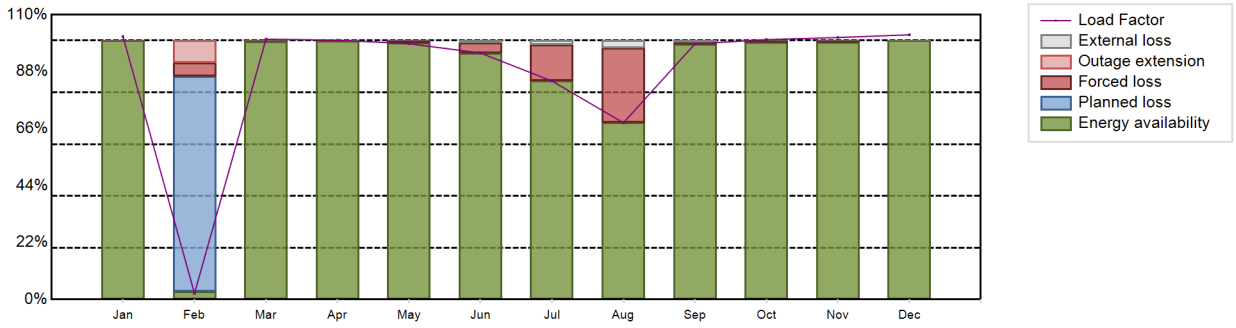
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	12.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	297
Fuel material	:	UO2	Number of SG	:	6
Refuelling type	:	OFF-line	Containment type	:	Confinement
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.15
Average fuel enrichment [% of U235]	:	3.6	**Secondary systems**		
Refuelling frequency [month]	:	12	Number of turbine-generators per unit/reactor	:	2
Part of the core refuelled [%]	:	30	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	37000	Number of LP cylinders per turbine	:	2
Active core diameter [m]	:	2.88	HP cylinder inlet steam pressure [MPa]	:	4.2
Active core height/length [m]	:	2.42	Output voltage [kV]	:	15.75
Number of fissile fuel assemblies/bundles	:	349	Primary means of condenser cooling	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	13.1	Number of main condensate pumps	:	3
Number of control rod assemblies	:	37	Number of FW pumps for full power operation	:	4
Number of external reactor coolant loops	:	6	Number of on-site safety related diesel generators	:	3
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	3709.65 GW(e).h	Forced Loss Rate (FLR)	:	4.97 %
Energy Availability Factor (EAF)	:	87.6 %	Unplanned Capability Loss Factor (UCL)	:	5.28 %
Unit Capability Factor (UCF)	:	88.11 %	Planned Unavailability Factor (PUF)	:	6.61 %
Load Factor (LF)	:	88.17 %	Externally cause unavailability (XUF)	:	0.51 %
Operating Factor (OF)	:	92.79 %	Total off-line time	:	633 hours

Annual Summary



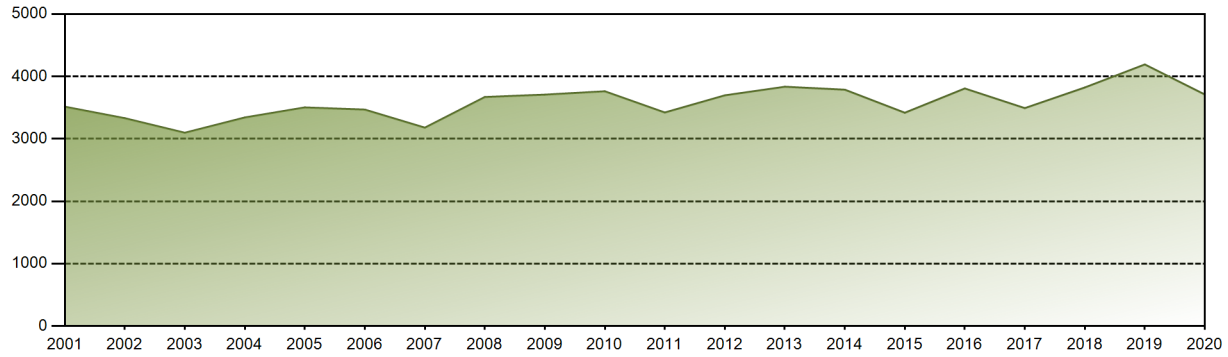
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	361.91	7.92	357.84	345.46	352.04	328.39	300.78	243.30	340.45	358.19	348.99	364.39	3709.65
EAF [%]	100.00	3.07	99.56	99.79	99.21	95.22	84.40	68.27	98.72	99.41	99.47	100.00	87.60
UCF [%]	100.00	3.07	99.56	99.79	99.21	96.05	86.06	71.08	99.44	99.41	99.47	100.00	88.11
LF [%]	101.55	2.37	100.54	100.17	98.78	95.22	84.40	68.27	98.72	100.37	101.19	102.25	88.17
OF [%]	100.00	9.05	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.79
FLR [%]	0.00	63.54	0.12	0.21	0.79	3.95	13.94	28.92	0.56	0.59	0.53	0.00	4.97
UCL [%]	0.00	13.83	0.12	0.21	0.79	3.95	13.94	28.92	0.56	0.59	0.53	0.00	5.28
PUF [%]	0.00	83.10	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.61
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.83	1.67	2.81	0.73	0.00	0.00	0.00	0.51

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Historical Summary

Lifetime energy generation	:	127886.65 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.67 %
Cumulative Energy Availability Factor (EAF)	:	86.78 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.96 %
Cumulative Unit Capability Factor (UCF)	:	86.91 %	Cumulative Planned Unavailability Factor (PUF)	:	11.13 %
Cumulative Load Factor (LF)	:	87.67 %	Cumulative Externally cause unavailability (XUF)	:	0.13 %
Cumulative Operating Factor (OF)	:	87.9 %			

Electricity Production (net) [GWh]

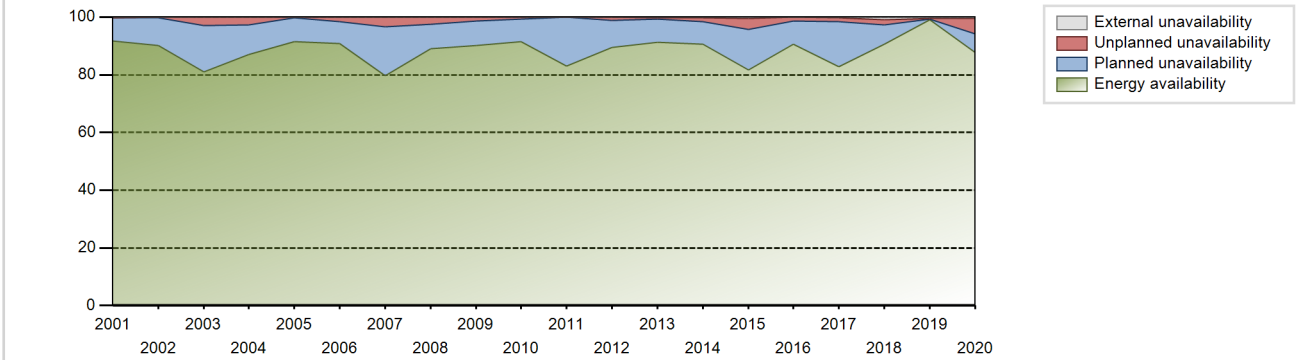


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	2299.70	7106	410	91.00	91.00	91.00	99.73	9.00	9.00	0.00	0.00
1984	2595.30	6901	403	75.63	75.73	73.25	78.56	1.28	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

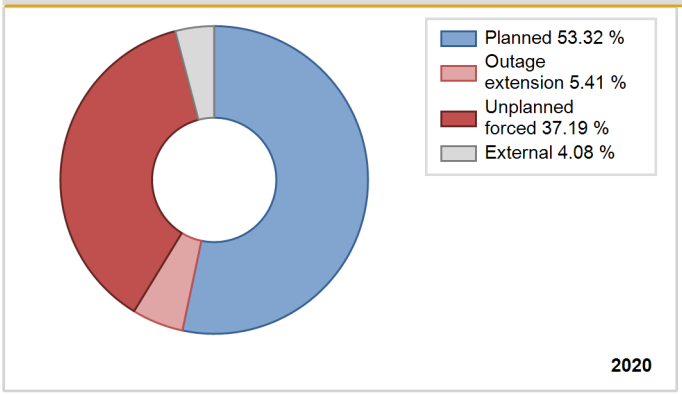
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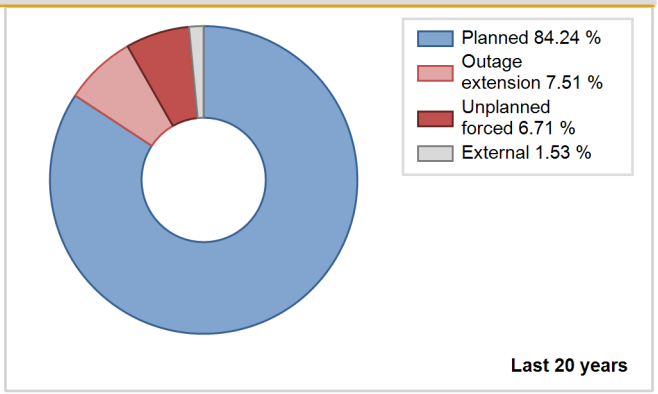
2020	3709.65	8151	479	87.60	88.11	88.17	92.79	4.97	5.28	6.61	0.51

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1983 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		61			88	
C. Inspection, maintenance or repair combined with refuelling	576			939	18	
D. Inspection, maintenance or repair without refuelling				15		
E. Testing of plant systems or components					1	
J. Grid limitation, failure or grid unavailability						0
L. Human factor related					1	
Z. Other					10	
Subtotal	576	61		954	118	0
Total	**637**			**1072**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		0
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		5
14. Safety Systems		13
15. Reactor Cooling Systems		9
16. Steam generation systems		11
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries	61	10
32. Feedwater and Main Steam System		8
33. Circulating Water System		7
34. Miscellaneous Systems		10
35. All other I&C Systems		0
41. Main Generator Systems		0
42. Electrical Power Supply Systems		4
Total	**61**	**91**

Highlights (2020)

Operation at full power in base load mode

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2020 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	:	500 MWe
Reference unit power (net)	:	477 MWe

Key Dates

Construction Date	:	1974-08-01
Grid Date	:	1984-09-06
Commercial Date	:	1984-11-14
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

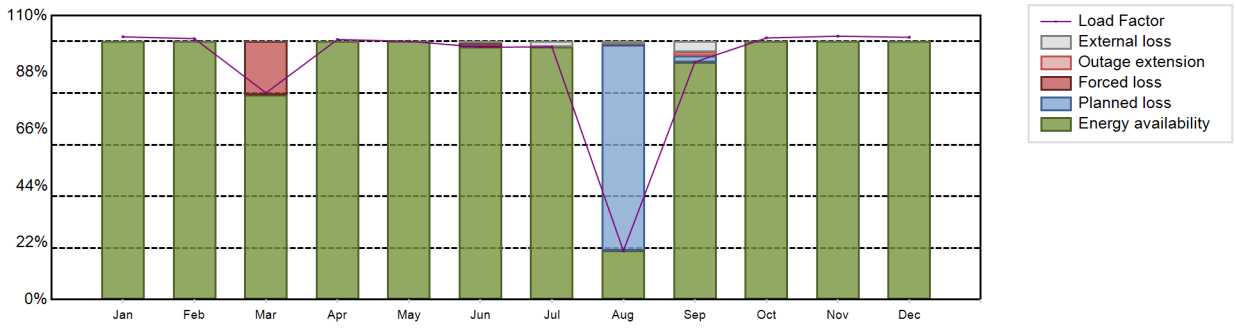
Operating coolant pressure [MPa]	:	12.5
Reactor outlet temperature [°C]	:	297
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.15
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	4.315
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 (2020)

Net Energy Production	:	3819.36 GW(e).h
Energy Availability Factor (EAF)	:	90.36 %
Unit Capability Factor (UCF)	:	91 %
Load Factor (LF)	:	91.15 %
Operating Factor (OF)	:	93.07 %
Equivalent non-electrical energy generated (NEG)	:	0.05 GW(e).h

Forced Loss Rate (FLR)	:	2.07 %
Unplanned Capability Loss Factor (UCL)	:	2.05 %
Planned Unavailability Factor (PUF)	:	6.95 %
Externally cause unavailability (XUF)	:	0.65 %
Total off-line time	:	609 hours

Annual Summary



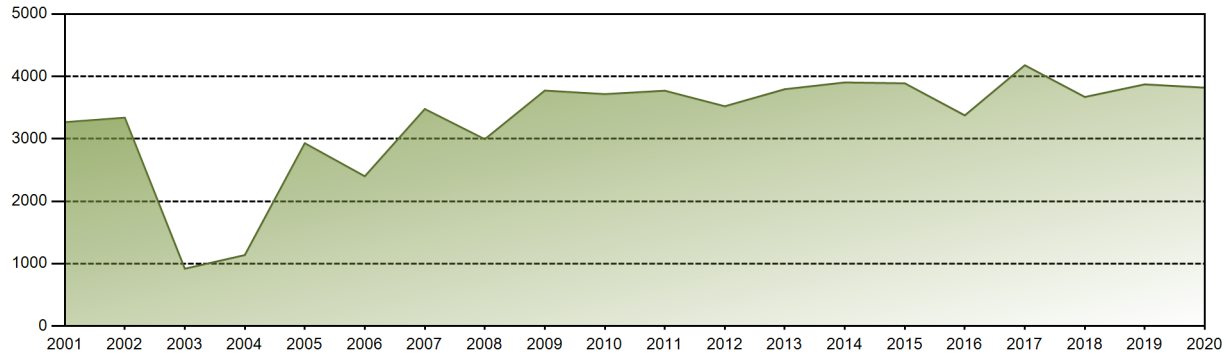
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	361.26	335.65	283.79	346.04	355.09	335.77	347.42	67.07	316.07	360.17	350.46	360.56	3819.36
EAF [%]	100.00	100.00	79.19	100.00	100.00	97.77	97.89	18.90	92.03	100.00	100.00	100.00	90.36
UCF [%]	100.00	100.00	79.19	100.00	100.00	98.34	100.00	19.98	96.06	100.00	100.00	100.00	91.00
LF [%]	101.80	101.10	80.07	100.76	100.06	97.77	97.89	18.90	92.03	101.35	102.04	101.60	91.15
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	20.97	97.08	100.00	100.00	100.00	93.07
FLR [%]	0.00	0.00	20.81	0.00	0.00	1.66	0.00	1.55	0.00	0.00	0.00	0.00	2.07
UCL [%]	0.00	0.00	20.81	0.00	0.00	1.66	0.00	0.31	1.54	0.00	0.00	0.00	2.05
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.70	2.40	0.00	0.00	0.00	6.95
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.57	2.11	1.08	4.03	0.00	0.00	0.00	0.65

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Historical Summary

Lifetime energy generation	:	118290.36 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.08 %
Cumulative Energy Availability Factor (EAF)	:	82.82 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.58 %
Cumulative Unit Capability Factor (UCF)	:	82.98 %	Cumulative Planned Unavailability Factor (PUF)	:	11.43 %
Cumulative Load Factor (LF)	:	83.72 %	Cumulative Externally cause unavailability (XUF)	:	0.17 %
Cumulative Operating Factor (OF)	:	83.66 %			

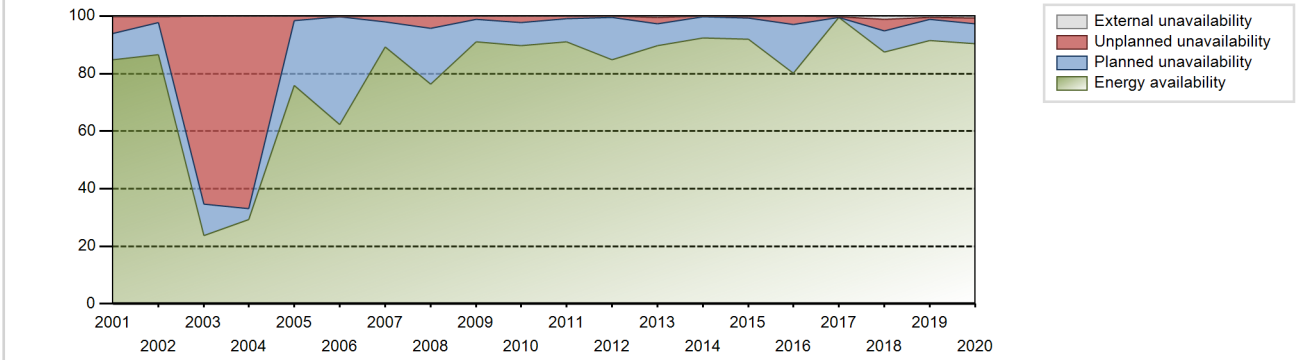
Electricity Production (net) [GWh]



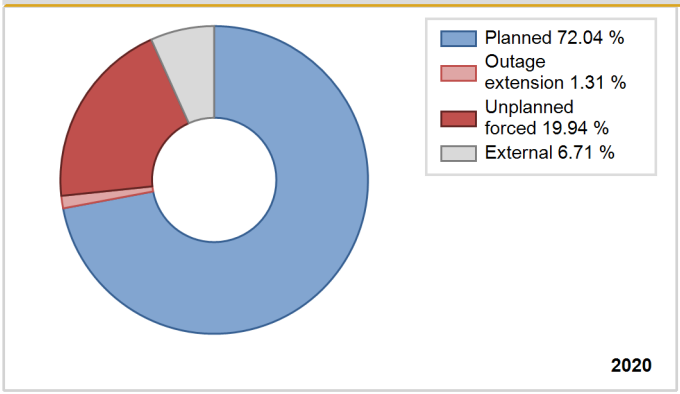
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	921.75	2659	425	94.06	94.06	97.33	99.45	1.21	1.15	4.78	0.00
1985	3101.62	7695	415	85.11	85.11	85.32	87.84	0.75	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

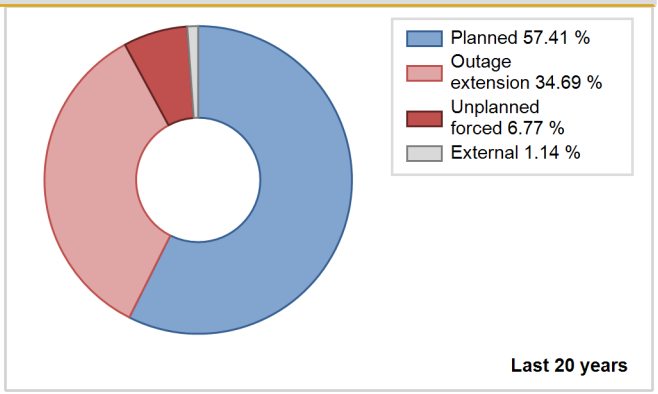
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		28			410	
C. Inspection, maintenance or repair combined with refuelling	609			911	12	
D. Inspection, maintenance or repair without refuelling				70		
E. Testing of plant systems or components				1	0	
J. Grid limitation, failure or grid unavailability						0
L. Human factor related					16	
Z. Other					18	
Subtotal	609	28		982	456	0
Total		**637**			**1438**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		157
12. Reactor I&C Systems		20
13. Reactor Auxiliary Systems		0
15. Reactor Cooling Systems		23
16. Steam generation systems		14
17. Safety I&C Systems (excluding reactor I&C)		14
21. Fuel Handling and Storage Facilities		160
31. Turbine and auxiliaries		13
32. Feedwater and Main Steam System		1
34. Miscellaneous Systems		3
41. Main Generator Systems	28	11
42. Electrical Power Supply Systems		2
Total	**28**	**418**

Highlights (2020)

Operation at full power in base load mode

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2020 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	:	500 MWe
Reference unit power (net)	:	473 MWe

Key Dates

Construction Date	:	1979-10-01
Grid Date	:	1986-09-28
Commercial Date	:	1986-12-01
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]	:	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

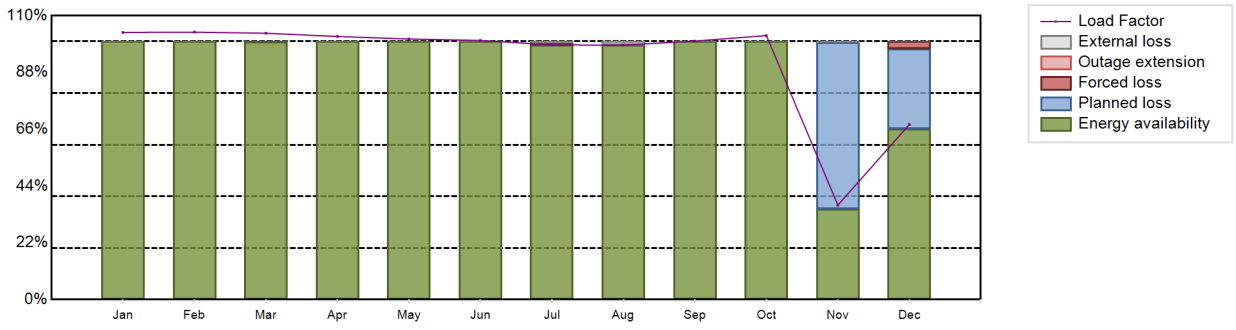
Operating coolant pressure [MPa]	:	12.5
Reactor outlet temperature [°C]	:	297
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.15
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	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 (2020)

Net Energy Production	:	3871.06 GW(e).h
Energy Availability Factor (EAF)	:	91.55 %
Unit Capability Factor (UCF)	:	91.75 %
Load Factor (LF)	:	93.17 %
Operating Factor (OF)	:	92.85 %
Equivalent non-electrical energy generated (NEG)	:	1.83 GW(e).h

Forced Loss Rate (FLR)	:	0.37 %
Unplanned Capability Loss Factor (UCL)	:	0.34 %
Planned Unavailability Factor (PUF)	:	7.92 %
Externally cause unavailability (XUF)	:	0.19 %
Total off-line time	:	628 hours

Annual Summary



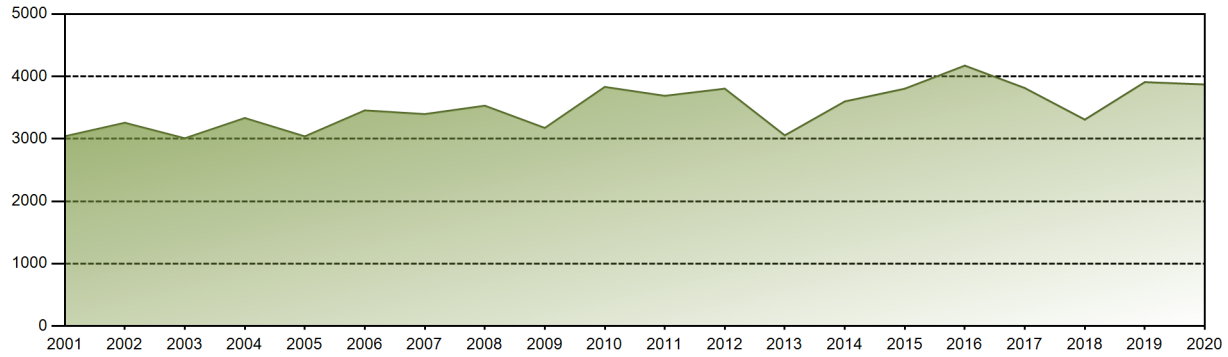
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	364.20	341.01	362.64	347.13	355.28	341.85	347.18	346.94	341.05	360.39	124.68	238.72	3871.06
EAF [%]	100.00	100.00	99.76	100.00	100.00	100.00	98.71	98.59	100.00	100.00	35.05	66.09	91.55
UCF [%]	100.00	100.00	99.76	100.00	100.00	100.00	99.25	100.00	100.00	100.00	35.40	66.09	91.75
LF [%]	103.49	103.58	103.19	101.93	100.96	100.38	98.66	98.59	100.14	102.27	36.61	67.84	93.17
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	36.94	76.61	92.85
FLR [%]	0.00	0.00	0.24	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	4.32	0.37
UCL [%]	0.00	0.00	0.24	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	2.98	0.34
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.60	30.93	7.92
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.53	1.41	0.00	0.00	0.35	0.00	0.19

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Historical Summary

Lifetime energy generation	:	116966.06 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.67 %
Cumulative Energy Availability Factor (EAF)	:	87.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.11 %
Cumulative Unit Capability Factor (UCF)	:	87.49 %	Cumulative Planned Unavailability Factor (PUF)	:	10.4 %
Cumulative Load Factor (LF)	:	87.95 %	Cumulative Externally cause unavailability (XUF)	:	0.37 %
Cumulative Operating Factor (OF)	:	88.12 %			

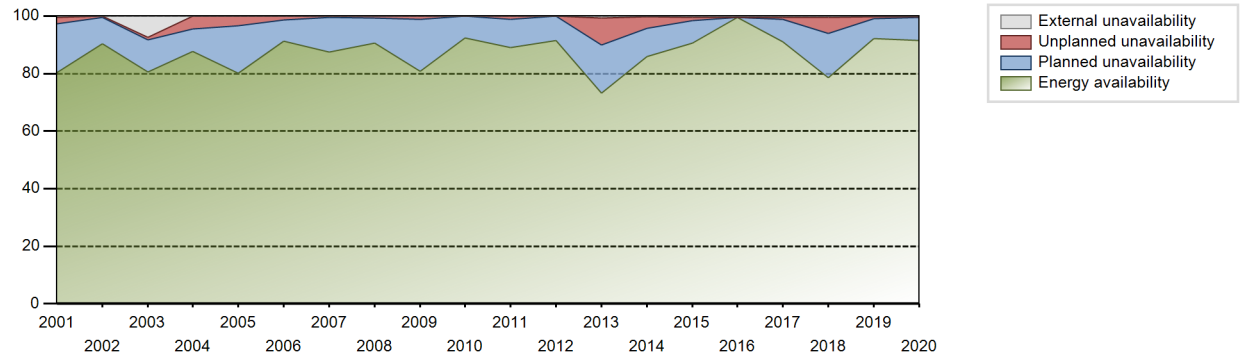
Electricity Production (net) [GWh]



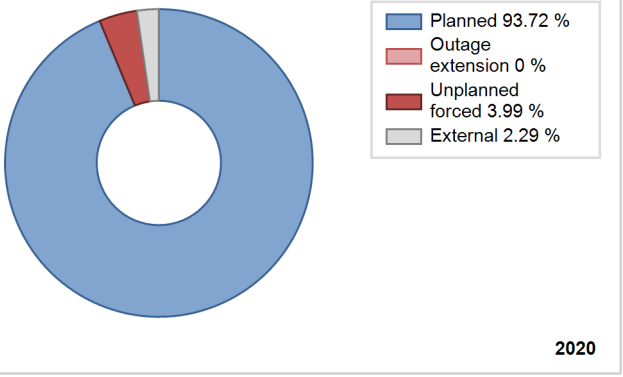
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	718.54	2109	427	99.65	99.65	101.72	100.00	0.00	0.00	0.35	0.00
1987	3209.58	7648	415	86.95	86.95	88.29	87.31	0.92	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

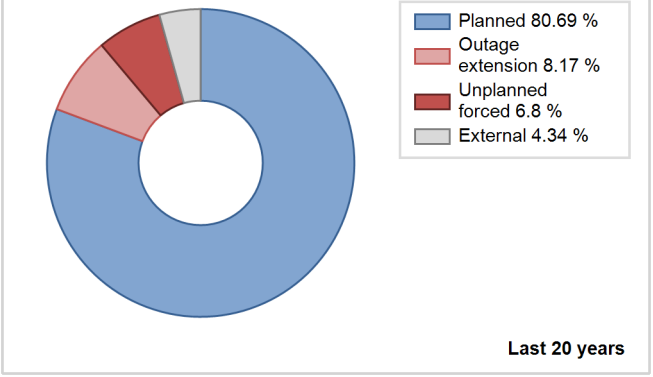
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 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	628			857	79	
D. Inspection, maintenance or repair without refuelling				32		
E. Testing of plant systems or components				1	4	
L. Human factor related					0	
Z. Other					7	
Subtotal	628			890	229	
Total	**628**			**1119**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		9
12. Reactor I&C Systems		30
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		31
31. Turbine and auxiliaries		6
32. Feedwater and Main Steam System		15
34. Miscellaneous Systems		6
42. Electrical Power Supply Systems		34
Total		**142**

Highlights (2020)

Operation at full power in base load mode

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2020 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	:	500 MWe
Reference unit power (net)	:	473 MWe

Key Dates

Construction Date	:	1979-10-01
Grid Date	:	1987-08-16
Commercial Date	:	1987-11-01
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]	:	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

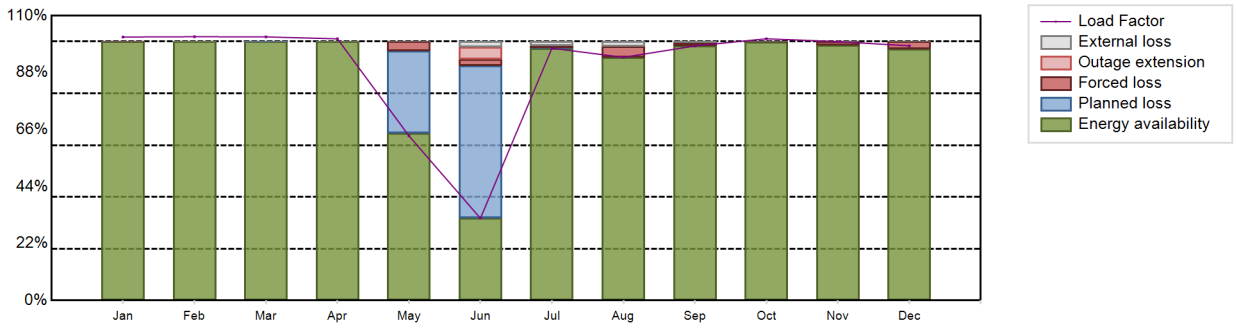
Operating coolant pressure [MPa]	:	12.5
Reactor outlet temperature [°C]	:	297
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.15
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	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 (2020)

Net Energy Production	:	3778.6 GW(e).h
Energy Availability Factor (EAF)	:	90.19 %
Unit Capability Factor (UCF)	:	90.7 %
Load Factor (LF)	:	90.94 %
Operating Factor (OF)	:	91.68 %
Equivalent non-electrical energy generated (NEG)	:	14.06 GW(e).h

Forced Loss Rate (FLR)	:	1.49 %
Unplanned Capability Loss Factor (UCL)	:	1.76 %
Planned Unavailability Factor (PUF)	:	7.55 %
Externally cause unavailability (XUF)	:	0.51 %
Total off-line time	:	731 hours

Annual Summary



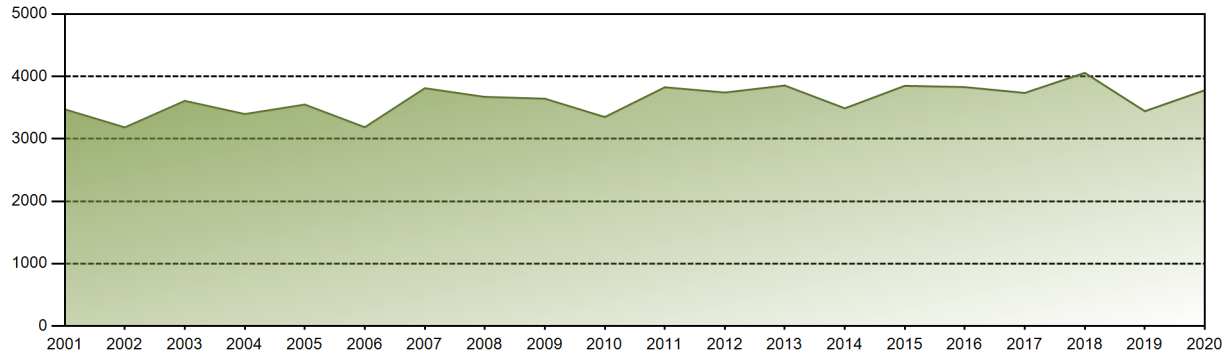
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	358.09	335.38	357.85	344.16	223.79	108.15	342.86	330.56	334.79	356.27	340.54	346.16	3778.60
EAF [%]	100.00	100.00	100.00	100.00	64.58	31.76	97.47	93.93	98.31	99.92	98.72	97.16	90.19
UCF [%]	100.00	100.00	100.00	100.00	64.58	33.89	99.12	95.92	98.61	99.92	98.72	97.16	90.70
LF [%]	101.75	101.88	101.82	101.06	63.59	31.76	97.43	93.93	98.31	101.10	99.99	98.37	90.94
OF [%]	100.00	100.00	100.00	100.00	68.01	35.42	100.00	96.24	100.00	100.00	100.00	100.00	91.68
FLR [%]	0.00	0.00	0.00	0.00	5.35	6.63	0.68	4.08	1.39	0.08	1.28	2.84	1.49
UCL [%]	0.00	0.00	0.00	0.00	3.65	7.07	0.68	4.08	1.39	0.08	1.28	2.84	1.76
PUF [%]	0.00	0.00	0.00	0.00	31.77	59.04	0.19	0.00	0.00	0.00	0.00	0.00	7.55
XUF [%]	0.00	0.00	0.00	0.00	0.00	2.14	1.65	1.99	0.31	0.00	0.00	0.00	0.51

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Historical Summary

Lifetime energy generation	:	116978.6 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.14 %
Cumulative Energy Availability Factor (EAF)	:	88.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.2 %
Cumulative Unit Capability Factor (UCF)	:	88.61 %	Cumulative Planned Unavailability Factor (PUF)	:	10.2 %
Cumulative Load Factor (LF)	:	89.37 %	Cumulative Externally cause unavailability (XUF)	:	0.32 %
Cumulative Operating Factor (OF)	:	89.4 %			

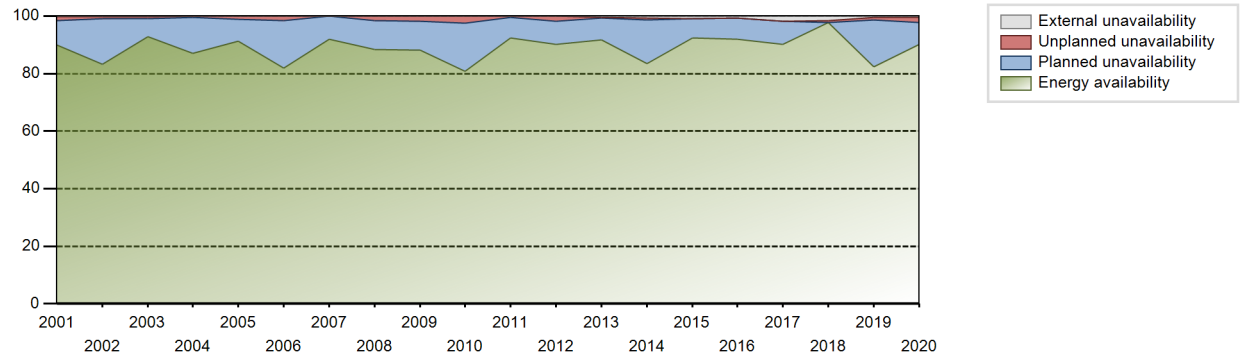
Electricity Production (net) [GWh]



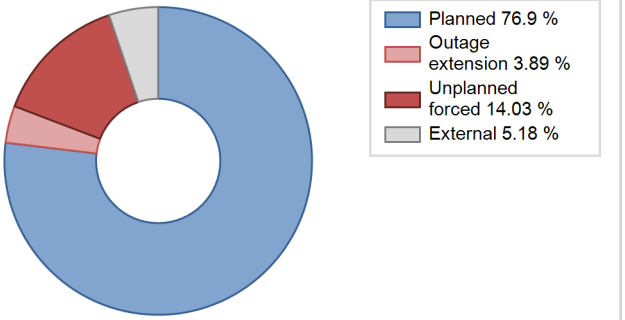
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	1039.12	2936	425	100.00	100.00	101.77	100.00	0.00	0.00	0.00	0.00
1988	3200.89	7564	415	85.65	85.65	87.81	86.11	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

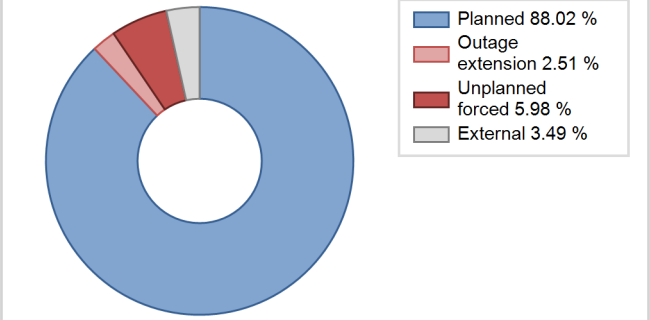
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		61			61	
C. Inspection, maintenance or repair combined with refuelling	674			851	17	
D. Inspection, maintenance or repair without refuelling				4		
E. Testing of plant systems or components				1		
L. Human factor related					2	
Z. Other				2	2	
Subtotal	674	61		858	82	
Total	**735**			**940**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems	34	11
15. Reactor Cooling Systems		11
16. Steam generation systems		15
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		12
32. Feedwater and Main Steam System	28	4
34. Miscellaneous Systems		4
41. Main Generator Systems		0
42. Electrical Power Supply Systems		3
Total	**62**	**61**

Highlights (2020)

Operation at full power in base load mode

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	1989-09-01
Grid Date	:	2000-10-12
Commercial Date	:	2000-11-16
Age at end of year	:	20 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	:	4
Number of external reactor coolant loops	:	1
Coolant type	:	D2O

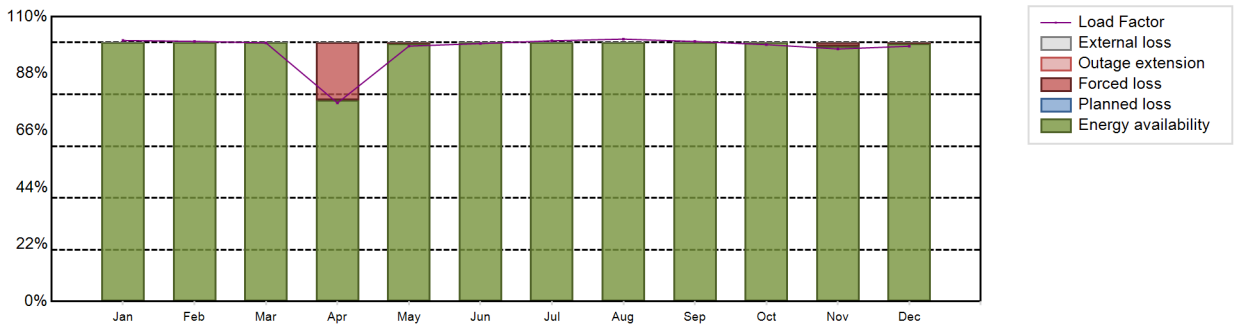
Operating coolant pressure [MPa]	:	8.7
Reactor outlet temperature [°C]	:	293
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	1.73
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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 (2020)

Net Energy Production	:	1736.35 GW(e).h
Energy Availability Factor (EAF)	:	97.98 %
Unit Capability Factor (UCF)	:	97.98 %
Load Factor (LF)	:	97.86 %
Operating Factor (OF)	:	98.35 %

Forced Loss Rate (FLR)	:	2.02 %
Unplanned Capability Loss Factor (UCL)	:	2.02 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	145 hours

Annual Summary



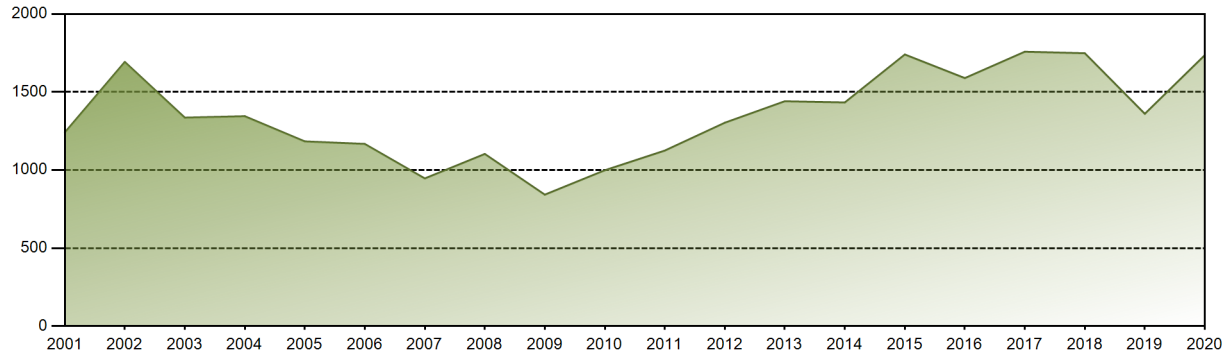
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	151.51	141.26	150.13	111.51	148.22	144.89	151.33	152.30	146.07	149.10	141.86	148.18	1736.35
EAF [%]	100.00	100.00	100.00	77.66	99.62	100.00	100.00	100.00	100.00	100.00	98.53	99.59	97.98
UCF [%]	100.00	100.00	100.00	77.66	99.62	100.00	100.00	100.00	100.00	100.00	98.53	99.59	97.98
LF [%]	100.81	100.47	99.89	76.67	98.63	99.62	100.69	101.34	100.43	99.21	97.54	98.60	97.86
OF [%]	100.00	100.00	100.00	79.86	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.35
FLR [%]	0.00	0.00	0.00	22.34	0.38	0.00	0.00	0.00	0.00	0.00	1.47	0.41	2.02
UCL [%]	0.00	0.00	0.00	22.34	0.38	0.00	0.00	0.00	0.00	0.00	1.47	0.41	2.02
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

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Historical Summary

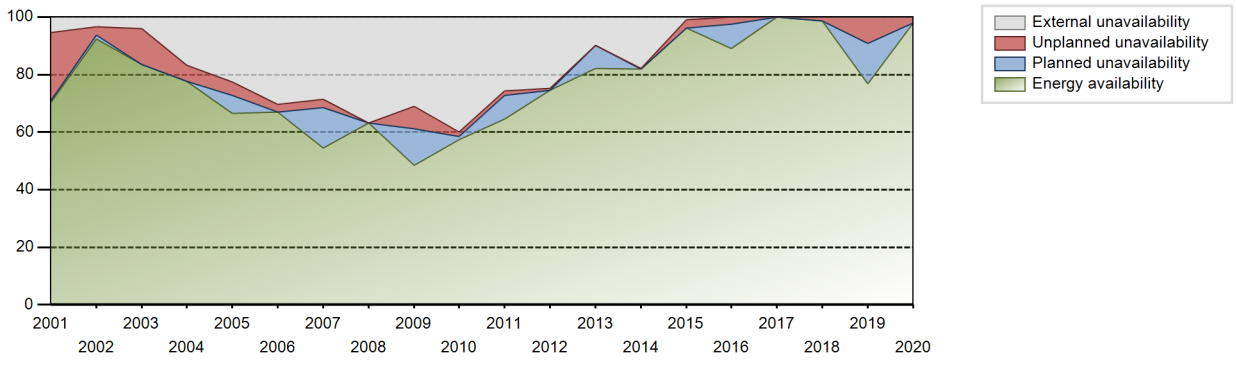
Lifetime energy generation	:	27170.56 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.11 %
Cumulative Energy Availability Factor (EAF)	:	77.23 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.2 %
Cumulative Unit Capability Factor (UCF)	:	92.07 %	Cumulative Planned Unavailability Factor (PUF)	:	3.73 %
Cumulative Load Factor (LF)	:	76.53 %	Cumulative Externally cause unavailability (XUF)	:	14.83 %
Cumulative Operating Factor (OF)	:	91.34 %			

Electricity Production (net) [GWh]



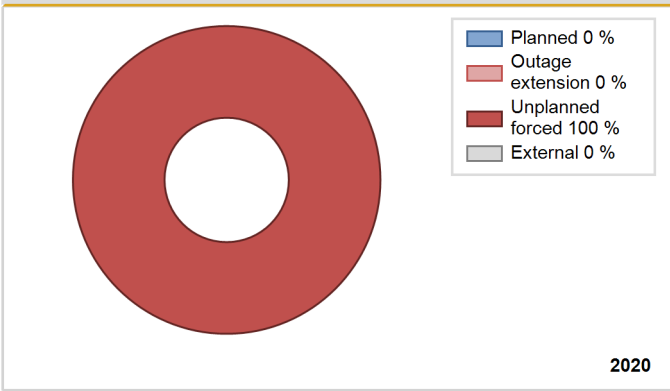
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2000	192.32	1173	200	100.00	100.00	74.50	75.94	0.00	0.00	0.00	0.00
2001	1241.14	6316	200	70.41	75.78	70.84	72.10	23.82	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

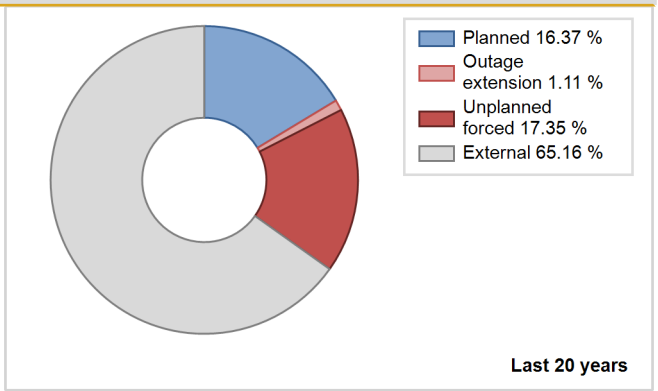
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2000 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		145			304	
D. Inspection, maintenance or repair without refuelling				320		
E. Testing of plant systems or components				6	5	
H. Nuclear regulatory requirements					13	
J. Grid limitation, failure or grid unavailability						79
L. Human factor related					11	
Z. Other					45	
Subtotal		145		326	378	79
Total		**145**			**783**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2000 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		56
12. Reactor I&C Systems		23
13. Reactor Auxiliary Systems		10
14. Safety Systems		14
15. Reactor Cooling Systems		13
17. Safety I&C Systems (excluding reactor I&C)		11
21. Fuel Handling and Storage Facilities		3
31. Turbine and auxiliaries		58
32. Feedwater and Main Steam System		15
34. Miscellaneous Systems		9
35. All other I&C Systems		0
41. Main Generator Systems		128
42. Electrical Power Supply Systems	145	20
Total	**145**	**360**

Highlights (2020)

Unit achieved an annual availability factor of 98.35% and annual capacity factor of 99.45%.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	1989-12-01
Grid Date	:	1999-12-02
Commercial Date	:	2000-03-16
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]	:	-
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	:	4
Number of external reactor coolant loops	:	1
Coolant type	:	D2O

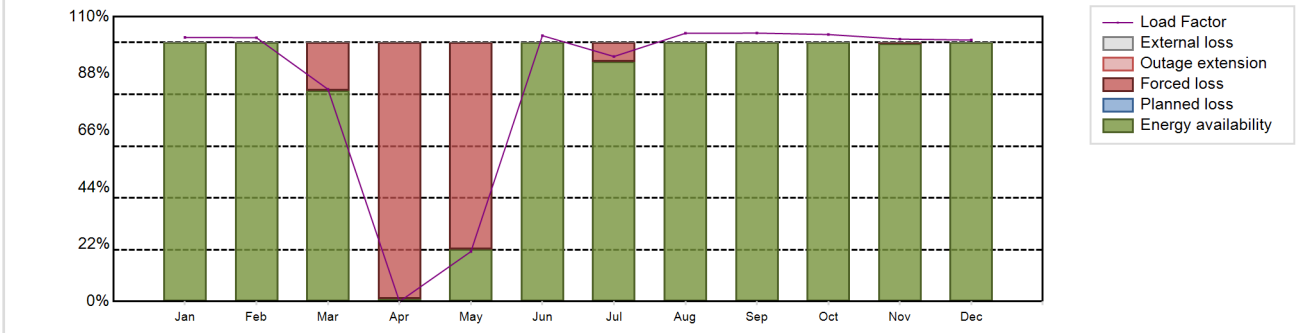
Operating coolant pressure [MPa]	:	8.7
Reactor outlet temperature [°C]	:	293
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	1.73
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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 (2020)

Net Energy Production	:	1500.83 GW(e).h
Energy Availability Factor (EAF)	:	82.93 %
Unit Capability Factor (UCF)	:	82.93 %
Load Factor (LF)	:	84.58 %
Operating Factor (OF)	:	83 %

Forced Loss Rate (FLR)	:	17.07 %
Unplanned Capability Loss Factor (UCL)	:	17.07 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1493 hours

Annual Summary



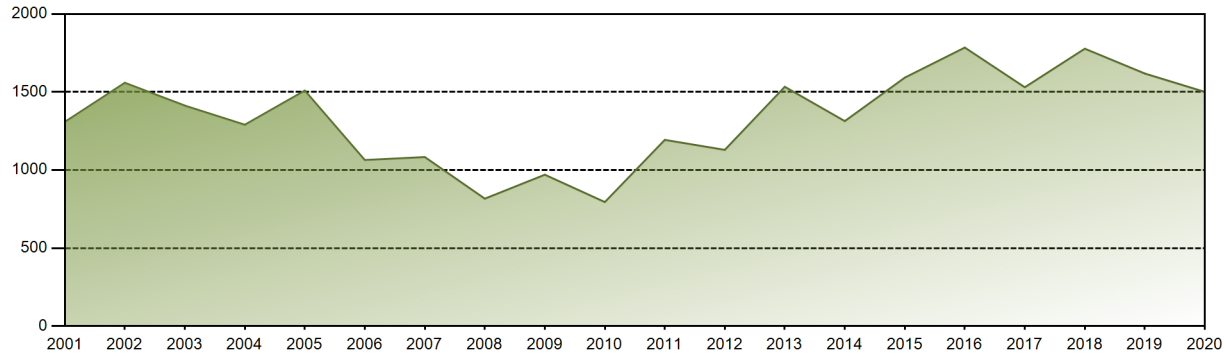
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	153.27	143.24	123.20	0.00	29.02	149.33	142.20	155.69	150.77	154.96	147.39	151.76	1500.83
EAF [%]	100.00	100.00	81.57	0.99	20.30	100.00	92.77	100.00	100.00	100.00	99.67	100.00	82.93
UCF [%]	100.00	100.00	81.57	0.99	20.30	100.00	92.77	100.00	100.00	100.00	99.67	100.00	82.93
LF [%]	101.99	101.88	81.98	0.00	19.31	102.68	94.62	103.60	103.66	103.11	101.34	100.98	84.58
OF [%]	100.00	100.00	81.45	0.00	22.18	100.00	92.74	100.00	100.00	100.00	99.72	100.00	83.00
FLR [%]	0.00	0.00	18.43	99.01	79.70	0.00	7.23	0.00	0.00	0.00	0.33	0.00	17.07
UCL [%]	0.00	0.00	18.43	99.01	79.70	0.00	7.23	0.00	0.00	0.00	0.33	0.00	17.07
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

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Historical Summary

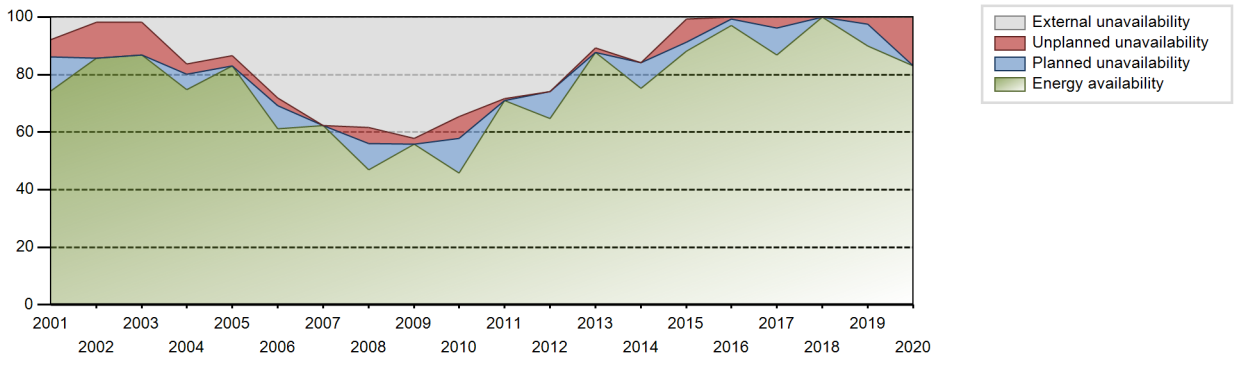
Lifetime energy generation	:	27769.72 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.11 %
Cumulative Energy Availability Factor (EAF)	:	76.17 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.01 %
Cumulative Unit Capability Factor (UCF)	:	90.83 %	Cumulative Planned Unavailability Factor (PUF)	:	4.16 %
Cumulative Load Factor (LF)	:	75.69 %	Cumulative Externally cause unavailability (XUF)	:	14.66 %
Cumulative Operating Factor (OF)	:	89.8 %			

Electricity Production (net) [GWh]



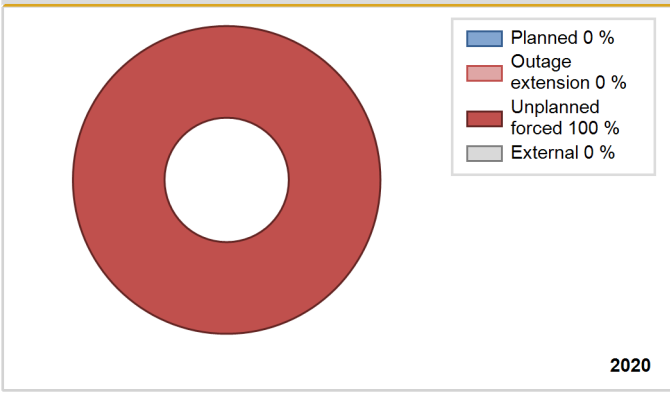
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2000	1086.47	5975	200	80.61	80.61	76.35	79.40	19.39	19.39	0.00	0.00
2001	1308.57	6670	200	74.24	82.08	74.69	76.14	6.84	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

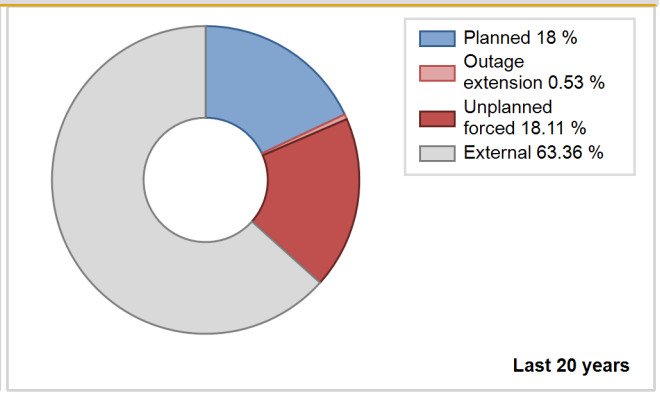
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2000 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		1495			453	
D. Inspection, maintenance or repair without refuelling				366	1	
E. Testing of plant systems or components					1	
H. Nuclear regulatory requirements				10		
J. Grid limitation, failure or grid unavailability						87
L. Human factor related					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.)						22
Z. Other					6	
Subtotal		1495		376	470	109
Total		**1495**			**955**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2000 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		27
12. Reactor I&C Systems		83
13. Reactor Auxiliary Systems		11
14. Safety Systems	54	3
15. Reactor Cooling Systems		42
16. Steam generation systems		3
17. Safety I&C Systems (excluding reactor I&C)		17
31. Turbine and auxiliaries		166
32. Feedwater and Main Steam System		17
34. Miscellaneous Systems		3
41. Main Generator Systems	1440	81
42. Electrical Power Supply Systems		45
Total	**1494**	**498**

Highlights (2020)

Unit achieved an annual availability factor of 82.98% and annual capacity factor of 85.15%.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	800 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	2002-03-30
Grid Date	:	2007-04-11
Commercial Date	:	2007-05-06
Age at end of year	:	13 years

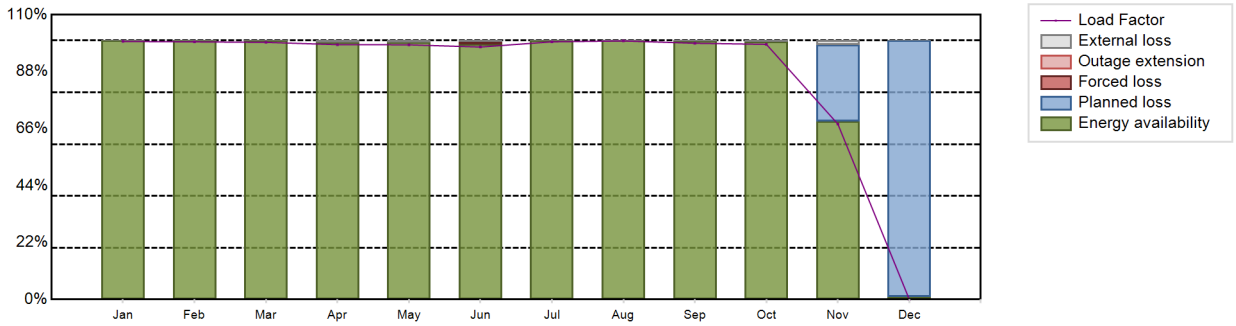
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	1.5
Reactor vessel centreline orientation	:	Horizontal	Reactor outlet temperature [°C]	:	-
Fuel material	:	UO2	Number of SG	:	-
Refuelling type	:	ON-line	Containment type	:	-
Moderator material	:	-	Containment design pressure [MPa]	:	-
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	-	Number of turbine-generators per unit/reactor	:	-
Part of the core refuelled [%]	:	-	Turbine speed [rpm]	:	-
Average discharge burnup [MWd/t]	:	-	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	-	HP cylinder inlet steam pressure [MPa]	:	-
Active core height/length [m]	:	-	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	-	Primary means of condenser cooling	:	-
Fuel linear heat generation rate [kW/m]	:	-	Number of main condensate pumps	:	-
Number of control rod assemblies	:	-	Number of FW pumps for full power operation	:	-
Number of external reactor coolant loops	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	1562.14 GW(e).h	Forced Loss Rate (FLR)	:	0.1 %
Energy Availability Factor (EAF)	:	88.79 %	Unplanned Capability Loss Factor (UCL)	:	0.09 %
Unit Capability Factor (UCF)	:	89.1 %	Planned Unavailability Factor (PUF)	:	10.82 %
Load Factor (LF)	:	88.04 %	Externally cause unavailability (XUF)	:	0.31 %
Operating Factor (OF)	:	88.98 %	Total off-line time	:	968 hours

Annual Summary



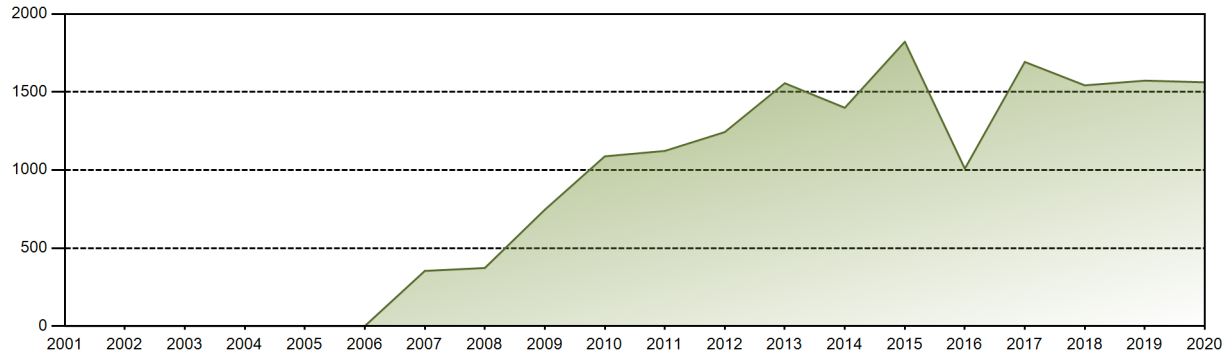
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	149.81	139.91	149.27	143.16	147.84	141.82	149.59	150.10	143.95	148.12	98.57	0.00	1562.14
EAF [%]	100.00	100.00	100.00	99.42	99.36	98.50	100.00	100.00	99.96	99.55	68.77	0.99	88.79
UCF [%]	100.00	100.00	100.00	100.00	100.00	98.95	100.00	100.00	100.00	100.00	70.36	0.99	89.10
LF [%]	99.68	99.52	99.32	98.43	98.37	97.51	99.53	99.87	98.97	98.56	67.77	0.00	88.04
OF [%]	100.00	100.00	100.00	100.00	100.00	98.89	100.00	100.00	100.00	100.00	70.00	0.00	88.98
FLR [%]	0.00	0.00	0.00	0.00	0.00	1.05	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	1.05	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	29.64	99.01	10.82
XUF [%]	0.00	0.00	0.00	0.58	0.64	0.45	0.00	0.00	0.04	0.45	1.59	0.00	0.31

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Historical Summary

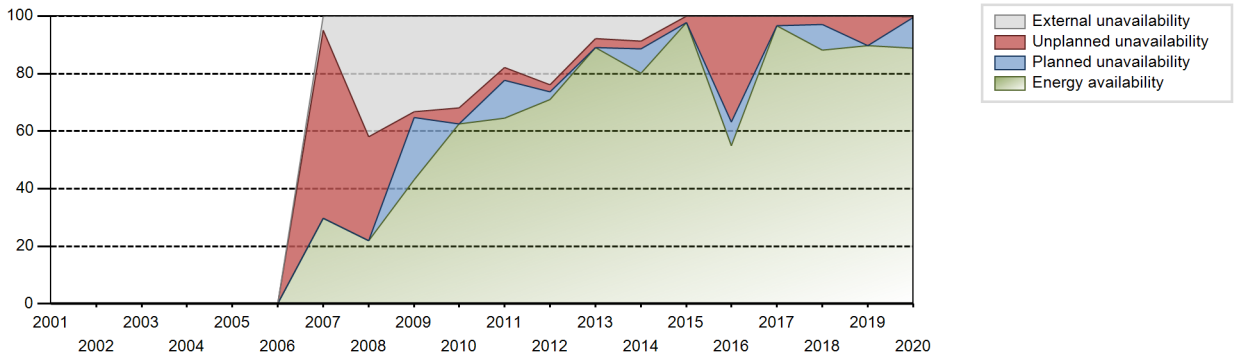
Lifetime energy generation	:	17080.17 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.79 %
Cumulative Energy Availability Factor (EAF)	:	70.79 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.43 %
Cumulative Unit Capability Factor (UCF)	:	83.18 %	Cumulative Planned Unavailability Factor (PUF)	:	5.39 %
Cumulative Load Factor (LF)	:	70.53 %	Cumulative Externally cause unavailability (XUF)	:	12.39 %
Cumulative Operating Factor (OF)	:	81.09 %			

Electricity Production (net) [GWh]



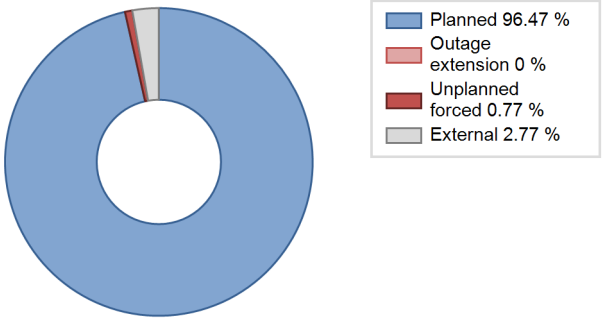
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2007	353.34	2181	202	29.85	34.82	29.33	34.14	65.18	65.18	0.00	4.97
2008	372.04	2532	202	21.96	63.85	20.97	28.83	36.15	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

Key Factors in Last 20 Years [%]

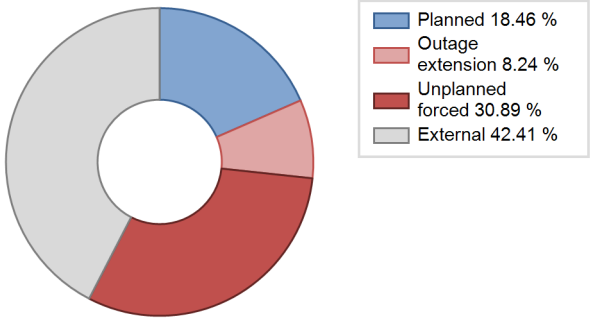


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2007 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		8			900	
D. Inspection, maintenance or repair without refuelling				161		
E. Testing of plant systems or components					35	
H. Nuclear regulatory requirements	960			177		
J. Grid limitation, failure or grid unavailability						4
L. Human factor related					19	
P. Fire					21	
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.)				140		223
Z. Other					0	
Subtotal	960	8		478	975	227
Total		**968**			**1680**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2007 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		257
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		23
14. Safety Systems		3
16. Steam generation systems		14
21. Fuel Handling and Storage Facilities		15
31. Turbine and auxiliaries		58
32. Feedwater and Main Steam System		0
35. All other I&C Systems		4
41. Main Generator Systems	8	759
42. Electrical Power Supply Systems		52
Total	**8**	**1189**

Highlights (2020)

Unit achieved an annual availability factor of 88.99%. It operated continuously for 360 days from 27th November 2019 to 22nd November 2020 before it was shutdown for BSD and replacement of generator stator.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	800 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	2002-05-10
Grid Date	:	2011-01-19
Commercial Date	:	2011-01-20
Age at end of year	:	9 years

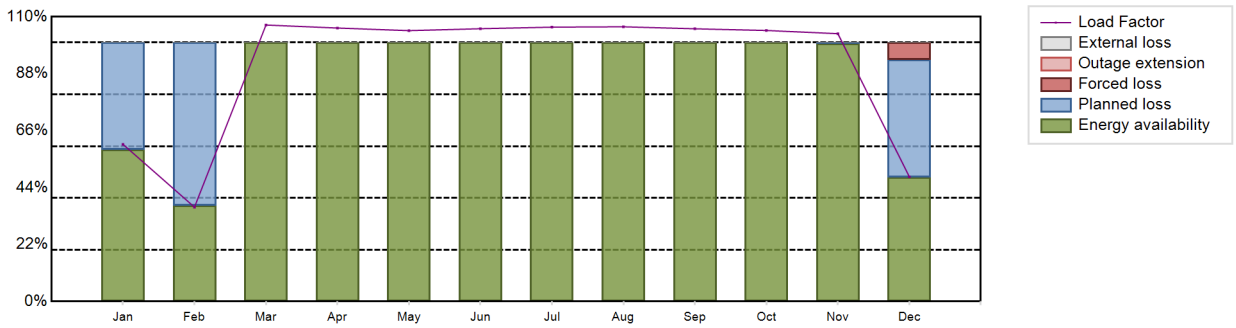
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	1.05
Reactor vessel centreline orientation	:	Horizontal	Reactor outlet temperature [°C]	:	-
Fuel material	:	UO2	Number of SG	:	-
Refuelling type	:	ON-line	Containment type	:	-
Moderator material	:	-	Containment design pressure [MPa]	:	-
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	-	Number of turbine-generators per unit/reactor	:	-
Part of the core refuelled [%]	:	-	Turbine speed [rpm]	:	-
Average discharge burnup [MWd/t]	:	-	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	-	HP cylinder inlet steam pressure [MPa]	:	-
Active core height/length [m]	:	-	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	-	Primary means of condenser cooling	:	-
Fuel linear heat generation rate [kW/m]	:	-	Number of main condensate pumps	:	-
Number of control rod assemblies	:	-	Number of FW pumps for full power operation	:	-
Number of external reactor coolant loops	:	-	Number of on-site safety related diesel generators	:	-
Coolant type	:	D2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	1619.09 GW(e).h	Forced Loss Rate (FLR)	:	0.63 %
Energy Availability Factor (EAF)	:	87.07 %	Unplanned Capability Loss Factor (UCL)	:	0.55 %
Unit Capability Factor (UCF)	:	87.07 %	Planned Unavailability Factor (PUF)	:	12.37 %
Load Factor (LF)	:	91.25 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	86.94 %	Total off-line time	:	1147 hours

Annual Summary



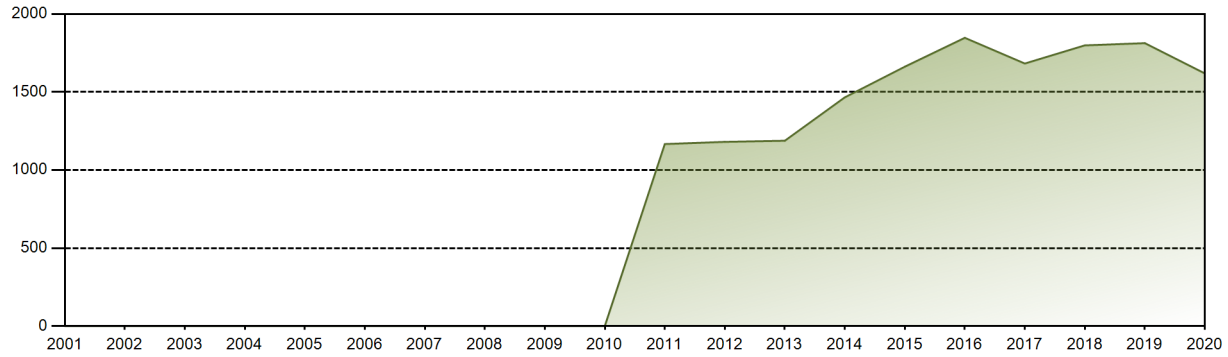
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	91.23	51.23	160.48	153.62	157.23	153.23	159.26	159.45	153.19	157.33	150.45	72.38	1619.09
EAF [%]	58.54	36.98	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.72	48.08	87.07
UCF [%]	58.54	36.98	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.72	48.08	87.07
LF [%]	60.71	36.44	106.78	105.62	104.62	105.36	105.97	106.10	105.33	104.68	103.45	48.16	91.25
OF [%]	58.06	36.35	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.72	47.58	86.94
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.97	0.63
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.54	0.55
PUF [%]	41.46	63.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	45.38	12.37
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

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Historical Summary

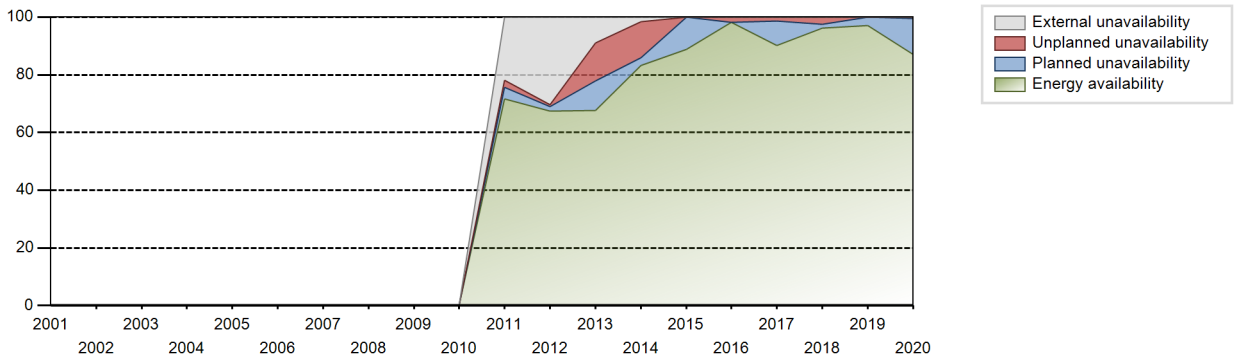
Lifetime energy generation	:	15423.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.58 %
Cumulative Energy Availability Factor (EAF)	:	84.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.54 %
Cumulative Unit Capability Factor (UCF)	:	90.99 %	Cumulative Planned Unavailability Factor (PUF)	:	5.46 %
Cumulative Load Factor (LF)	:	87.7 %	Cumulative Externally cause unavailability (XUF)	:	6.14 %
Cumulative Operating Factor (OF)	:	90.83 %			

Electricity Production (net) [GWh]



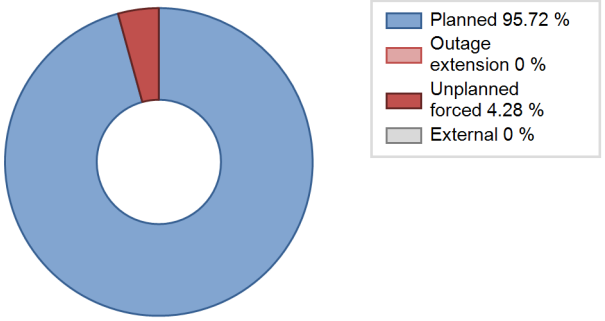
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2011	1166.35	7720	202	71.67	93.49	70.52	92.58	2.53	2.56	3.95	21.82
2012	1180.55	8585	202	67.52	97.77	66.53	97.73	0.82	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

Key Factors in Last 20 Years [%]

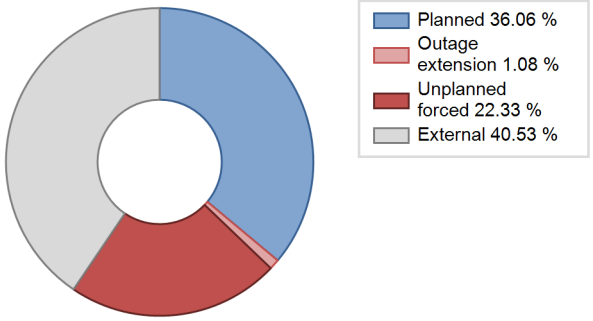


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2011 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		49			262	
D. Inspection, maintenance or repair without refuelling				178		
E. Testing of plant systems or components				20		
H. Nuclear regulatory requirements	1098			286	13	
J. Grid limitation, failure or grid unavailability						7
Z. Other					39	
Subtotal	1098	49		484	314	7
Total		**1147**			**805**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2011 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		18
12. Reactor I&C Systems	49	5
16. Steam generation systems		32
21. Fuel Handling and Storage Facilities		12
31. Turbine and auxiliaries		71
32. Feedwater and Main Steam System		0
35. All other I&C Systems		7
41. Main Generator Systems		165
42. Electrical Power Supply Systems		1
Total	**49**	**311**

Highlights (2020)

Unit achieved an annual availability factor of 86.95%.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	1984-12-01
Grid Date	:	1992-11-24
Commercial Date	:	1993-05-06
Age at end of year	:	28 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]	:	6500
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]	:	29.57
Number of control rod assemblies	:	4
Number of external reactor coolant loops	:	1
Coolant type	:	D2O

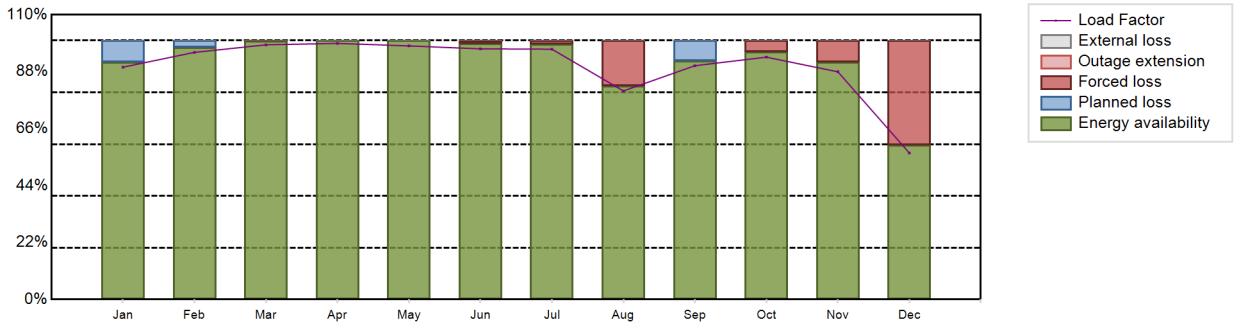
Operating coolant pressure [MPa]	:	8.7
Reactor outlet temperature [°C]	:	293
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	1.25
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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 (2020)

Net Energy Production	:	1600.12 GW(e).h
Energy Availability Factor (EAF)	:	92.29 %
Unit Capability Factor (UCF)	:	92.29 %
Load Factor (LF)	:	90.18 %
Operating Factor (OF)	:	95.82 %

Forced Loss Rate (FLR)	:	6.27 %
Unplanned Capability Loss Factor (UCL)	:	6.17 %
Planned Unavailability Factor (PUF)	:	1.54 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	367 hours

Annual Summary



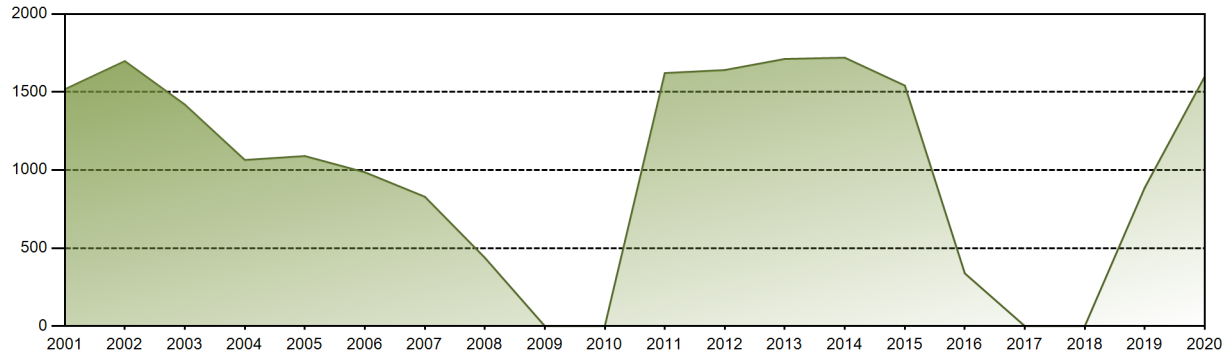
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	134.87	134.20	147.83	143.88	147.21	140.80	145.32	121.04	131.34	140.67	127.92	85.05	1600.12
EAF [%]	91.72	97.43	99.82	100.00	100.00	98.79	98.67	82.52	92.29	95.58	91.77	59.70	92.29
UCF [%]	91.72	97.43	99.82	100.00	100.00	98.79	98.67	82.52	92.29	95.58	91.77	59.70	92.29
LF [%]	89.74	95.45	98.37	98.93	97.95	96.81	96.69	80.54	90.30	93.60	87.95	56.59	90.18
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.67	58.87	95.82
FLR [%]	0.00	0.00	0.18	0.00	0.00	1.21	1.33	17.48	0.00	4.42	8.23	40.30	6.27
UCL [%]	0.00	0.00	0.18	0.00	0.00	1.21	1.33	17.48	0.00	4.42	8.23	40.30	6.17
PUF [%]	8.28	2.57	0.00	0.00	0.00	0.00	0.00	0.00	7.71	0.00	0.00	0.00	1.54
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

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Historical Summary

Lifetime energy generation	:	27952.96 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.32 %
Cumulative Energy Availability Factor (EAF)	:	61.06 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.67 %
Cumulative Unit Capability Factor (UCF)	:	66.07 %	Cumulative Planned Unavailability Factor (PUF)	:	26.26 %
Cumulative Load Factor (LF)	:	58.48 %	Cumulative Externally cause unavailability (XUF)	:	5 %
Cumulative Operating Factor (OF)	:	65.58 %			

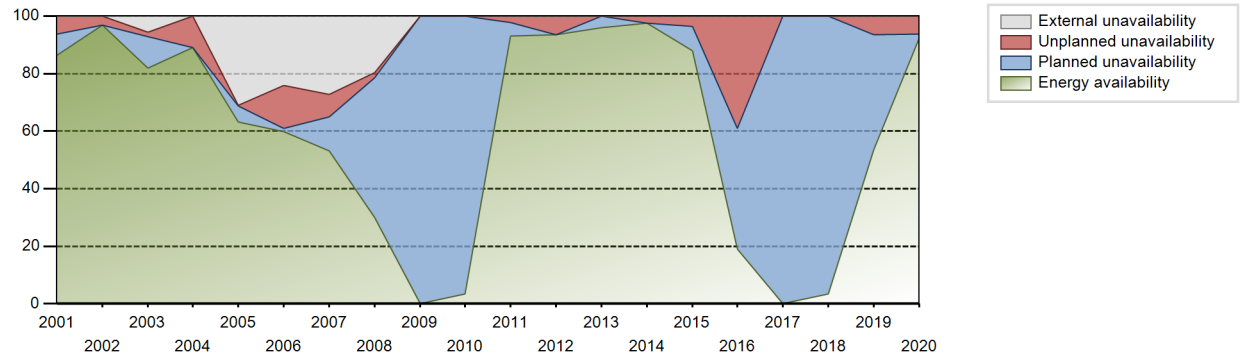
Electricity Production (net) [GWh]



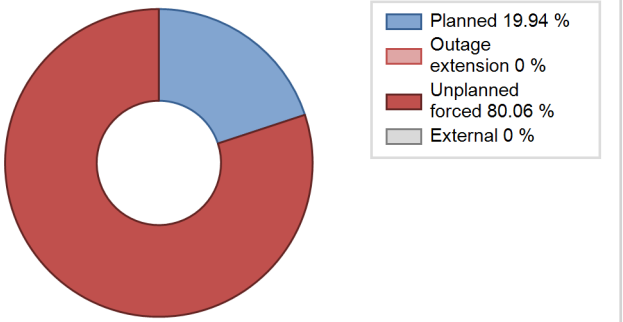
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	Data not provided										
1994	130.28	1049	194	11.98	13.24	7.67	11.97	52.21	14.46	72.30	1.25
1995	1089.07	6225	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

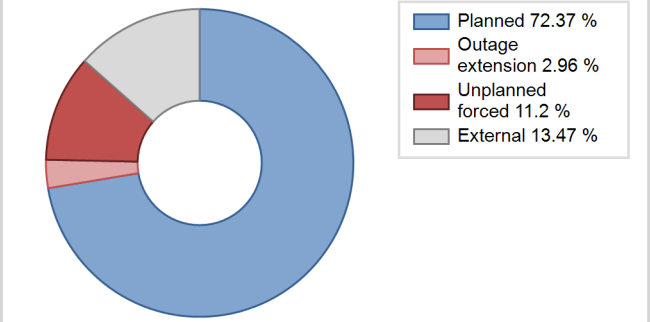
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1993 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		368			543	
D. Inspection, maintenance or repair without refuelling				520		
E. Testing of plant systems or components				44	38	
F. Major backfitting, refurbishment or upgrading activities with refuelling				823		
G. Major backfitting, refurbishment or upgrading activities without refuelling				912		
H. Nuclear regulatory requirements					42	
J. Grid limitation, failure or grid unavailability						38
L. Human factor related					6	
P. Fire					5	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						12
Z. Other					2	5
Subtotal		368		2299	636	55
Total		**368**			**2990**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1993 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		165
12. Reactor I&C Systems	1	32
13. Reactor Auxiliary Systems		9
14. Safety Systems		6
15. Reactor Cooling Systems		90
16. Steam generation systems		33
17. Safety I&C Systems (excluding reactor I&C)		10
21. Fuel Handling and Storage Facilities		17
31. Turbine and auxiliaries		70
32. Feedwater and Main Steam System		9
35. All other I&C Systems		36
41. Main Generator Systems	306	83
42. Electrical Power Supply Systems	60	46
Total	**367**	**606**

Highlights (2020)

Unit operated continuously for 334 days from 13 December 2019 to 11 November 2020.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	1985-04-01
Grid Date	:	1995-03-04
Commercial Date	:	1995-09-01
Age at end of year	:	25 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]	:	6500
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]	:	29.57
Number of control rod assemblies	:	4
Number of external reactor coolant loops	:	1
Coolant type	:	D2O

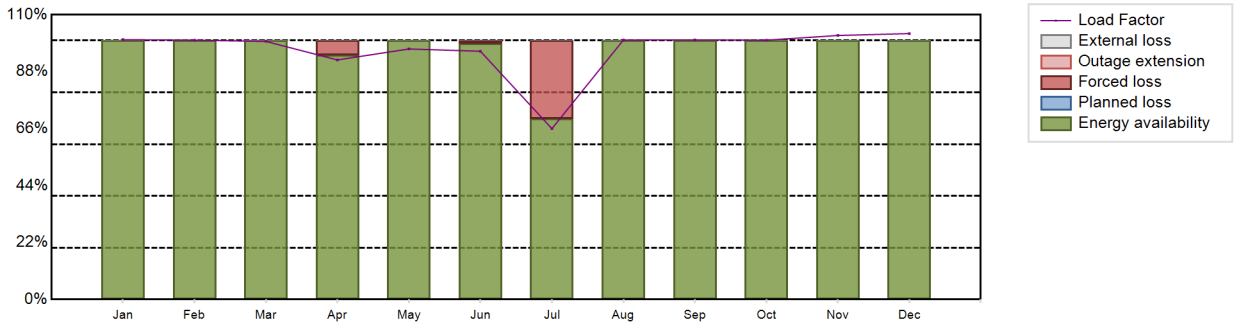
Operating coolant pressure [MPa]	:	8.7
Reactor outlet temperature [°C]	:	293
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	1.25
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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 (2020)

Net Energy Production	:	1709.8 GW(e).h
Energy Availability Factor (EAF)	:	96.9 %
Unit Capability Factor (UCF)	:	96.9 %
Load Factor (LF)	:	96.36 %
Operating Factor (OF)	:	97.29 %

Forced Loss Rate (FLR)	:	3.1 %
Unplanned Capability Loss Factor (UCL)	:	3.1 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	238 hours

Annual Summary



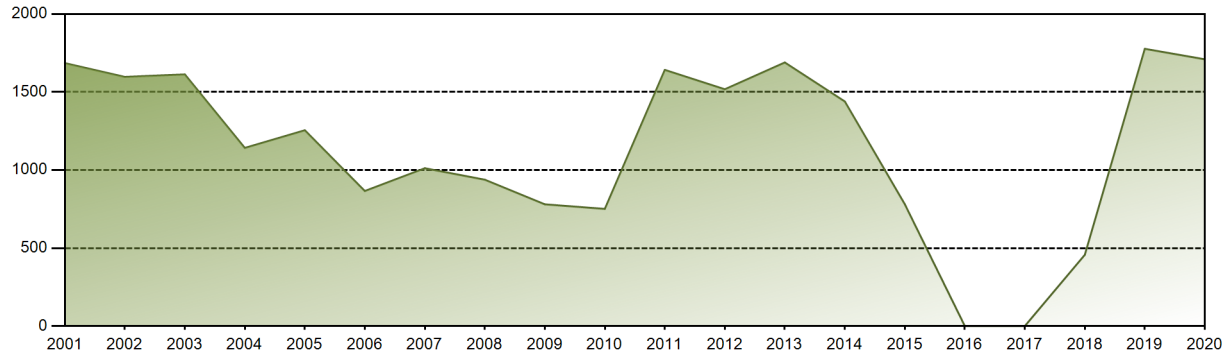
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	150.85	140.82	149.81	134.58	145.43	139.45	99.18	150.62	145.86	150.53	148.33	154.36	1709.80
EAF [%]	100.00	100.00	100.00	94.51	100.00	98.83	69.83	100.00	100.00	100.00	100.00	100.00	96.90
UCF [%]	100.00	100.00	100.00	94.51	100.00	98.83	69.83	100.00	100.00	100.00	100.00	100.00	96.90
LF [%]	100.37	100.16	99.68	92.53	96.77	95.88	65.99	100.22	100.29	100.16	101.99	102.71	96.36
OF [%]	100.00	100.00	100.00	100.00	100.00	98.75	69.22	100.00	100.00	100.00	100.00	100.00	97.29
FLR [%]	0.00	0.00	0.00	5.49	0.00	1.17	30.17	0.00	0.00	0.00	0.00	0.00	3.10
UCL [%]	0.00	0.00	0.00	5.49	0.00	1.17	30.17	0.00	0.00	0.00	0.00	0.00	3.10
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

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Historical Summary

Lifetime energy generation	:	30017.12 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.24 %
Cumulative Energy Availability Factor (EAF)	:	69.8 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.77 %
Cumulative Unit Capability Factor (UCF)	:	78.79 %	Cumulative Planned Unavailability Factor (PUF)	:	12.45 %
Cumulative Load Factor (LF)	:	67.05 %	Cumulative Externally cause unavailability (XUF)	:	8.99 %
Cumulative Operating Factor (OF)	:	78.64 %			

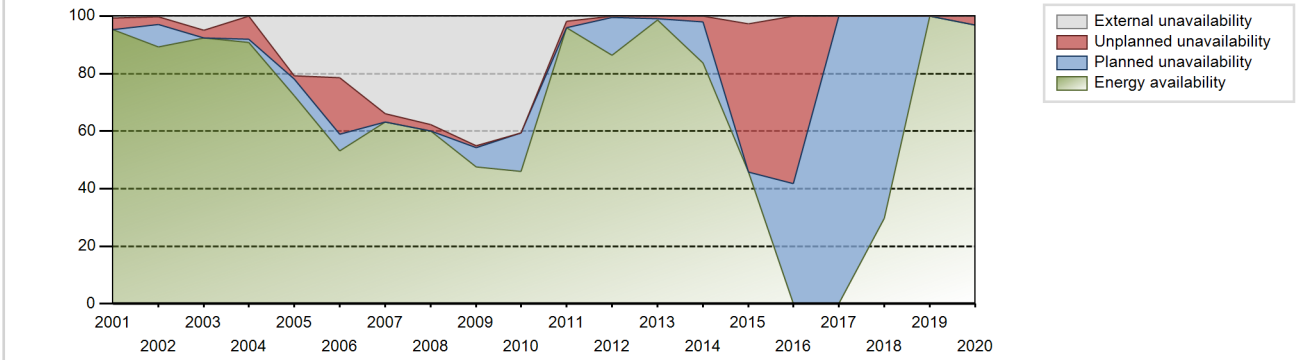
Electricity Production (net) [GWh]



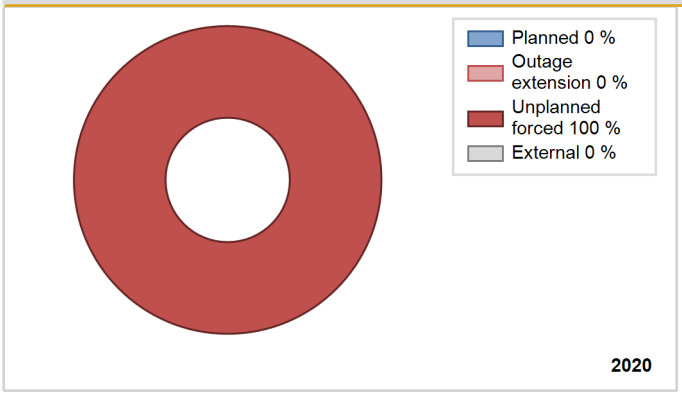
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1995	825.53	5401	196	88.25	91.95	79.29	85.83	1.15	1.07	6.98	3.70
1996	1326.81	7663	195	77.46	86.25	77.46	87.24	12.65	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

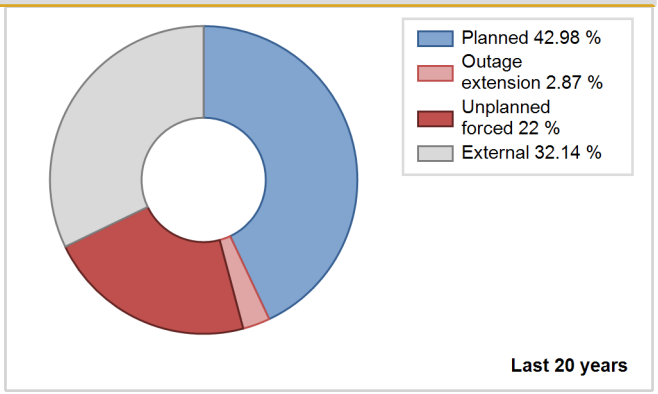
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1995 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		238			689	
D. Inspection, maintenance or repair without refuelling				335	29	
E. Testing of plant systems or components				6	14	
G. Major backfitting, refurbishment or upgrading activities without refuelling				741		
H. Nuclear regulatory requirements					35	
J. Grid limitation, failure or grid unavailability						20
L. Human factor related					6	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						2
Z. Other					3	
Subtotal		238		1082	776	22
Total		**238**			**1880**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1995 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		375
12. Reactor I&C Systems		41
13. Reactor Auxiliary Systems		6
14. Safety Systems		6
15. Reactor Cooling Systems		16
16. Steam generation systems		12
17. Safety I&C Systems (excluding reactor I&C)		21
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries	238	81
32. Feedwater and Main Steam System		51
35. All other I&C Systems		2
41. Main Generator Systems		42
42. Electrical Power Supply Systems		47
Total	**238**	**709**

Highlights (2020)

Unit had continuous operation of 647 days since its startup on 22 September 2018 after successful completion of EMCCR and EMFR.

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2020 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

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	:	2002-03-31
Grid Date	:	2013-10-22
Commercial Date	:	2014-12-31
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]	:	10
Part of the core refuelled [%]	:	30
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

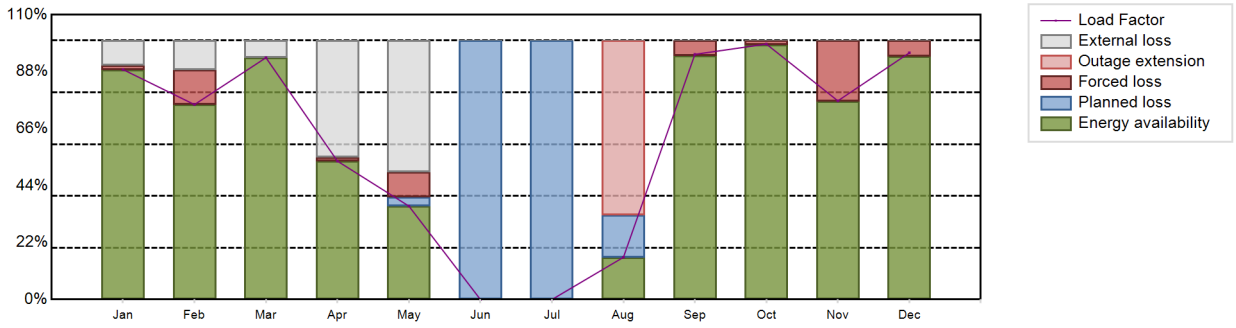
Operating coolant pressure [MPa]	:	2.7
Reactor outlet temperature [°C]	:	321
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	5.6
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4968.8 GW(e).h
Energy Availability Factor (EAF)	:	60.49 %
Unit Capability Factor (UCF)	:	70.74 %
Load Factor (LF)	:	60.69 %
Operating Factor (OF)	:	72.51 %

Forced Loss Rate (FLR)	:	6.86 %
Unplanned Capability Loss Factor (UCL)	:	10.92 %
Planned Unavailability Factor (PUF)	:	18.34 %
Externally cause unavailability (XUF)	:	10.25 %
Total off-line time	:	2415 hours

Annual Summary



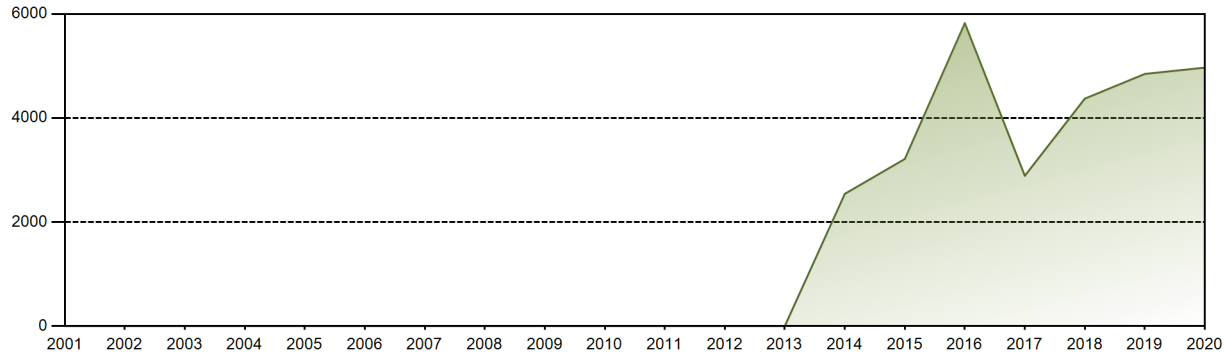
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	615.83	488.43	647.60	358.69	250.10	0.00	0.00	113.09	635.40	684.02	514.95	660.68	4968.80
EAF [%]	88.81	75.30	93.39	53.45	36.07	0.00	0.00	16.31	94.26	98.27	76.65	93.80	60.49
UCF [%]	98.30	86.59	100.00	98.42	86.92	0.00	0.00	16.31	94.26	98.27	76.65	93.80	70.74
LF [%]	88.81	75.30	93.39	53.45	36.07	0.00	0.00	16.31	94.69	98.65	76.74	95.28	60.69
OF [%]	98.79	87.50	100.00	98.47	87.10	0.00	0.00	25.94	100.00	100.00	78.61	94.22	72.51
FLR [%]	1.70	13.41	0.00	1.58	10.01	0.00	0.00	0.00	5.74	1.73	23.35	6.20	6.86
UCL [%]	1.70	13.41	0.00	1.58	9.67	0.00	0.00	67.35	5.74	1.73	23.35	6.20	10.92
PUF [%]	0.00	0.00	0.00	0.00	3.41	100.00	100.00	16.34	0.00	0.00	0.00	0.00	18.34
XUF [%]	9.49	11.29	6.61	44.96	50.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.25

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Historical Summary

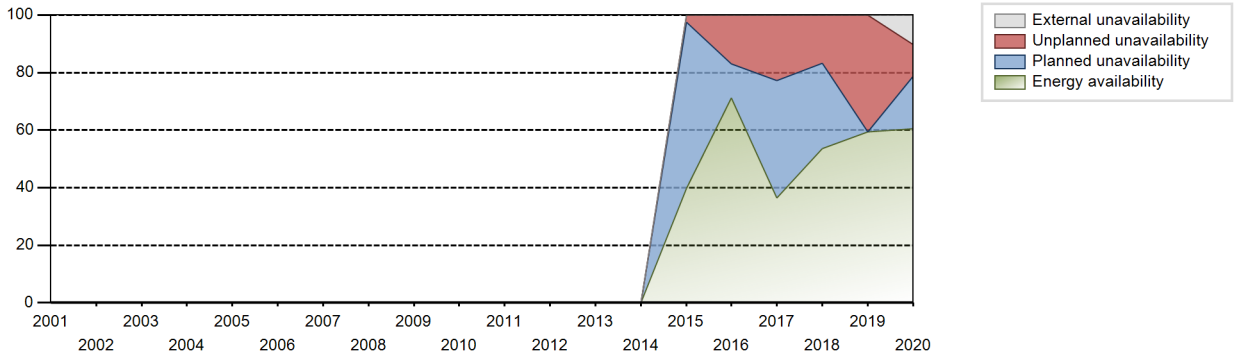
Lifetime energy generation	:	28657.36 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	24.03 %
Cumulative Energy Availability Factor (EAF)	:	53.55 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	18.43 %
Cumulative Unit Capability Factor (UCF)	:	55.27 %	Cumulative Planned Unavailability Factor (PUF)	:	26.3 %
Cumulative Load Factor (LF)	:	53.41 %	Cumulative Externally cause unavailability (XUF)	:	1.72 %
Cumulative Operating Factor (OF)	:	59.83 %			

Electricity Production (net) [GWh]

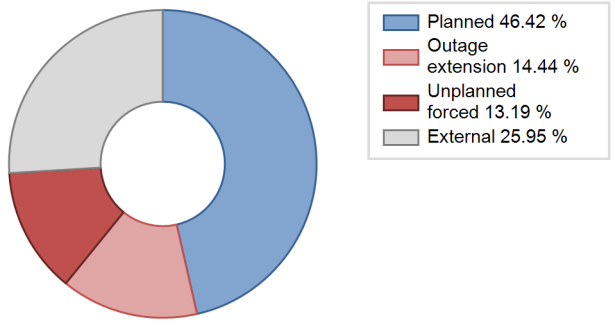


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2014	2542.23	4212	917	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2015	3212.83	3993	917	39.74	39.74	40.00	45.58	5.74	2.42	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

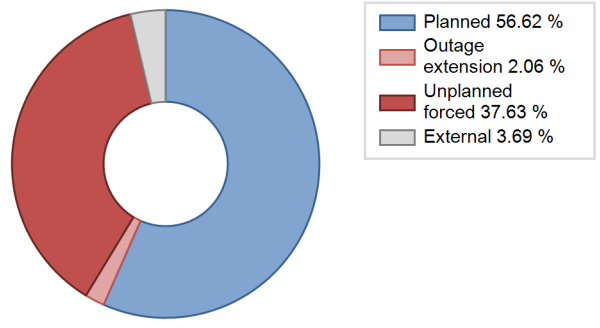
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2014 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		376			1312	
C. Inspection, maintenance or repair combined with refuelling	1572			2125		
E. Testing of plant systems or components				5		
Z. Other		467			78	
Subtotal	1572	843		2130	1390	
Total	**2415**			**3520**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2014 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems	80	13
15. Reactor Cooling Systems	68	11
16. Steam generation systems		1
31. Turbine and auxiliaries	169	821
32. Feedwater and Main Steam System	43	43
33. Circulating Water System	16	3
35. All other I&C Systems		27
41. Main Generator Systems		329
42. Electrical Power Supply Systems		63
Total	**376**	**1311**

Highlights (2020)

Unit achieved an annual availability factor and annual capacity factor of 72.42% and 61.73%, respectively.

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2020 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	:	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]	:	-
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

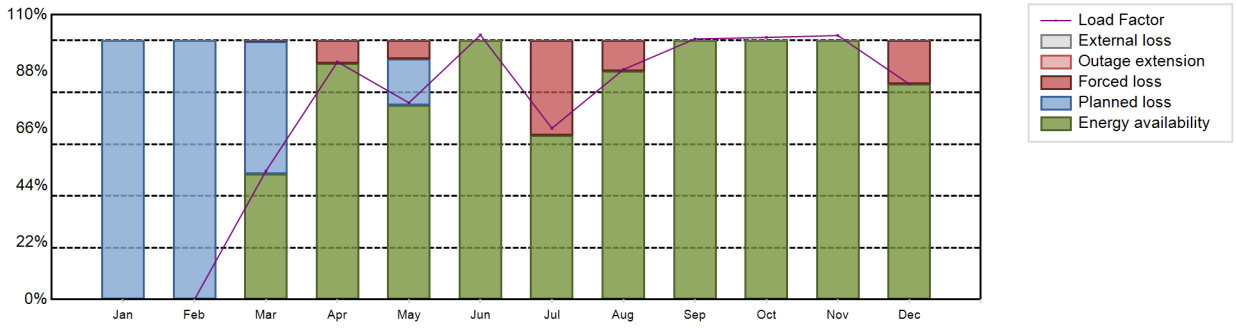
Operating coolant pressure [MPa]	:	1.27
Reactor outlet temperature [°C]	:	320.1
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	5.6
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP 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 (2020)

Net Energy Production	:	5885.37 GW(e).h
Energy Availability Factor (EAF)	:	70.9 %
Unit Capability Factor (UCF)	:	70.9 %
Load Factor (LF)	:	71.89 %
Operating Factor (OF)	:	73.38 %

Forced Loss Rate (FLR)	:	8.84 %
Unplanned Capability Loss Factor (UCL)	:	6.88 %
Planned Unavailability Factor (PUF)	:	22.23 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	2338 hours

Annual Summary



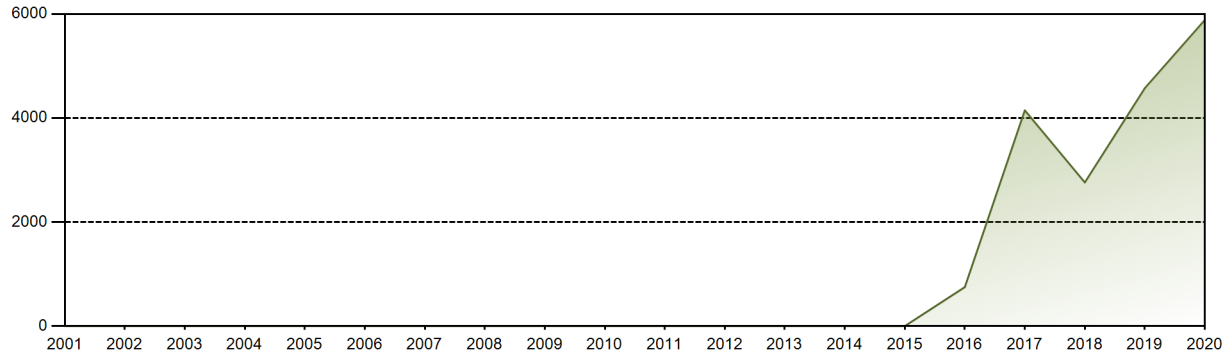
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	344.29	615.92	526.86	685.55	458.65	615.88	675.27	701.90	684.17	576.89	5885.37
EAF [%]	0.00	0.00	48.53	91.15	75.14	100.00	63.39	88.17	100.00	100.00	100.00	83.26	70.90
UCF [%]	0.00	0.00	48.53	91.15	75.14	100.00	63.39	88.17	100.00	100.00	100.00	83.26	70.90
LF [%]	0.00	0.00	49.65	91.79	75.98	102.16	66.14	88.82	100.63	101.22	101.96	83.20	71.89
OF [%]	0.00	0.00	53.76	100.00	84.41	100.00	65.86	90.46	100.00	100.00	100.00	84.81	73.38
FLR [%]	0.00	0.00	0.92	8.85	8.49	0.00	36.61	11.83	0.00	0.00	0.00	16.74	8.84
UCL [%]	0.00	0.00	0.45	8.85	6.97	0.00	36.61	11.83	0.00	0.00	0.00	16.74	6.88
PUF [%]	100.00	100.00	51.02	0.00	17.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.23
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

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Historical Summary

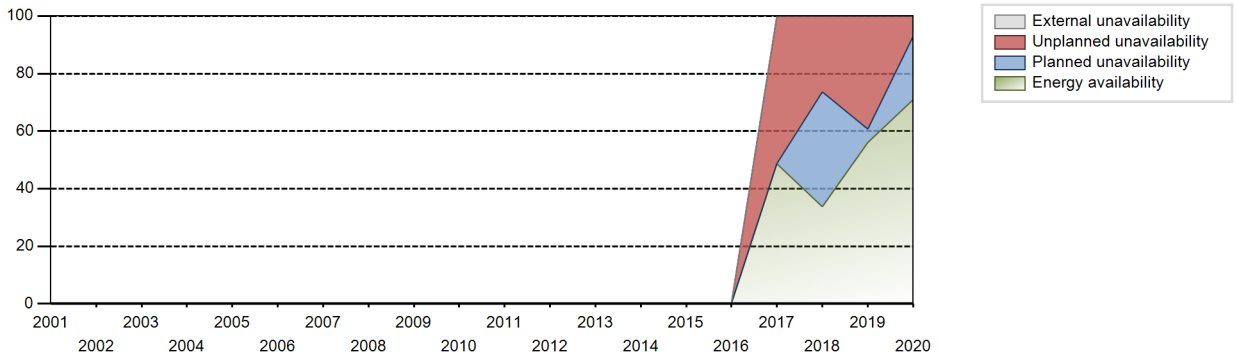
Lifetime energy generation	:	18122.84 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	36 %
Cumulative Energy Availability Factor (EAF)	:	52.63 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	29.6 %
Cumulative Unit Capability Factor (UCF)	:	52.63 %	Cumulative Planned Unavailability Factor (PUF)	:	17.77 %
Cumulative Load Factor (LF)	:	52.3 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	66.31 %			

Electricity Production (net) [GWh]

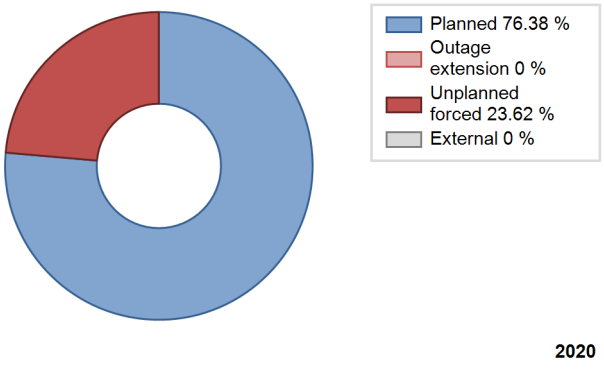


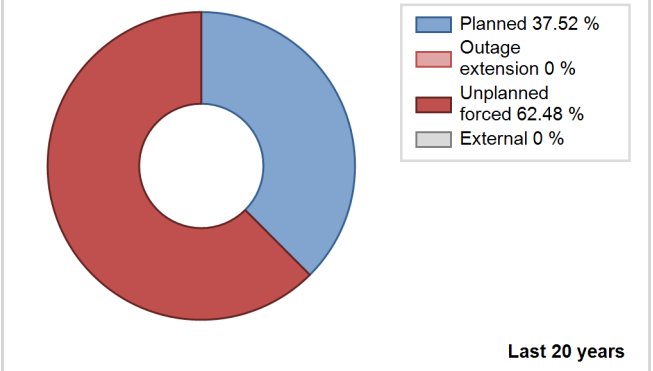
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2017	4147.80	4991	932	48.64	48.64	45.81	50.17	51.32	51.29	0.07	0.00
2018	2761.23	3846	932	33.82	33.82	33.82	43.90	43.78	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2017 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		438			1441	
C. Inspection, maintenance or repair combined with refuelling	1760			1485		
D. Inspection, maintenance or repair without refuelling	116			31		
Subtotal	1876	438		1516	1441	
Total	**2314**			**2957**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2017 to 2020
	Hours Lost	Average hours lost per reactor-year
15. Reactor Cooling Systems		103
31. Turbine and auxiliaries		50
32. Feedwater and Main Steam System	113	60
35. All other I&C Systems		30
41. Main Generator Systems	325	1109
Total	**438**	**1352**

Highlights (2020)

Unit achieved an annual availability factor and annual capacity factor of 73.38% and 72.08%, respectively.

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2020 Operating Experience

IN-5 MADRAS-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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	205 MWe

Key Dates

Construction Date	:	1971-01-01
Grid Date	:	1983-07-23
Commercial Date	:	1984-01-27
Age at end of year	:	37 years

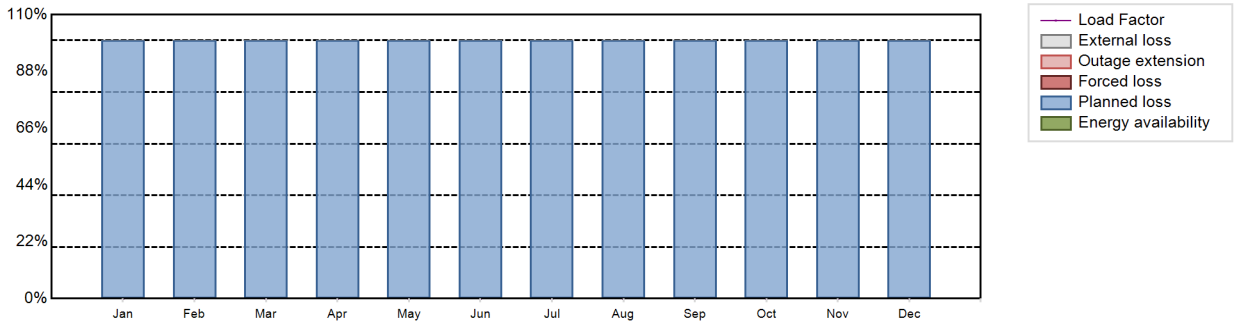
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	8.5
Reactor vessel centreline orientation	:	Horizontal	Reactor outlet temperature [°C]	:	293
Fuel material	:	UO2	Number of SG	:	8
Refuelling type	:	ON-line	Containment type	:	Confinement
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.16
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	:	-	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**	:	DS

Annual Production Results (2020)

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	:	8784 hours
Equivalent non-electrical energy generated (NEG)	:	0 GW(e).h			

Annual Summary



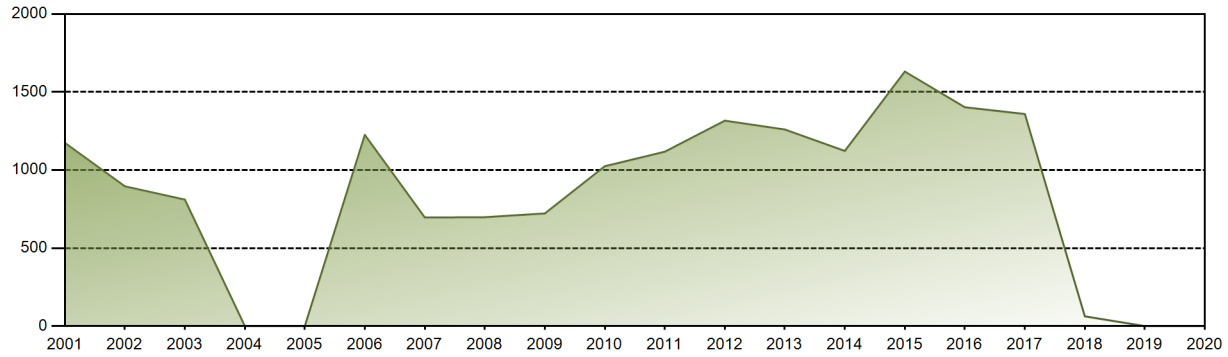
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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	:	31490.62 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	17.27 %
Cumulative Energy Availability Factor (EAF)	:	52.84 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.01 %
Cumulative Unit Capability Factor (UCF)	:	62.06 %	Cumulative Planned Unavailability Factor (PUF)	:	24.93 %
Cumulative Load Factor (LF)	:	49.65 %	Cumulative Externally cause unavailability (XUF)	:	9.23 %
Cumulative Operating Factor (OF)	:	63.85 %			

Electricity Production (net) [GWh]

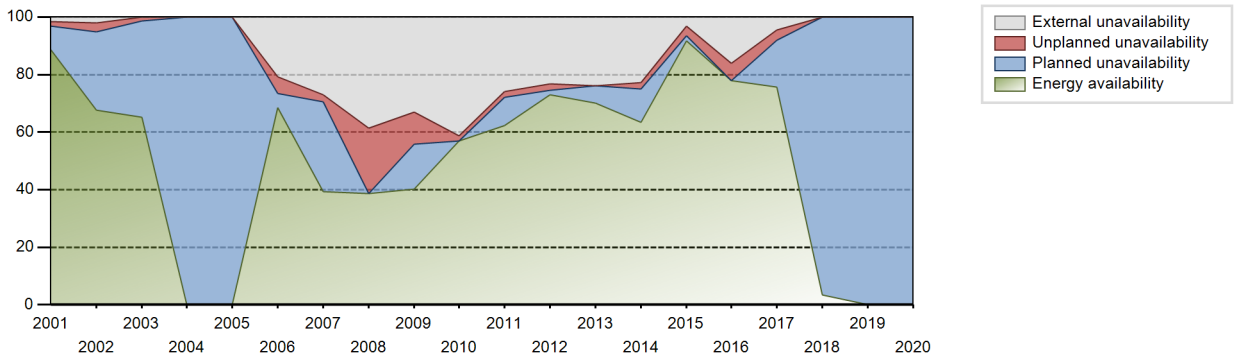


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	1115.82	6333	210	63.65	64.21	63.65	75.00	25.95	22.50	13.29	0.56
1985	822.08	4827	215	49.47	50.10	43.65	55.10	27.07	18.59	31.31	0.63
1986	757.12	4629	220	39.29	40.74	39.29	52.84	56.15	52.17	7.09	1.46
1987	1100.00	6047	220	57.08	61.02	57.08	69.03	23.72	18.98	20.00	3.94
1988	1258.00	6691	220	65.10	65.67	65.10	76.17	20.52	16.95	17.38	0.57
1989	404.57	4350	220	20.99	20.99	20.99	49.66	75.20	63.64	15.36	0.00
1990	863.72	7320	215	45.59	47.78	45.86	83.56	52.22	52.22	0.00	2.19
1991	499.90	3546	215	44.36	44.85	26.54	40.48	55.15	55.15	0.00	0.49
1992	1082.59	7412	194	84.55	87.29	63.53	84.38	12.71	12.71	0.00	2.73
1993	538.94	3836	194	43.91	46.34	31.71	43.79	20.00	11.59	42.07	2.43
1994	809.00	5974	194	66.56	72.52	47.60	68.20	13.63	11.45	16.03	5.96
1995	1085.16	7584	194	86.81	98.42	63.85	86.58	1.58	1.58	0.00	11.60
1996	617.15	4348	161	50.62	50.62	43.66	49.50	15.89	9.57	39.81	0.00
1997	893.02	6451	150	67.96	74.33	67.96	73.64	14.81	12.93	12.74	6.37
1998	703.44	4858	150	55.52	56.08	53.53	55.46	7.97	4.86	39.06	0.56
1999	1182.43	8095	150	92.47	92.47	89.99	92.41	7.53	7.53	0.00	0.00
2000	667.75	4468	150	50.89	50.89	50.68	50.87	12.64	7.36	41.74	0.00
2001	1174.49	7751	150	88.55	90.14	89.38	88.48	1.76	1.61	8.24	1.60
2002	895.76	5885	155	67.73	69.74	65.97	67.18	1.41	3.07	27.20	2.01
2003	810.57	5421	155	65.25	65.25	59.70	61.88	1.57	1.32	33.42	0.00
2004	0.00	0	155	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2005	0.00	0	155	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2006	1224.96	7823	185	68.57	89.30	70.18	89.30	6.08	5.78	4.92	20.74
2007	695.77	5814	205	39.29	66.38	38.74	66.37	3.48	2.39	31.23	27.08
2008	697.94	6791	205	38.76	77.31	38.76	77.31	22.69	22.69	0.00	38.56
2009	721.62	6404	205	40.18	73.10	40.18	73.11	13.25	11.17	15.73	32.92
2010	1024.38	8614	205	57.04	98.34	57.04	98.33	1.66	1.66	0.00	41.29

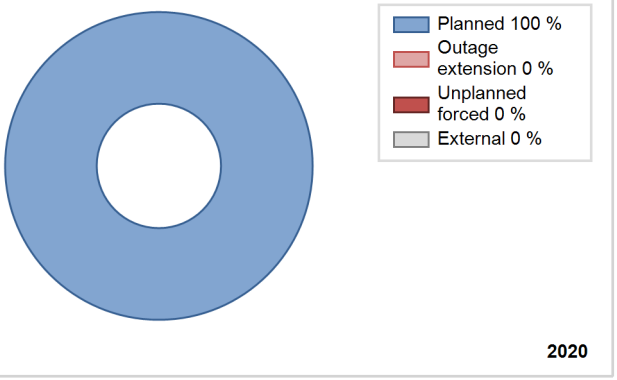
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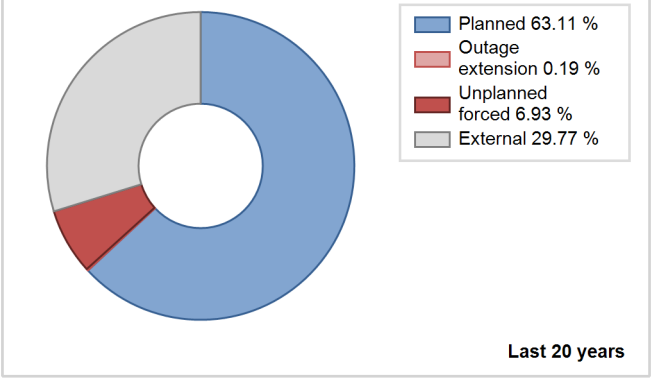
2011	1117.42	7655	205	62.22	88.19	62.22	87.39	2.09	1.89	9.92	25.97
2012	1316.32	8459	205	73.10	96.30	73.10	96.30	2.33	2.29	1.41	23.20
2013	1259.80	8231	205	70.15	93.96	70.15	93.96	0.00	0.00	6.04	23.81
2014	1122.29	7474	205	63.41	86.23	62.50	85.32	2.50	2.21	11.55	22.82
2015	1631.27	8312	205	91.71	94.89	90.84	94.89	3.38	3.32	1.78	3.19
2016	1402.44	8130	205	77.88	93.97	77.88	92.55	6.03	6.03	0.00	16.09
2017	1359.21	7025	205	75.69	80.17	75.69	80.19	4.35	3.64	16.18	4.49
2018	62.39	378	205	3.47	3.47	3.47	4.32	0.00	0.00	96.53	0.00
2019	0.00	0	205	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	205	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	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					710	
D. Inspection, maintenance or repair without refuelling	8784			1753		
E. Testing of plant systems or components				8	43	
F. Major backfitting, refurbishment or upgrading activities with refuelling				249		
G. Major backfitting, refurbishment or upgrading activities without refuelling				238		
J. Grid limitation, failure or grid unavailability						85
L. Human factor related					10	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						7
P. Fire					6	
Z. Other					5	
Subtotal	8784			2248	774	92
Total	**8784**			**3114**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		122
12. Reactor I&C Systems		62
13. Reactor Auxiliary Systems		20
15. Reactor Cooling Systems		61
16. Steam generation systems		24
17. Safety I&C Systems (excluding reactor I&C)		22
21. Fuel Handling and Storage Facilities		25
31. Turbine and auxiliaries		104
32. Feedwater and Main Steam System		42
33. Circulating Water System		5
34. Miscellaneous Systems		16
35. All other I&C Systems		1
41. Main Generator Systems		25
42. Electrical Power Supply Systems		247
Total		**776**

Highlights (2020)

Unit continued to remain shutdown throughout the year for investigation on the reasons for high D2O collection.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	205 MWe

Key Dates

Construction Date	:	1972-10-01
Grid Date	:	1985-09-20
Commercial Date	:	1986-03-21
Age at end of year	:	35 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	:	1
Coolant type	:	D2O

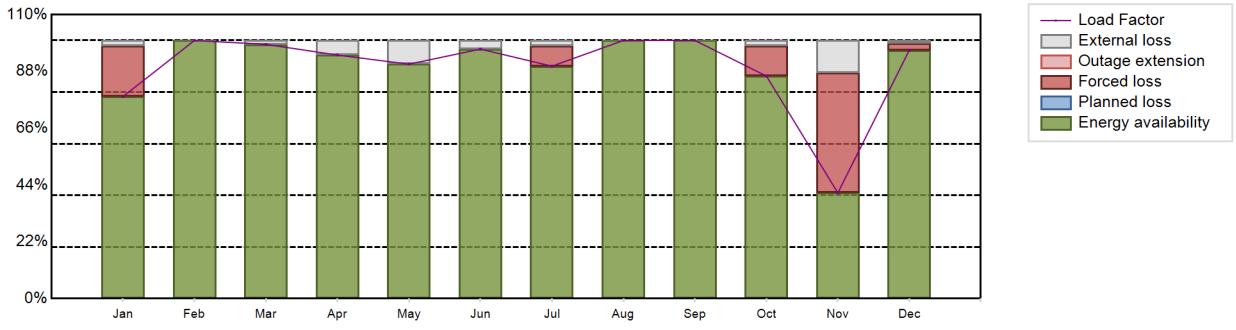
Operating coolant pressure [MPa]	:	8.5
Reactor outlet temperature [°C]	:	293
Number of SG	:	8
Containment type	:	Confinement
Containment design pressure [MPa]	:	1.16
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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	:	DS

Annual Production Results (2020)

Net Energy Production	:	1608.9 GW(e).h
Energy Availability Factor (EAF)	:	89.35 %
Unit Capability Factor (UCF)	:	92.68 %
Load Factor (LF)	:	89.35 %
Operating Factor (OF)	:	92.79 %
Equivalent non-electrical energy generated (NEG)	:	0 GW(e).h

Forced Loss Rate (FLR)	:	7.32 %
Unplanned Capability Loss Factor (UCL)	:	7.32 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	3.34 %
Total off-line time	:	633 hours

Annual Summary



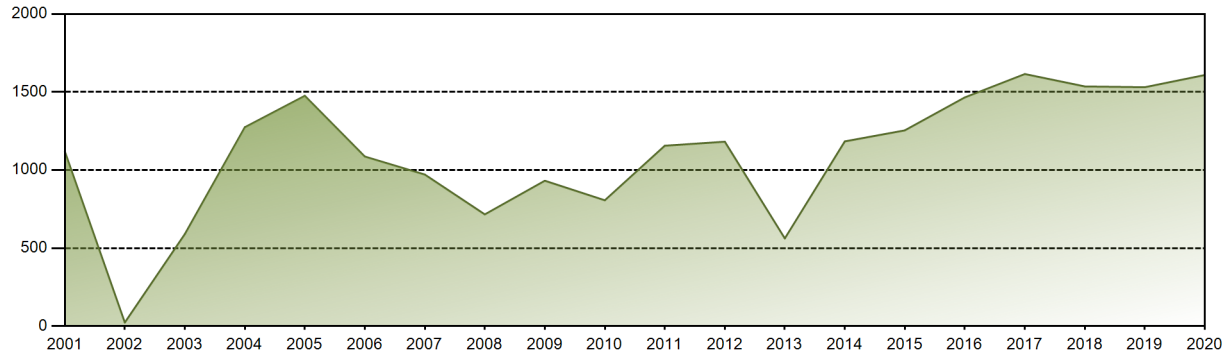
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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	119.35	142.68	150.22	139.25	138.51	142.66	137.33	152.52	147.60	131.50	60.47	146.80	1608.90
EAF [%]	78.25	100.00	98.49	94.34	90.82	96.66	90.04	100.00	100.00	86.22	40.97	96.25	89.35
UCF [%]	80.47	100.00	100.00	100.00	100.00	100.00	92.24	100.00	100.00	88.35	53.62	97.46	92.68
LF [%]	78.25	100.00	98.49	94.34	90.82	96.66	90.04	100.00	100.00	86.22	40.97	96.25	89.35
OF [%]	80.91	100.00	100.00	100.00	100.00	100.00	92.88	100.00	100.00	93.55	45.83	100.00	92.79
FLR [%]	19.53	0.00	0.00	0.00	0.00	0.00	7.76	0.00	0.00	11.65	46.38	2.54	7.32
UCL [%]	19.53	0.00	0.00	0.00	0.00	0.00	7.76	0.00	0.00	11.65	46.38	2.54	7.32
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 [%]	2.22	0.00	1.51	5.66	9.18	3.34	2.20	0.00	0.00	2.14	12.65	1.21	3.34

Historical Summary

Lifetime energy generation	:	35499.45 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	15.71 %
Cumulative Energy Availability Factor (EAF)	:	62.77 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.96 %
Cumulative Unit Capability Factor (UCF)	:	74.18 %	Cumulative Planned Unavailability Factor (PUF)	:	11.86 %
Cumulative Load Factor (LF)	:	60.35 %	Cumulative Externally cause unavailability (XUF)	:	11.41 %
Cumulative Operating Factor (OF)	:	75.94 %			

Electricity Production (net) [GWh]

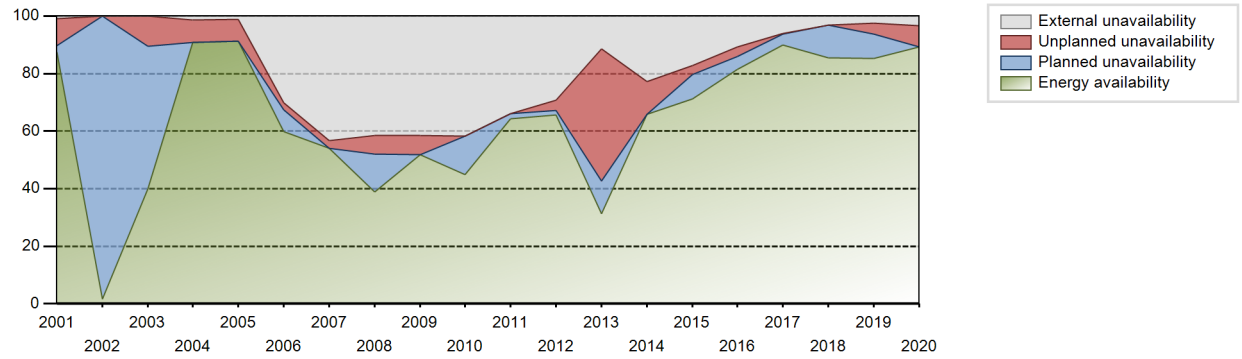


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	783.74	5303	220	36.50	36.50	36.50	56.27	63.49	63.49	0.01	0.00
1987	1066.00	6382	220	55.47	62.45	55.31	72.85	32.66	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

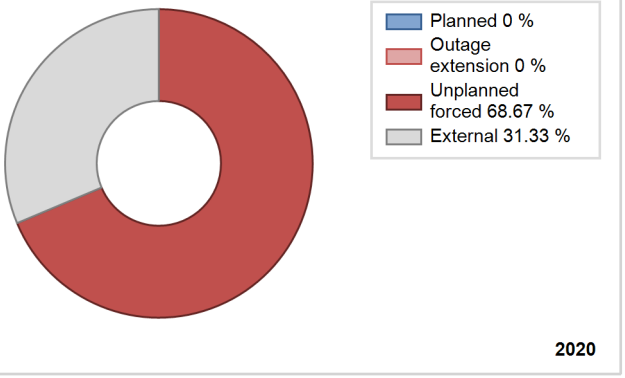
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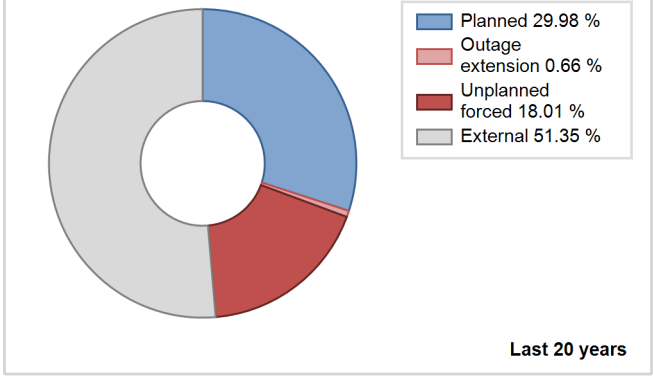
2013	561.74	3735	205	31.28	42.64	31.28	42.64	51.93	46.06	11.30	11.36
2014	1183.61	7755	205	65.91	88.66	65.91	88.53	11.34	11.34	0.00	22.75
2015	1254.20	7739	205	71.13	88.34	69.84	88.34	3.45	3.15	8.50	17.21
2016	1465.58	7865	205	81.39	92.09	81.39	89.54	3.45	3.29	4.62	10.70
2017	1615.20	8400	205	89.94	95.89	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		633			811	
D. Inspection, maintenance or repair without refuelling				693		
E. Testing of plant systems or components				41	6	
J. Grid limitation, failure or grid unavailability						75
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
P. Fire					4	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				388		
Z. Other					8	
Subtotal		633		1122	836	82
Total		**633**			**2040**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		179
12. Reactor I&C Systems	53	45
13. Reactor Auxiliary Systems		11
14. Safety Systems		3
15. Reactor Cooling Systems	142	118
16. Steam generation systems		56
17. Safety I&C Systems (excluding reactor I&C)		10
21. Fuel Handling and Storage Facilities		63
31. Turbine and auxiliaries		98
32. Feedwater and Main Steam System	231	28
33. Circulating Water System		7
34. Miscellaneous Systems		9
35. All other I&C Systems		2
41. Main Generator Systems		36
42. Electrical Power Supply Systems	207	163
Total	**633**	**828**

Highlights (2020)

Unit had 100% availability factor for 8 months (February to June, August, September and December 2020.)

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	1976-12-01
Grid Date	:	1989-07-29
Commercial Date	:	1991-01-01
Age at end of year	:	31 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]	:	15000
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	:	4
Number of external reactor coolant loops	:	2
Coolant type	:	D2O

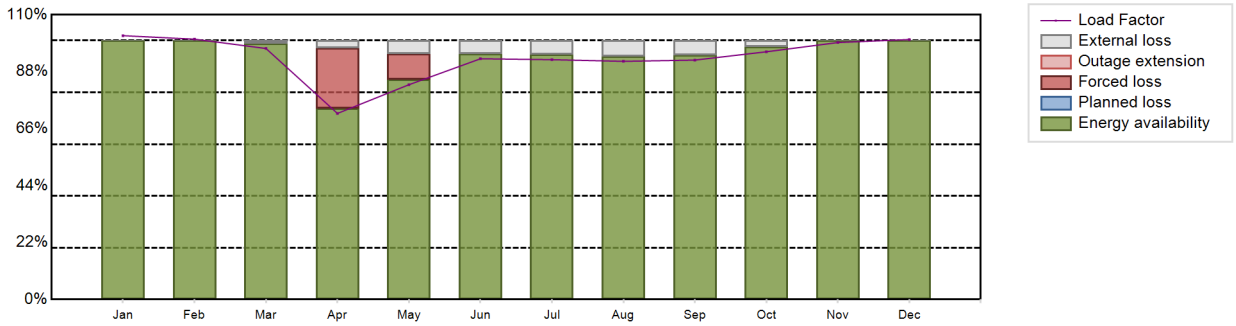
Operating coolant pressure [MPa]	:	8.7
Reactor outlet temperature [°C]	:	293.4
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	1.25
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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 (2020)

Net Energy Production	:	1655.65 GW(e).h
Energy Availability Factor (EAF)	:	94.46 %
Unit Capability Factor (UCF)	:	97.23 %
Load Factor (LF)	:	93.31 %
Operating Factor (OF)	:	97.26 %

Forced Loss Rate (FLR)	:	2.77 %
Unplanned Capability Loss Factor (UCL)	:	2.77 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	2.78 %
Total off-line time	:	241 hours

Annual Summary



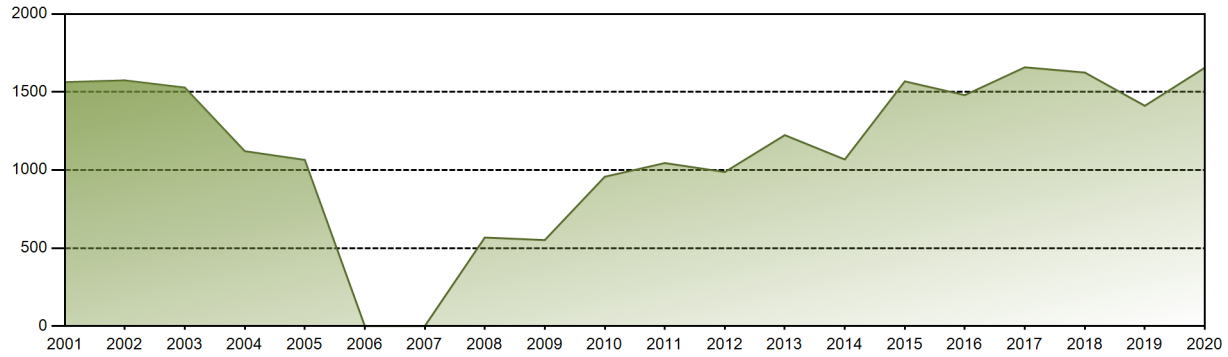
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	153.15	141.37	145.71	104.52	124.68	135.23	139.20	138.25	134.49	143.80	144.35	150.90	1655.65
EAF [%]	100.00	100.00	98.93	73.85	84.94	94.96	94.60	93.97	94.45	97.66	100.00	100.00	94.46
UCF [%]	100.00	100.00	100.00	76.61	89.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.23
LF [%]	101.90	100.55	96.95	71.87	82.96	92.98	92.62	91.99	92.47	95.68	99.25	100.41	93.31
OF [%]	100.00	100.00	100.00	76.53	90.32	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.26
FLR [%]	0.00	0.00	0.00	23.39	10.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77
UCL [%]	0.00	0.00	0.00	23.39	10.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77
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	1.07	2.76	5.04	5.04	5.40	6.03	5.55	2.34	0.00	0.00	2.78

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Historical Summary

Lifetime energy generation	:	32108.83 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	8.95 %
Cumulative Energy Availability Factor (EAF)	:	62.51 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.53 %
Cumulative Unit Capability Factor (UCF)	:	73.47 %	Cumulative Planned Unavailability Factor (PUF)	:	19 %
Cumulative Load Factor (LF)	:	60.11 %	Cumulative Externally cause unavailability (XUF)	:	10.97 %
Cumulative Operating Factor (OF)	:	73.59 %			

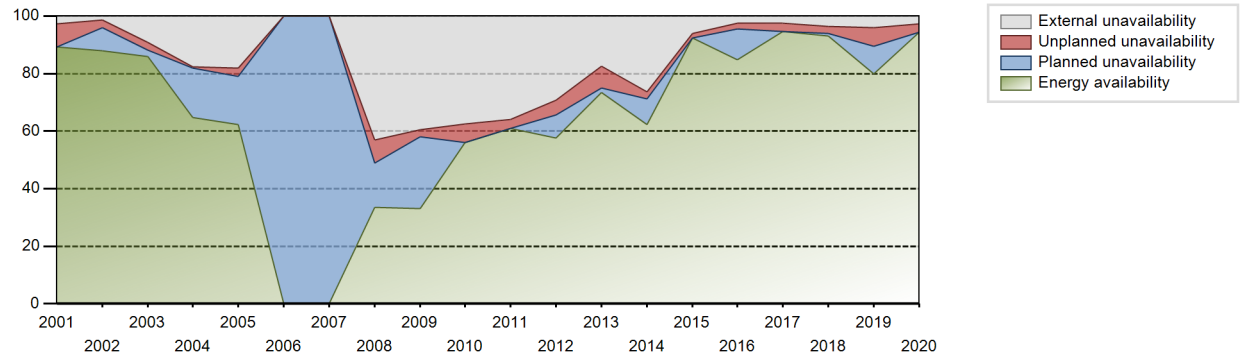
Electricity Production (net) [GWh]



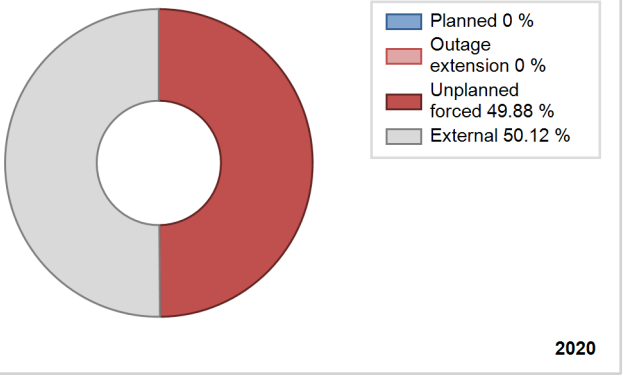
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1991	449.26	4331	210	42.32	42.80	24.42	49.44	36.61	24.72	32.49	0.48
1992	742.66	5514	200	42.27	42.77	42.27	62.77	57.23	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

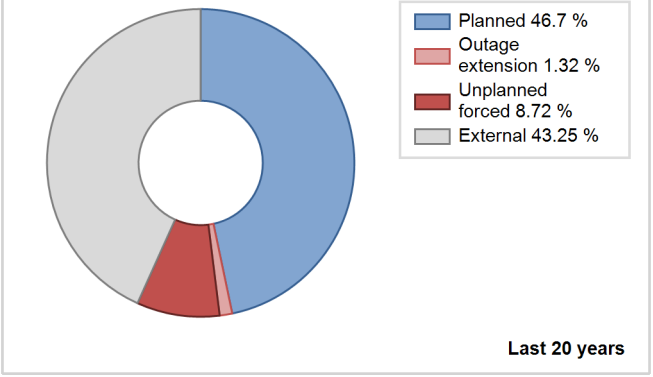
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1991 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		239			705	
C. Inspection, maintenance or repair combined with refuelling				66		
D. Inspection, maintenance or repair without refuelling				591	21	
E. Testing of plant systems or components				16	15	
F. Major backfitting, refurbishment or upgrading activities with refuelling				93		
G. Major backfitting, refurbishment or upgrading activities without refuelling				584		
H. Nuclear regulatory requirements				68	7	
J. Grid limitation, failure or grid unavailability						57
L. Human factor related					5	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						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.)						21
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				28	12	
Z. Other		2			3	2
Subtotal		241		1446	768	88
Total		**241**			**2302**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1991 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		43
12. Reactor I&C Systems		55
13. Reactor Auxiliary Systems		18
15. Reactor Cooling Systems	72	108
16. Steam generation systems		9
17. Safety I&C Systems (excluding reactor I&C)		20
21. Fuel Handling and Storage Facilities		31
31. Turbine and auxiliaries		304
32. Feedwater and Main Steam System		15
33. Circulating Water System		10
34. Miscellaneous Systems		9
41. Main Generator Systems	2	74
42. Electrical Power Supply Systems	167	86
Total	**241**	**782**

Highlights (2020)

Unit achieved an annual availability factor and annual capacity factor of 97.26% and 94.83%, respectively. It operated continuously for 413 days from 24 February 2019 to 12 April 2020.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	1977-11-01
Grid Date	:	1992-01-05
Commercial Date	:	1992-07-01
Age at end of year	:	28 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]	:	15000
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	:	4
Number of external reactor coolant loops	:	2
Coolant type	:	D2O

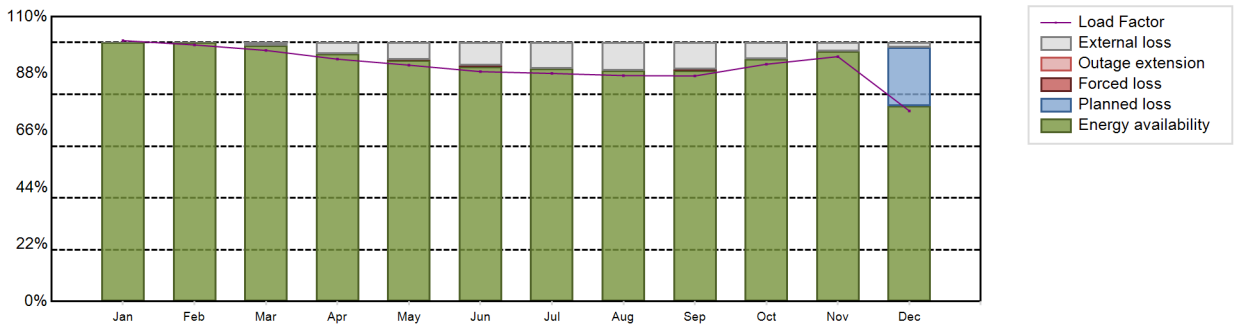
Operating coolant pressure [MPa]	:	8.7
Reactor outlet temperature [°C]	:	293.4
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	1.25
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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 (2020)

Net Energy Production	:	1615.02 GW(e).h
Energy Availability Factor (EAF)	:	92.68 %
Unit Capability Factor (UCF)	:	97.97 %
Load Factor (LF)	:	91.02 %
Operating Factor (OF)	:	98.05 %

Forced Loss Rate (FLR)	:	0.12 %
Unplanned Capability Loss Factor (UCL)	:	0.12 %
Planned Unavailability Factor (PUF)	:	1.91 %
Externally cause unavailability (XUF)	:	5.29 %
Total off-line time	:	171 hours

Annual Summary



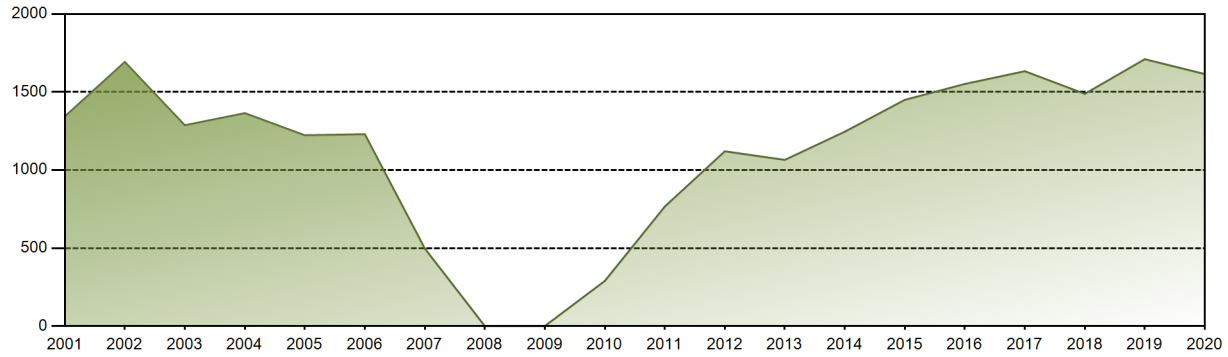
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	151.42	139.31	145.74	136.13	137.19	129.12	132.37	131.13	126.69	137.72	137.56	110.62	1615.02
EAF [%]	100.00	100.00	98.96	95.58	93.26	90.76	90.06	89.24	89.09	93.62	96.56	75.59	92.68
UCF [%]	100.00	100.00	100.00	100.00	99.75	99.54	100.00	100.00	99.28	100.00	100.00	77.47	97.97
LF [%]	100.76	99.09	96.98	93.60	91.28	88.78	88.08	87.26	87.11	91.64	94.58	73.61	91.02
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	77.02	98.05
FLR [%]	0.00	0.00	0.00	0.00	0.25	0.46	0.00	0.00	0.72	0.00	0.00	0.00	0.12
UCL [%]	0.00	0.00	0.00	0.00	0.25	0.46	0.00	0.00	0.72	0.00	0.00	0.00	0.12
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.53	1.91
XUF [%]	0.00	0.00	1.04	4.42	6.48	8.78	9.94	10.76	10.20	6.38	3.44	1.89	5.29

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Historical Summary

Lifetime energy generation	:	31922.36 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.9 %
Cumulative Energy Availability Factor (EAF)	:	64.69 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.54 %
Cumulative Unit Capability Factor (UCF)	:	74.9 %	Cumulative Planned Unavailability Factor (PUF)	:	18.56 %
Cumulative Load Factor (LF)	:	63.44 %	Cumulative Externally cause unavailability (XUF)	:	10.21 %
Cumulative Operating Factor (OF)	:	75.09 %			

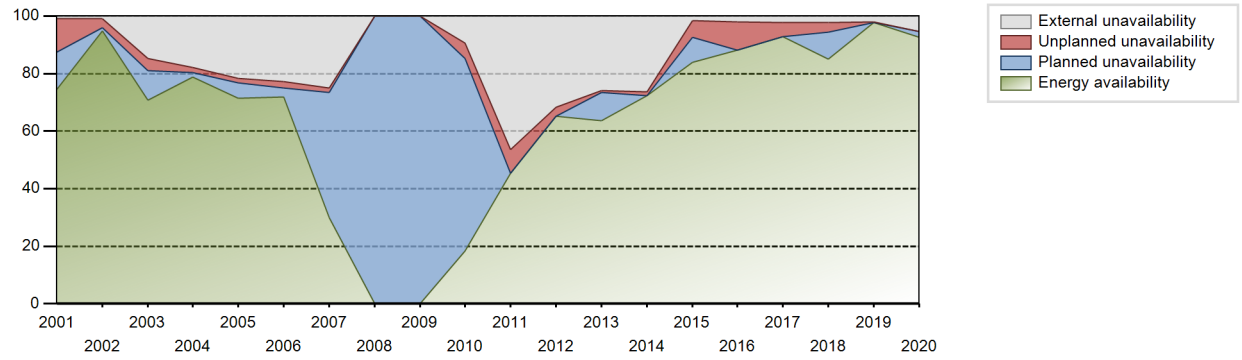
Electricity Production (net) [GWh]



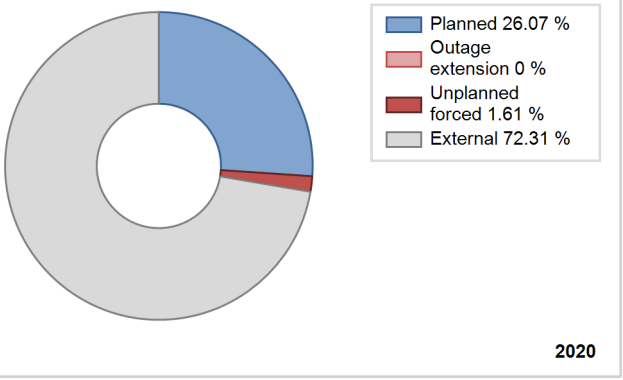
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1992	567.04	3553	201	64.20	65.16	64.20	80.46	34.83	34.83	0.00	0.96
1993	83.31	548	200	4.85	4.85	4.76	6.26	60.06	7.29	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

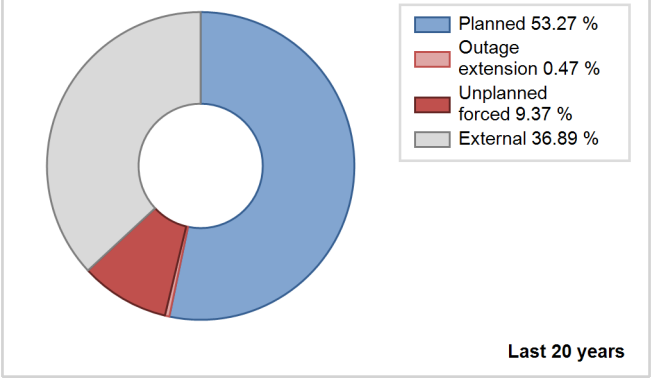
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1992 to 2020		
	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				45		
D. Inspection, maintenance or repair without refuelling	171			689	10	
E. Testing of plant systems or components				16	14	
F. Major backfitting, refurbishment or upgrading activities with refuelling				836		
H. Nuclear regulatory requirements					16	
J. Grid limitation, failure or grid unavailability						62
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						4
L. Human factor related					6	
P. Fire					16	
Z. Other					42	
Subtotal	171			1586	489	66
Total	**171**			**2141**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1992 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		30
12. Reactor I&C Systems		50
13. Reactor Auxiliary Systems		3
14. Safety Systems		2
15. Reactor Cooling Systems		35
16. Steam generation systems		21
17. Safety I&C Systems (excluding reactor I&C)		8
21. Fuel Handling and Storage Facilities		20
31. Turbine and auxiliaries		125
32. Feedwater and Main Steam System		16
33. Circulating Water System		2
34. Miscellaneous Systems		16
41. Main Generator Systems		23
42. Electrical Power Supply Systems		88
Total		**439**

Highlights (2020)

Unit achieved an annual availability factor and annual capacity factor of 98.05% and 93.15%, respectively. Unit completed continuous operation of 852 days from 25 August 2018 to 24 December 2020.

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2020 Operating Experience

IN-3 RAJASTHAN-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	:	AECL (ATOMIC ENERGY OF CANADA, LTD.)
Turbine Supplier	:	EE (THE ENGLISH ELECTRIC CO., LTD.)

Reactor Unit Details

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	346 MWth
Gross electrical power	:	100 MWe
Reference unit power (net)	:	90 MWe

Key Dates

Construction Date	:	1965-08-01
Grid Date	:	1972-11-30
Commercial Date	:	1973-12-16
Age at end of year	:	48 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

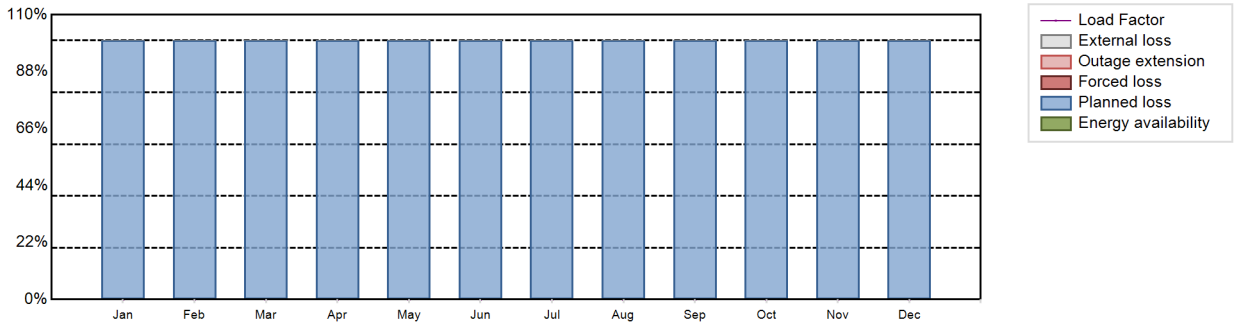
Operating coolant pressure [MPa]	:	11.6
Reactor outlet temperature [°C]	:	304
Number of SG	:	8
Containment type	:	-
Containment design pressure [MPa]	:	1.44
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	PH

Annual Production Results (2020)

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 %
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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



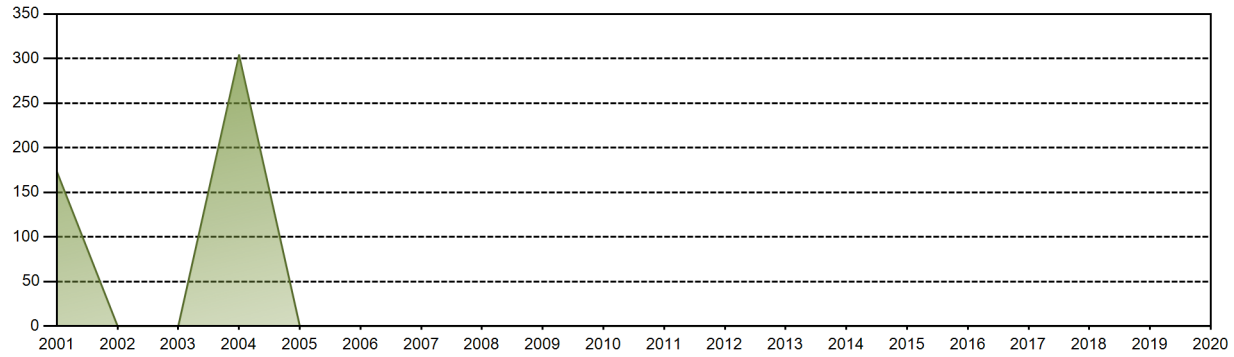
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	10138.38 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	63.03 %
Cumulative Energy Availability Factor (EAF)	:	20.18 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	35.79 %
Cumulative Unit Capability Factor (UCF)	:	20.99 %	Cumulative Planned Unavailability Factor (PUF)	:	43.22 %
Cumulative Load Factor (LF)	:	17.4 %	Cumulative Externally cause unavailability (XUF)	:	0.81 %
Cumulative Operating Factor (OF)	:	21.5 %			

Electricity Production (net) [GWh]

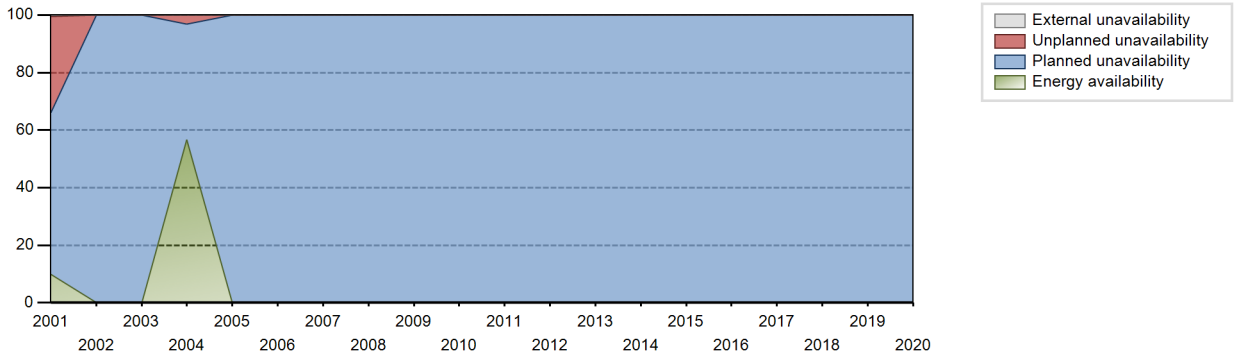


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	218.40	2855	145	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	667.60	4690	207	36.81	36.81	36.82	53.54	63.19	63.19	0.00	0.00
1975	599.70	3817	206	33.22	33.22	33.23	43.57	55.75	41.85	24.93	0.00
1976	801.90	5728	206	44.32	44.32	44.32	65.21	55.68	55.68	0.00	0.00
1977	456.90	3312	206	26.41	26.41	25.32	37.81	60.22	39.98	33.61	0.00
1978	153.20	1537	206	8.49	8.49	8.49	17.55	91.51	91.51	0.00	0.00
1979	1147.30	7217	206	63.58	63.58	63.58	82.39	34.19	33.04	3.38	0.00
1980	953.10	6346	206	52.68	52.68	52.67	72.24	44.46	42.17	5.16	0.00
1981	441.50	3732	220	22.90	22.90	22.91	42.60	54.43	27.36	49.75	0.00
1982	38.20	496	206	2.11	2.11	2.12	5.66	97.71	90.25	7.63	0.00
1983	0.00	0	202	0.01	0.01	0.00	0.00	99.99	99.99	0.00	0.00
1984	0.00	0	180	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00
1985	226.25	1914	204	12.66	12.66	12.66	21.85	87.34	87.34	0.00	0.00
1986	0.00	0	207	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1987	169.85	2555	207	9.37	16.59	9.37	29.17	82.09	76.02	7.38	7.22
1988	376.48	5793	207	20.71	25.34	20.71	65.95	72.30	66.15	8.51	4.63
1989	312.82	4779	207	17.25	18.72	17.25	54.55	74.93	55.94	25.34	1.47
1990	364.06	5789	192	19.43	22.32	21.65	66.08	59.87	33.29	44.40	2.88
1991	197.54	2858	192	74.78	74.78	11.74	32.63	3.96	3.08	22.14	0.00
1992	57.68	1070	84	12.19	12.19	7.82	12.18	86.85	80.49	7.32	0.00
1993	167.63	2435	84	22.78	22.78	22.78	27.80	72.17	59.07	18.15	0.00
1994	2.91	195	84	2.22	2.22	0.40	2.23	81.05	9.50	88.29	0.00
1995	0.00	0	84	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1996	0.00	0	84	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1997	264.64	2792	84	31.91	39.15	35.97	31.88	48.15	36.36	24.49	7.24
1998	567.36	5448	134	62.19	63.81	48.33	62.19	36.19	36.19	0.00	1.62
1999	795.02	6443	134	73.59	81.02	67.73	73.55	14.44	13.68	5.31	7.42
2000	681.33	5008	134	57.01	57.54	57.88	57.01	14.05	9.41	33.05	0.54
2001	173.19	860	134	9.98	10.46	14.75	9.82	76.18	33.44	56.10	0.48
2002	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2003	0.00	0	134	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2004	303.83	3785	134	56.77	56.77	25.81	43.09	5.28	3.16	40.07	0.00
2005	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2006	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2007	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2008	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

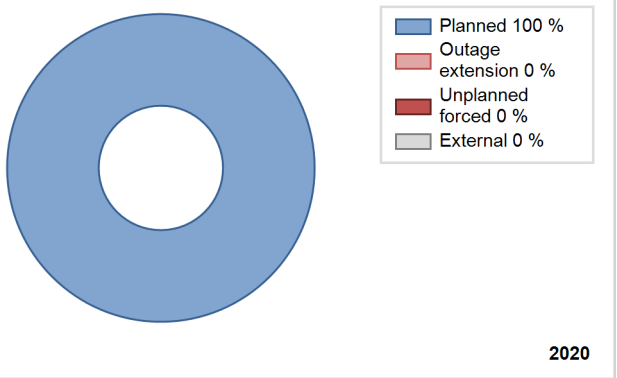
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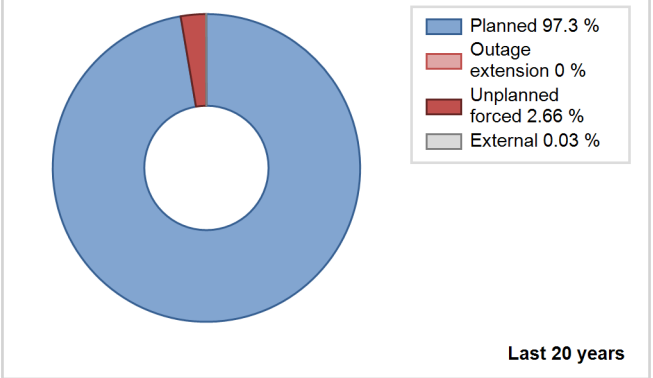
2010	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2011	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2012	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	90	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	90	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		2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					1724	
D.	Inspection, maintenance or repair without refuelling				1999		
E.	Testing of plant systems or components					5	
G.	Major backfitting, refurbishment or upgrading activities without refuelling				995		
J.	Grid limitation, failure or grid unavailability						84
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						2
L.	Human factor related					26	
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.)						34
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				6	15	
Z.	Other	8784			2056		
Subtotal		8784			5056	1770	120
Total		**8784**			**6946**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		735
12. Reactor I&C Systems		118
13. Reactor Auxiliary Systems		38
14. Safety Systems		22
15. Reactor Cooling Systems		297
16. Steam generation systems		5
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		11
31. Turbine and auxiliaries		318
32. Feedwater and Main Steam System		8
34. Miscellaneous Systems		5
41. Main Generator Systems		68
42. Electrical Power Supply Systems		80
Total		**1706**

Highlights (2020)

Unit continued to remain shutdown. Reactor core does not have any fuel.

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2020 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	:	40 years

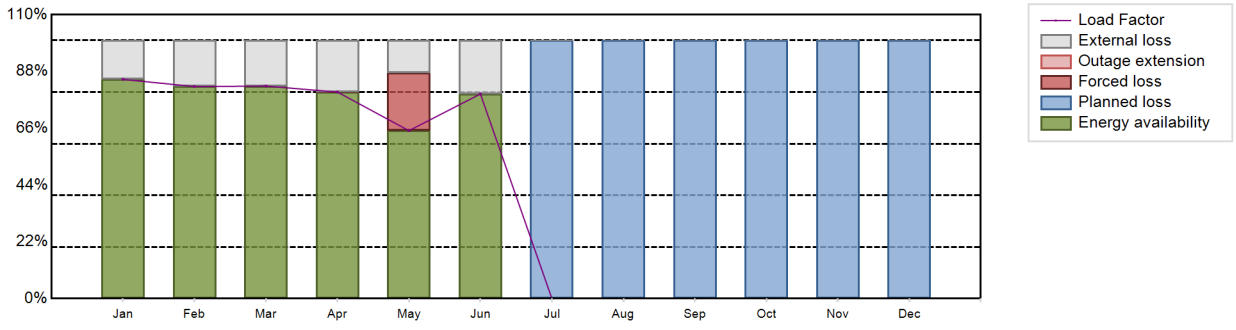
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	11.6
Reactor vessel centreline orientation	:	Horizontal	Reactor outlet temperature [°C]	:	304
Fuel material	:	UO2	Number of SG	:	8
Refuelling type	:	ON-line	Containment type	:	Confinement
Moderator material	:	D2O	Containment design pressure [MPa]	:	1.44
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]	:	4.1
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	:	-	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**	:	PH

Annual Production Results (2020)

Net Energy Production	:	644.59 GW(e).h	Forced Loss Rate (FLR)	:	3.83 %
Energy Availability Factor (EAF)	:	39.24 %	Unplanned Capability Loss Factor (UCL)	:	1.9 %
Unit Capability Factor (UCF)	:	47.83 %	Planned Unavailability Factor (PUF)	:	50.27 %
Load Factor (LF)	:	39.24 %	Externally cause unavailability (XUF)	:	8.58 %
Operating Factor (OF)	:	47.83 %	Total off-line time	:	4583 hours
Equivalent non-electrical energy generated (NEG)	:	12.21 GW(e).h			

Annual Summary



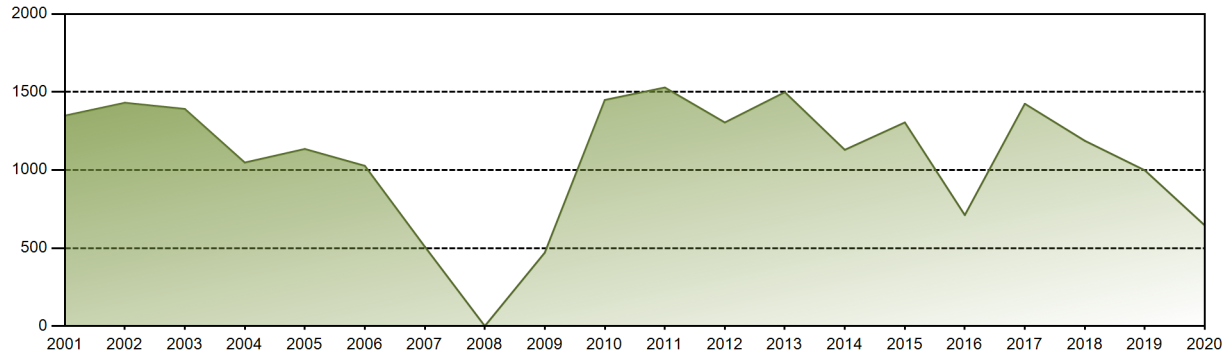
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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	118.15	106.91	114.54	107.74	90.53	106.73	0.00	0.00	0.00	0.00	0.00	0.00	644.59
EAF [%]	84.92	82.14	82.32	80.00	65.07	79.27	0.03	0.00	0.00	0.00	0.00	0.00	39.24
UCF [%]	100.00	100.00	100.00	99.98	77.55	100.00	0.03	0.00	0.00	0.00	0.00	0.00	47.83
LF [%]	84.92	82.14	82.32	80.02	65.07	79.27	0.00	0.00	0.00	0.00	0.00	0.00	39.24
OF [%]	100.00	100.00	100.00	100.00	77.55	100.00	0.00	0.00	0.00	0.00	0.00	0.00	47.83
FLR [%]	0.00	0.00	0.00	0.02	22.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.83
UCL [%]	0.00	0.00	0.00	0.02	22.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	99.97	100.00	100.00	100.00	100.00	100.00	50.27
XUF [%]	15.08	17.86	17.68	19.98	12.48	20.73	0.01	0.00	0.00	0.00	0.00	0.00	8.58

Historical Summary

Lifetime energy generation	:	35651.75 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	18.67 %
Cumulative Energy Availability Factor (EAF)	:	59.21 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	14.41 %
Cumulative Unit Capability Factor (UCF)	:	62.64 %	Cumulative Planned Unavailability Factor (PUF)	:	22.95 %
Cumulative Load Factor (LF)	:	56.41 %	Cumulative Externally cause unavailability (XUF)	:	3.43 %
Cumulative Operating Factor (OF)	:	66.28 %			

Electricity Production (net) [GWh]

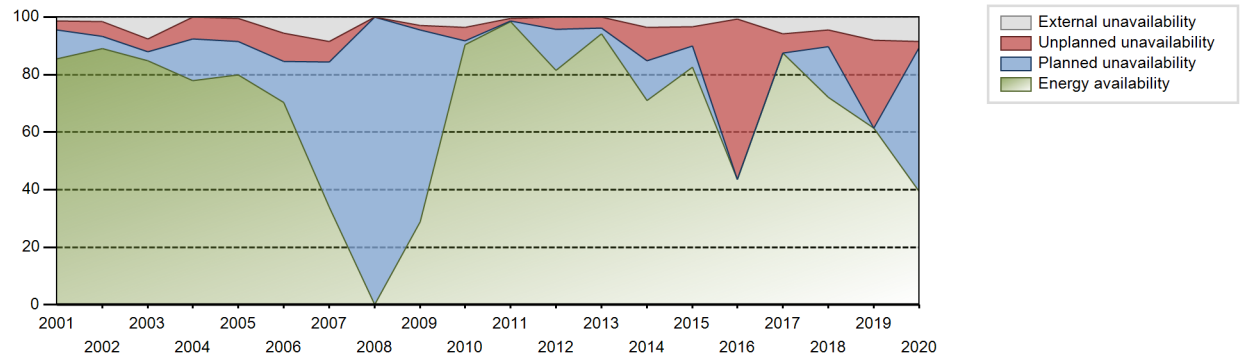


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	686.00	7068	220	38.37	38.37	38.01	80.55	33.17	19.05	42.58	0.00
1982	372.90	3651	206	20.67	20.67	20.66	41.68	79.33	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

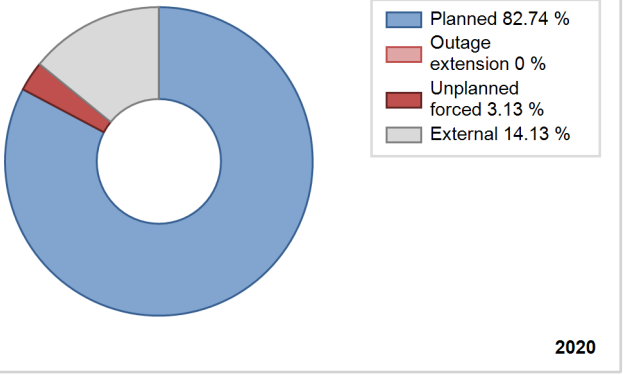
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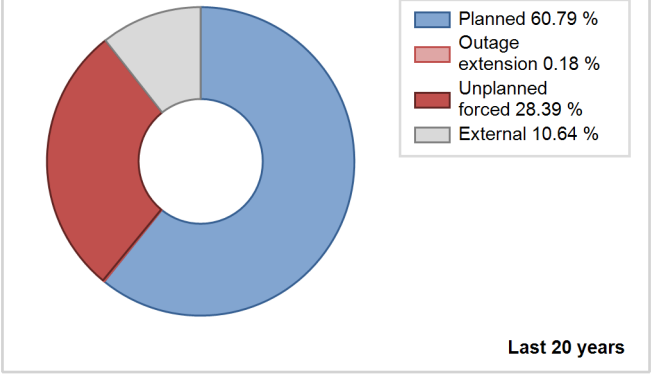
2008	0.00	0	187	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	470.72	2795	187	28.74	31.73	28.74	31.91	4.49	1.49	66.77	3.00
2010	1449.01	8286	187	90.47	94.16	88.46	94.59	4.56	4.50	1.34	3.69
2011	1528.78	8518	187	98.34	98.92	93.33	97.24	0.75	0.75	0.33	0.58
2012	1304.66	7265	187	81.50	81.50	79.43	82.71	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		167			854	
C.	Inspection, maintenance or repair combined with refuelling				111		
D.	Inspection, maintenance or repair without refuelling	4415			1307	2	
E.	Testing of plant systems or components					10	
G.	Major backfitting, refurbishment or upgrading activities without refuelling				479		
H.	Nuclear regulatory requirements					3	
J.	Grid limitation, failure or grid unavailability						134
L.	Human factor related					9	
P.	Fire					8	
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						11
Z.	Other				34	29	2
Subtotal		4415	167		1931	915	147
Total		**4582**			**2993**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		60
12. Reactor I&C Systems		130
13. Reactor Auxiliary Systems	167	26
14. Safety Systems		19
15. Reactor Cooling Systems		149
16. Steam generation systems		97
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		10
31. Turbine and auxiliaries		191
32. Feedwater and Main Steam System		71
33. Circulating Water System		2
34. Miscellaneous Systems		8
35. All other I&C Systems		12
41. Main Generator Systems		50
42. Electrical Power Supply Systems		54
Total	**167**	**880**

Highlights (2020)

In July 2020, unit was shutdown for Biennial Shutdown. In this BSD replacement of boiler hairpin heatexchangers was taken up.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	1990-02-01
Grid Date	:	2000-03-10
Commercial Date	:	2000-06-01
Age at end of year	:	20 years

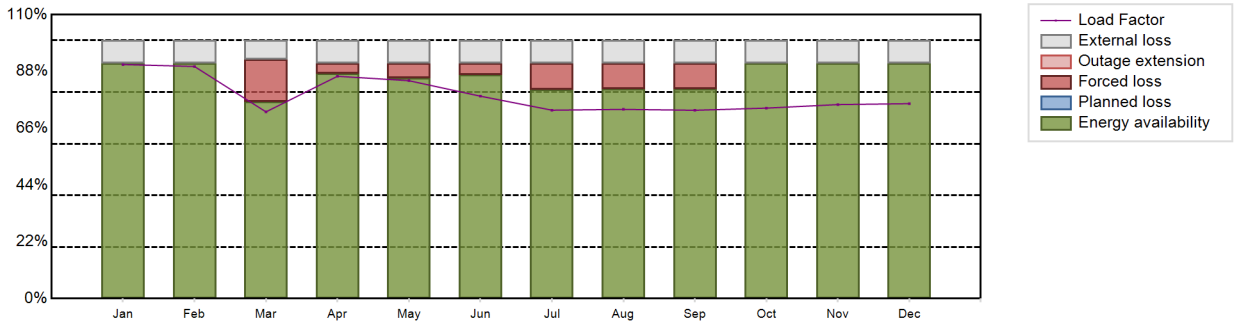
Design Characteristics

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 (2020)

Net Energy Production	:	1397.32 GW(e).h	Forced Loss Rate (FLR)	:	5.04 %
Energy Availability Factor (EAF)	:	86.17 %	Unplanned Capability Loss Factor (UCL)	:	5.04 %
Unit Capability Factor (UCF)	:	94.96 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	78.75 %	Externally cause unavailability (XUF)	:	8.79 %
Operating Factor (OF)	:	98.61 %	Total off-line time	:	122 hours
Equivalent non-electrical energy generated (NEG)	:	113.45 GW(e).h			

Annual Summary



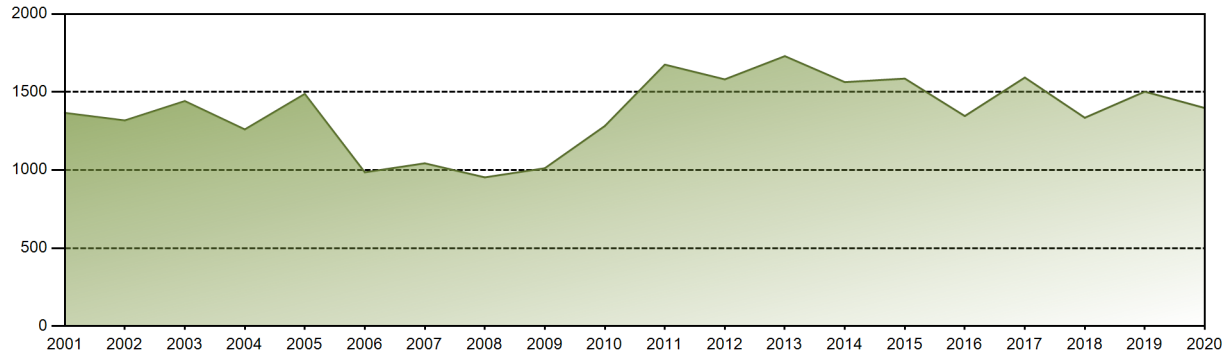
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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	136.26	126.42	108.72	125.27	126.87	114.05	109.71	110.19	106.11	110.91	109.31	113.51	1397.32
EAF [%]	91.09	91.09	76.34	87.12	85.41	86.63	80.98	81.30	81.17	91.09	91.09	91.09	86.17
UCF [%]	100.00	100.00	83.79	96.03	94.32	95.54	89.89	90.21	90.08	100.00	100.00	100.00	94.96
LF [%]	90.67	89.92	72.34	86.13	84.42	78.42	73.00	73.32	72.96	73.80	75.16	75.53	78.75
OF [%]	100.00	100.00	83.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.61
FLR [%]	0.00	0.00	16.21	3.97	5.68	4.46	10.11	9.79	9.92	0.00	0.00	0.00	5.04
UCL [%]	0.00	0.00	16.21	3.97	5.68	4.46	10.11	9.79	9.92	0.00	0.00	0.00	5.04
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 [%]	8.91	8.91	7.45	8.91	8.91	8.91	8.91	8.91	8.91	8.91	8.91	8.91	8.79

Historical Summary

Lifetime energy generation	:	28628.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.94 %
Cumulative Energy Availability Factor (EAF)	:	80.69 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.71 %
Cumulative Unit Capability Factor (UCF)	:	90.57 %	Cumulative Planned Unavailability Factor (PUF)	:	4.73 %
Cumulative Load Factor (LF)	:	77.57 %	Cumulative Externally cause unavailability (XUF)	:	9.87 %
Cumulative Operating Factor (OF)	:	90.77 %			

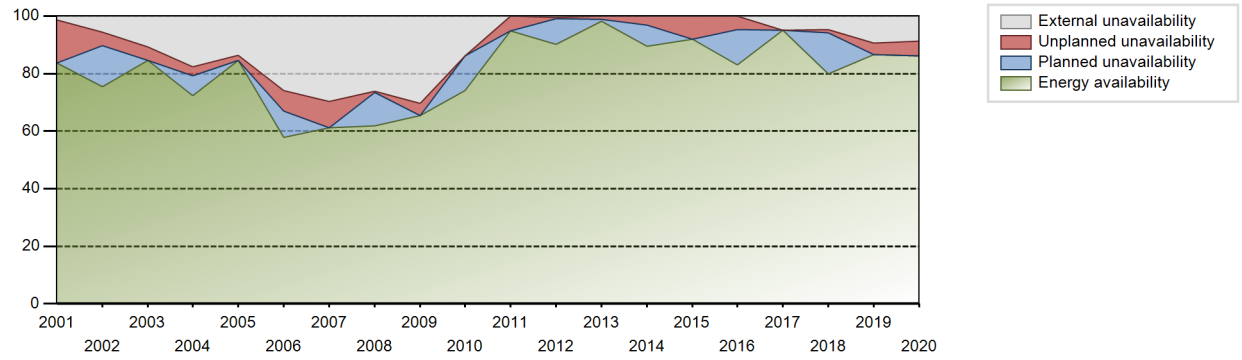
Electricity Production (net) [GWh]



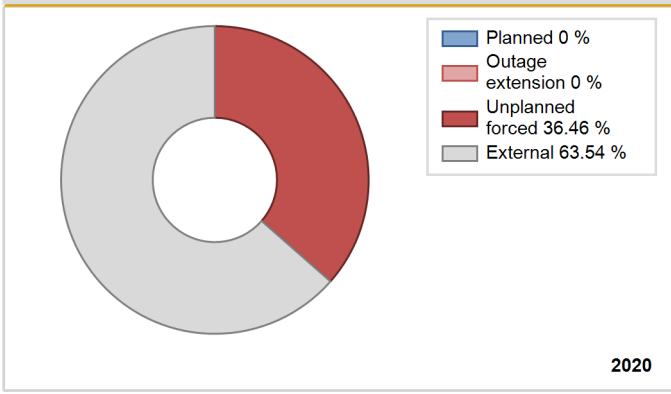
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2000	893.76	4794	200	76.36	76.36	77.64	77.59	23.64	23.64	0.00	0.00
2001	1366.08	7317	200	83.58	84.85	77.97	83.53	15.15	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	94.96	78.75	98.61	5.04	5.04	0.00	8.79

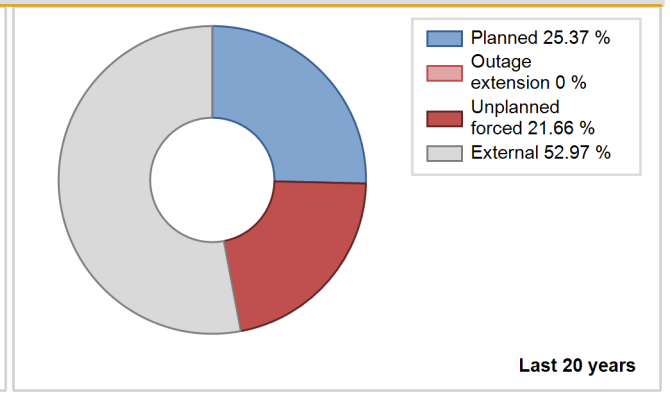
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2000 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		122			345	
D. Inspection, maintenance or repair without refuelling				427		
E. Testing of plant systems or components					18	
J. Grid limitation, failure or grid unavailability						35
L. Human factor related					6	
Subtotal		122		427	369	35
Total		**122**			**831**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2000 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		81
13. Reactor Auxiliary Systems		24
15. Reactor Cooling Systems		31
16. Steam generation systems		20
17. Safety I&C Systems (excluding reactor I&C)		2
21. Fuel Handling and Storage Facilities		11
31. Turbine and auxiliaries		54
32. Feedwater and Main Steam System	122	43
33. Circulating Water System		2
34. Miscellaneous Systems		3
41. Main Generator Systems		38
42. Electrical Power Supply Systems		45
Total	**122**	**367**

Highlights (2020)

Unit achieved an annual availability factor of 98.61% and annual capacity factor of 97.68% at permissible power level.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	1990-10-01
Grid Date	:	2000-11-17
Commercial Date	:	2000-12-23
Age at end of year	:	20 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]	:	20.6
Number of control rod assemblies	:	4
Number of external reactor coolant loops	:	1
Coolant type	:	D2O

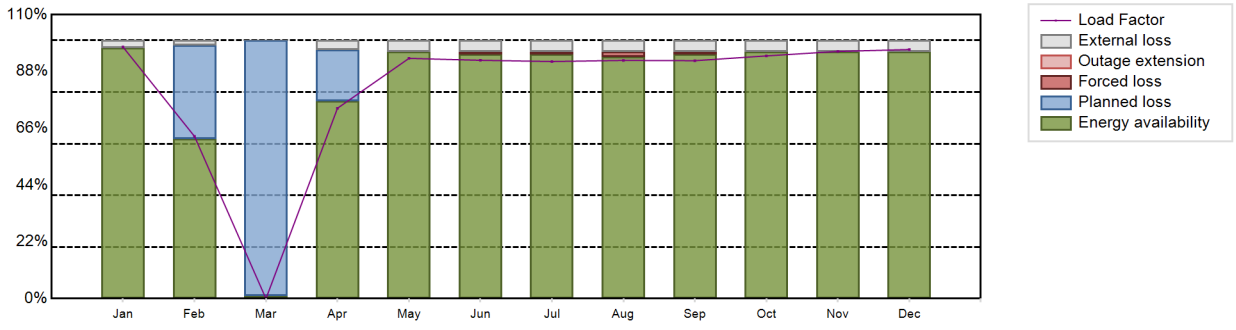
Operating coolant pressure [MPa]	:	8.7
Reactor outlet temperature [°C]	:	293
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	0.42
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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	:	PH

Annual Production Results (2020)

Net Energy Production	:	1452.54 GW(e).h
Energy Availability Factor (EAF)	:	83.07 %
Unit Capability Factor (UCF)	:	86.74 %
Load Factor (LF)	:	81.86 %
Operating Factor (OF)	:	86.99 %
Equivalent non-electrical energy generated (NEG)	:	4.97 GW(e).h

Forced Loss Rate (FLR)	:	0.44 %
Unplanned Capability Loss Factor (UCL)	:	0.38 %
Planned Unavailability Factor (PUF)	:	12.88 %
Externally cause unavailability (XUF)	:	3.68 %
Total off-line time	:	1143 hours

Annual Summary



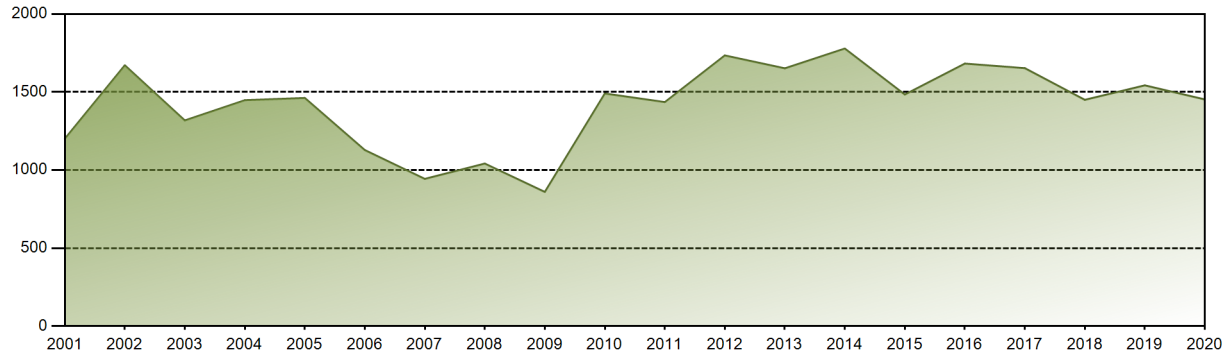
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	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	146.49	88.38	0.00	107.25	139.85	134.26	138.04	138.66	134.03	141.30	139.26	145.00	1452.54
EAF [%]	97.03	62.01	0.99	76.51	95.54	94.68	94.70	93.58	94.68	95.54	95.54	95.54	83.07
UCF [%]	100.00	63.90	0.99	80.07	100.00	99.13	99.16	98.04	99.13	100.00	100.00	100.00	86.74
LF [%]	97.47	62.86	0.00	73.74	93.06	92.32	91.85	92.27	92.15	94.02	95.75	96.48	81.86
OF [%]	100.00	63.51	0.00	79.86	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.99
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.87	0.84	1.96	0.87	0.00	0.00	0.00	0.44
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.87	0.84	1.96	0.87	0.00	0.00	0.00	0.38
PUF [%]	0.00	36.10	99.01	19.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.88
XUF [%]	2.97	1.89	0.00	3.56	4.46	4.46	4.46	4.46	4.46	4.46	4.46	4.46	3.68

Historical Summary

Lifetime energy generation	:	28796.29 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.7 %
Cumulative Energy Availability Factor (EAF)	:	82.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.52 %
Cumulative Unit Capability Factor (UCF)	:	91.64 %	Cumulative Planned Unavailability Factor (PUF)	:	4.84 %
Cumulative Load Factor (LF)	:	80.32 %	Cumulative Externally cause unavailability (XUF)	:	9.55 %
Cumulative Operating Factor (OF)	:	90.8 %			

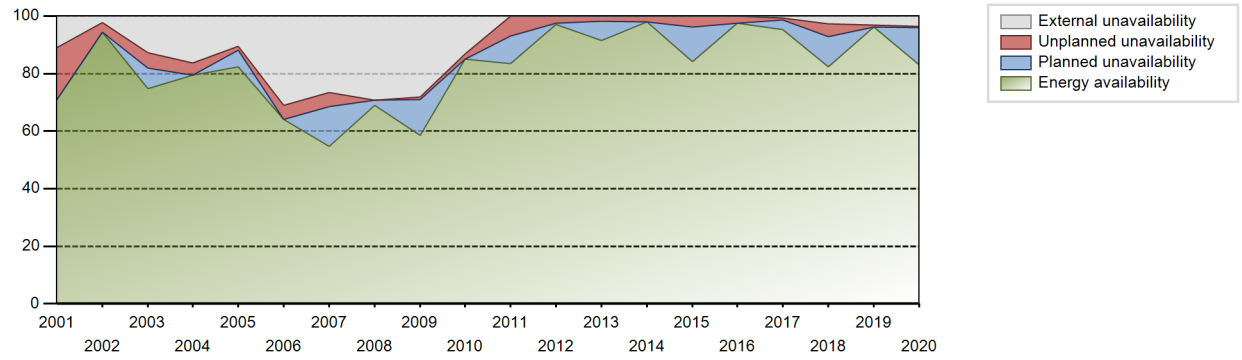
Electricity Production (net) [GWh]



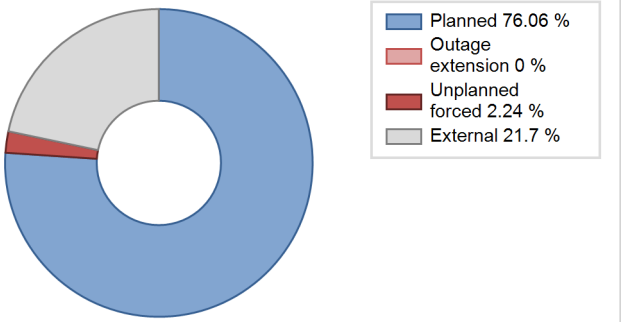
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2000	57.46	518	200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	1200.83	6214	200	71.01	81.99	68.54	70.94	18.01	18.01	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	86.74	81.86	86.99	0.44	0.38	12.88	3.68

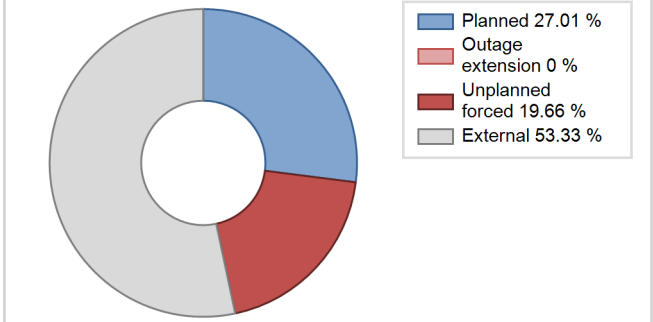
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2000 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					247	
D. Inspection, maintenance or repair without refuelling	1143			428		
E. Testing of plant systems or components					0	
J. Grid limitation, failure or grid unavailability						58
L. Human factor related					10	
Subtotal	1143			428	257	58
Total	**1143**			**743**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2000 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		9
12. Reactor I&C Systems		29
14. Safety Systems		15
15. Reactor Cooling Systems		32
16. Steam generation systems		40
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		12
32. Feedwater and Main Steam System		32
34. Miscellaneous Systems		4
41. Main Generator Systems		24
42. Electrical Power Supply Systems		49
Total		**255**

Highlights (2020)

Unit achieved an annual availability factor of 86.99% and annual capacity factor of 87.46% at permissible power level.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	2002-09-18
Grid Date	:	2009-12-22
Commercial Date	:	2010-02-04
Age at end of year	:	11 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	:	1
Coolant type	:	D2O

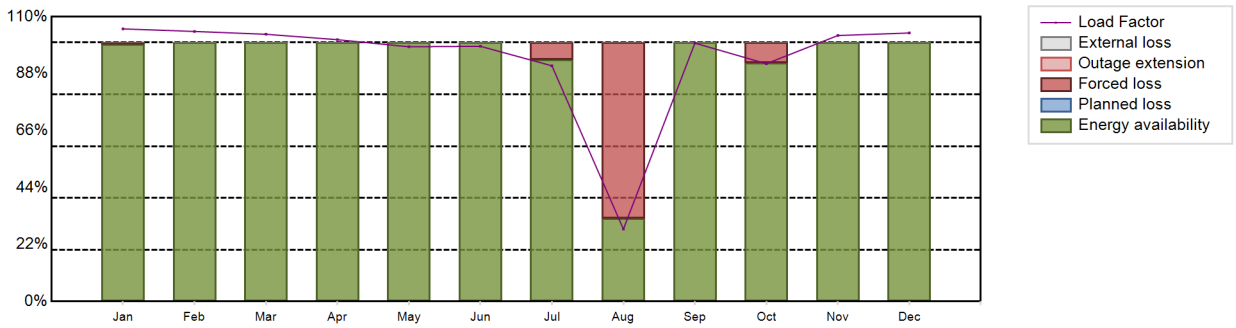
Operating coolant pressure [MPa]	:	1.034
Reactor outlet temperature [°C]	:	293
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	1.73
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.972
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 (2020)

Net Energy Production	:	1665.66 GW(e).h
Energy Availability Factor (EAF)	:	92.98 %
Unit Capability Factor (UCF)	:	92.98 %
Load Factor (LF)	:	93.87 %
Operating Factor (OF)	:	92.88 %

Forced Loss Rate (FLR)	:	7.02 %
Unplanned Capability Loss Factor (UCL)	:	7.02 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	625 hours

Annual Summary



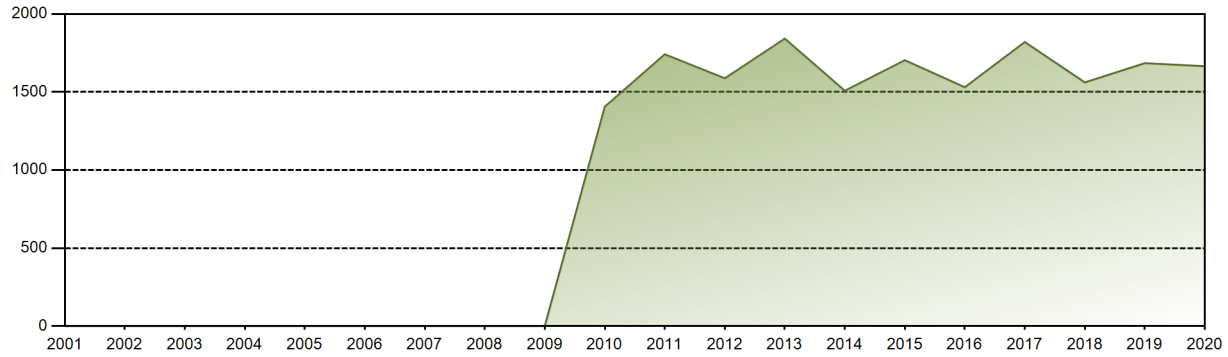
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	158.24	146.65	155.13	147.07	147.85	143.37	136.82	42.05	145.15	138.02	149.42	155.87	1665.65
EAF [%]	99.46	100.00	100.00	100.00	100.00	100.00	93.44	32.07	100.00	92.09	100.00	100.00	92.98
UCF [%]	99.46	100.00	100.00	100.00	100.00	100.00	93.44	32.07	100.00	92.09	100.00	100.00	92.98
LF [%]	105.29	104.31	103.22	101.12	98.38	98.57	91.04	27.98	99.80	91.84	102.73	103.71	93.87
OF [%]	99.46	100.00	100.00	100.00	100.00	100.00	93.28	31.32	100.00	91.94	100.00	100.00	92.88
FLR [%]	0.54	0.00	0.00	0.00	0.00	0.00	6.56	67.93	0.00	7.91	0.00	0.00	7.02
UCL [%]	0.54	0.00	0.00	0.00	0.00	0.00	6.56	67.93	0.00	7.91	0.00	0.00	7.02
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

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Historical Summary

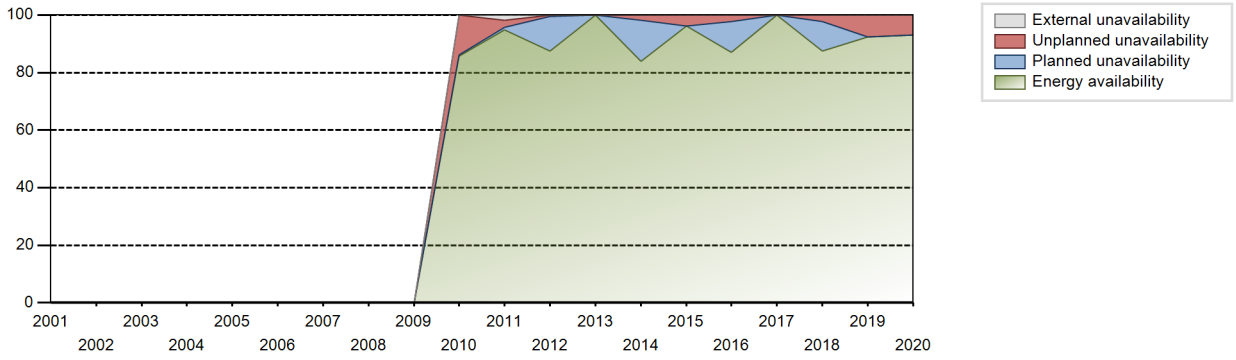
Lifetime energy generation	:	18053.38 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.89 %
Cumulative Energy Availability Factor (EAF)	:	91.71 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.72 %
Cumulative Unit Capability Factor (UCF)	:	91.87 %	Cumulative Planned Unavailability Factor (PUF)	:	4.42 %
Cumulative Load Factor (LF)	:	93.4 %	Cumulative Externally cause unavailability (XUF)	:	0.16 %
Cumulative Operating Factor (OF)	:	91.85 %			

Electricity Production (net) [GWh]



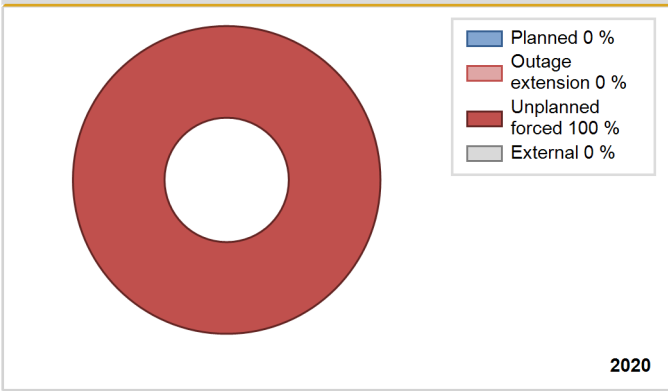
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2010	1406.17	7158	202	85.72	85.72	86.84	89.30	14.00	13.95	0.32	0.00
2011	1741.80	8325	202	94.91	96.66	98.43	95.03	2.56	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

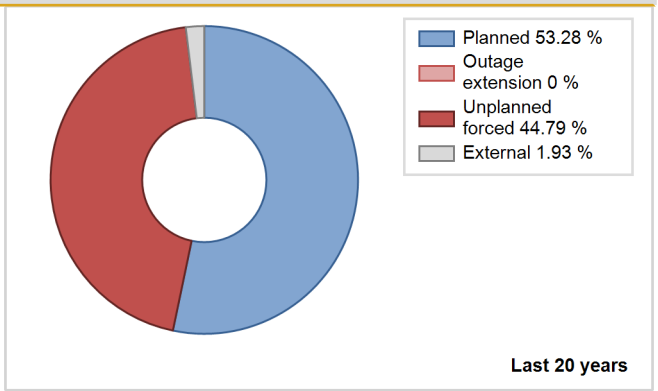
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2010 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		619			296	
D. Inspection, maintenance or repair without refuelling				389		
E. Testing of plant systems or components				2	0	
J. Grid limitation, failure or grid unavailability						22
L. Human factor related					5	
Z. Other		4			0	
Subtotal		623		391	301	22
Total		**623**			**714**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2010 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	560	70
12. Reactor I&C Systems		47
15. Reactor Cooling Systems	59	42
16. Steam generation systems		5
31. Turbine and auxiliaries		22
33. Circulating Water System		13
34. Miscellaneous Systems		4
35. All other I&C Systems		0
41. Main Generator Systems		106
42. Electrical Power Supply Systems	4	5
Total	**623**	**314**

Highlights (2020)

Unit performed satisfactorily during the year. Had 3 units outages. Two outages involved reactor manual trip.

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2020 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

Reactor type and model	:	PHWR / Horizontal Pressure Tube type
Thermal power	:	801 MWth
Gross electrical power	:	220 MWe
Reference unit power (net)	:	202 MWe

Key Dates

Construction Date	:	2003-01-20
Grid Date	:	2010-03-28
Commercial Date	:	2010-03-31
Age at end of year	:	10 years

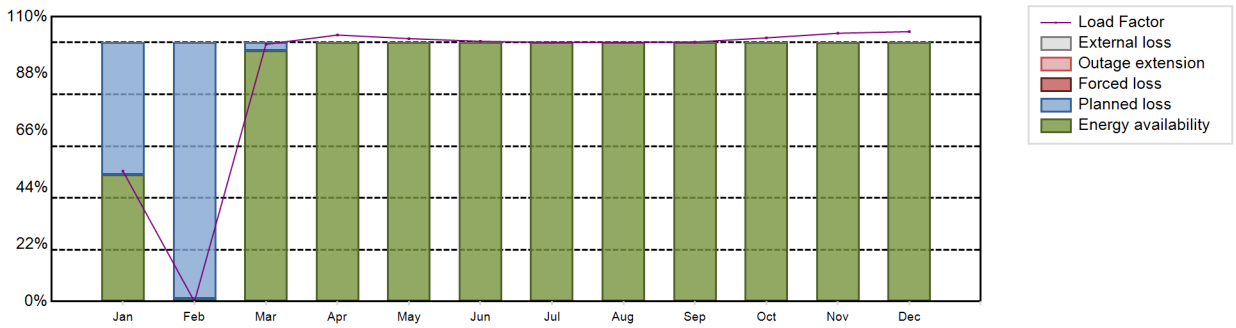
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	0.991
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 (2020)

Net Energy Production	:	1580.22 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	87.56 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	87.56 %	Planned Unavailability Factor (PUF)	:	12.44 %
Load Factor (LF)	:	89.06 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	87.43 %	Total off-line time	:	1104 hours

Annual Summary



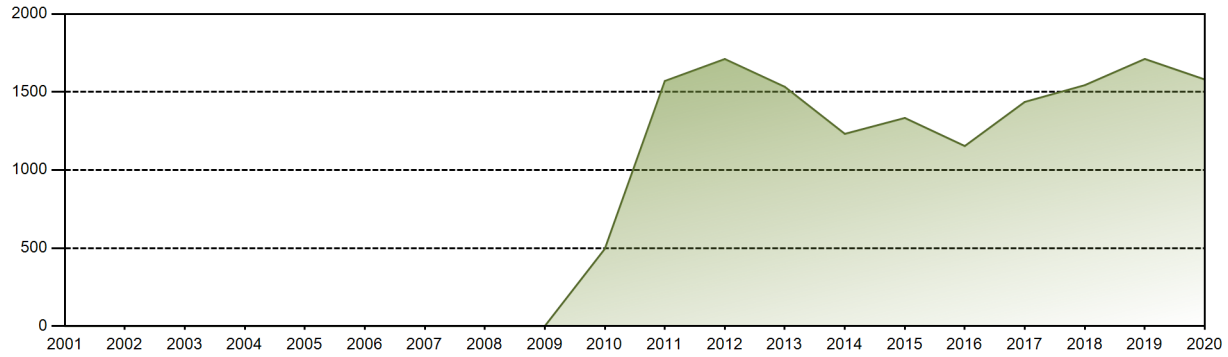
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	75.65	0.00	149.30	149.70	152.58	146.16	150.37	150.38	145.74	153.01	150.68	156.64	1580.22
EAF [%]	48.89	0.99	96.80	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	87.56
UCF [%]	48.89	0.99	96.80	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	87.56
LF [%]	50.34	0.00	99.34	102.93	101.53	100.49	100.06	100.06	100.21	101.81	103.60	104.22	89.06
OF [%]	48.39	0.00	96.77	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	87.43
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 [%]	51.11	99.01	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.44
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

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Historical Summary

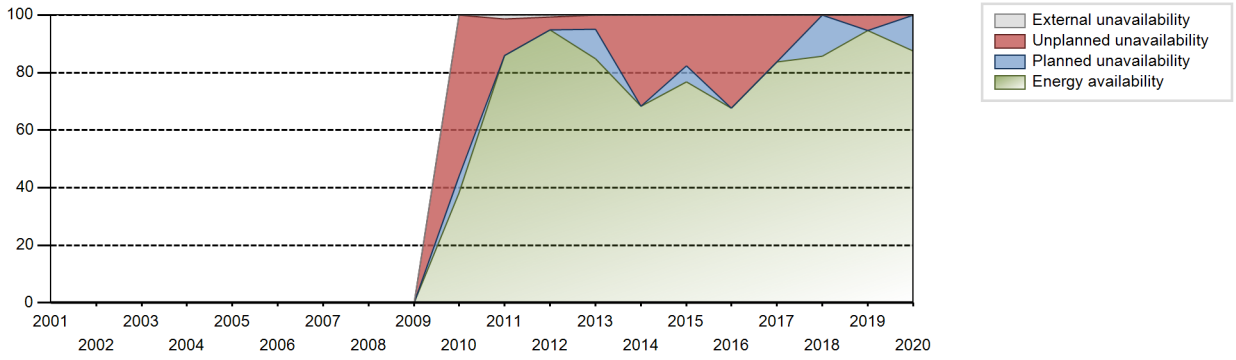
Lifetime energy generation	:	15301.93 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	16.29 %
Cumulative Energy Availability Factor (EAF)	:	79.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	15.58 %
Cumulative Unit Capability Factor (UCF)	:	80.06 %	Cumulative Planned Unavailability Factor (PUF)	:	4.36 %
Cumulative Load Factor (LF)	:	80.35 %	Cumulative Externally cause unavailability (XUF)	:	0.2 %
Cumulative Operating Factor (OF)	:	81.18 %			

Electricity Production (net) [GWh]



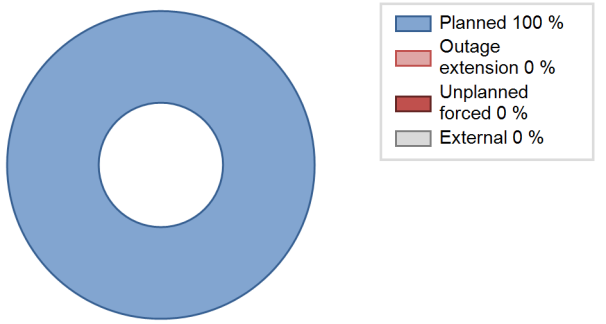
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2010	494.85	3041	202	38.11	38.11	37.12	46.08	59.53	56.06	5.83	0.00
2011	1570.55	7506	202	85.84	87.27	88.76	85.68	12.73	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	0.00	12.44	0.00

Key Factors in Last 20 Years [%]

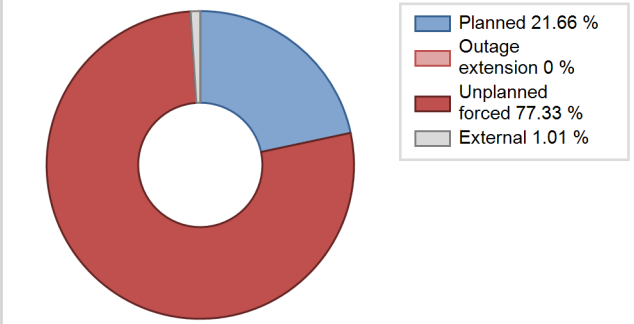


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2010 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					1221	
D. Inspection, maintenance or repair without refuelling	1104			384		
J. Grid limitation, failure or grid unavailability						18
L. Human factor related					22	
Subtotal	1104			384	1243	18
Total	**1104**			**1645**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2010 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		33
12. Reactor I&C Systems		24
15. Reactor Cooling Systems		5
16. Steam generation systems		36
31. Turbine and auxiliaries		196
32. Feedwater and Main Steam System		9
33. Circulating Water System		18
35. All other I&C Systems		6
41. Main Generator Systems		582
42. Electrical Power Supply Systems		329
Total		**1238**

Highlights (2020)

Unit had satisfactory performance in the year. It had availed Biennial Shutdown from 15th January to 2nd March 2020.

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2020 Operating Experience

IN-1 TARAPUR-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	:	GE (GENERAL ELECTRIC CO.)
Turbine Supplier	:	GE (GENERAL ELECTRIC CO.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-1 (Mark 2)
Thermal power	:	530 MWth
Gross electrical power	:	160 MWe
Reference unit power (net)	:	150 MWe

Key Dates

Construction Date	:	1964-10-01
Grid Date	:	1969-04-01
Commercial Date	:	1969-10-28
Age at end of year	:	51 years

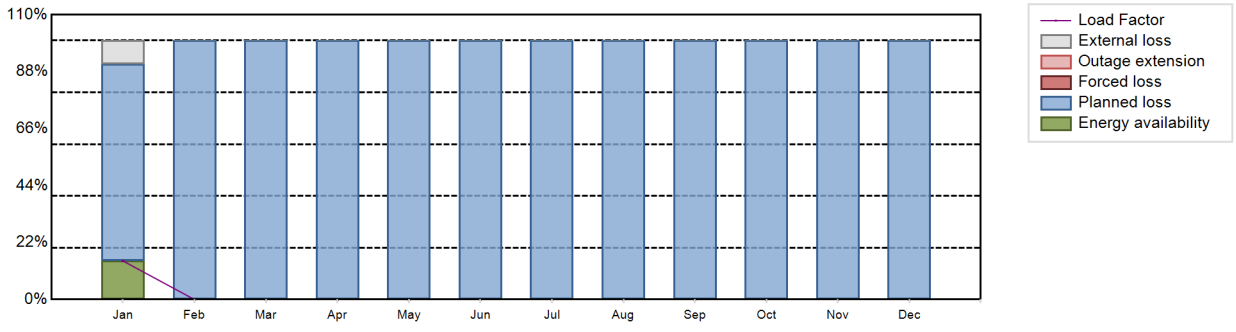
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.44
Refuelling frequency [month]	:	18
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	21600
Active core diameter [m]	:	2.416
Active core height/length [m]	:	3.66
Number of fissile fuel assemblies/bundles	:	284
Fuel linear heat generation rate [kW/m]	:	14.2
Number of control rod assemblies	:	69
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.03
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	3.06
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]	:	6.879
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 (2020)

Net Energy Production	:	16.62 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	1.26 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	2.03 %	Planned Unavailability Factor (PUF)	:	97.97 %
Load Factor (LF)	:	1.26 %	Externally cause unavailability (XUF)	:	0.77 %
Operating Factor (OF)	:	2.04 %	Total off-line time	:	8605 hours

Annual Summary



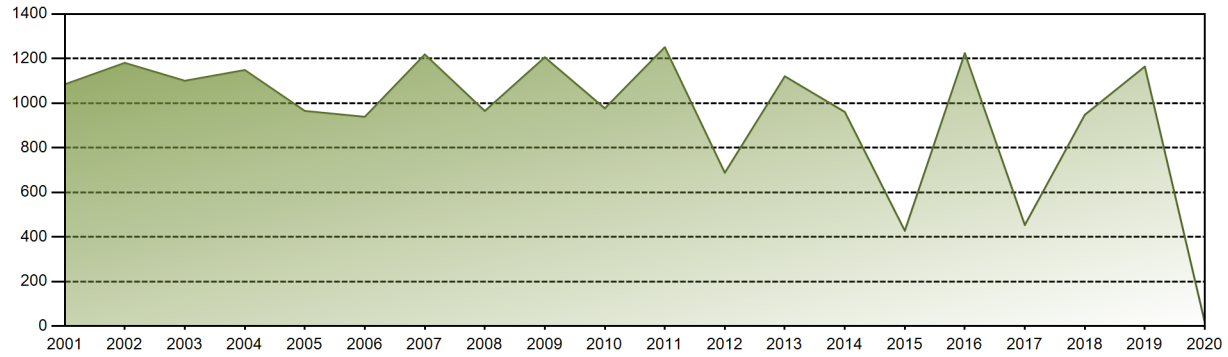
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	16.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.62
EAF [%]	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26
UCF [%]	24.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.03
LF [%]	14.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26
OF [%]	24.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04
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 [%]	75.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.97
XUF [%]	9.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77

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Historical Summary

Lifetime energy generation	:	45392.58 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	10.44 %
Cumulative Energy Availability Factor (EAF)	:	66.26 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.93 %
Cumulative Unit Capability Factor (UCF)	:	67 %	Cumulative Planned Unavailability Factor (PUF)	:	25.07 %
Cumulative Load Factor (LF)	:	62.06 %	Cumulative Externally cause unavailability (XUF)	:	0.74 %
Cumulative Operating Factor (OF)	:	74 %			

Electricity Production (net) [GWh]

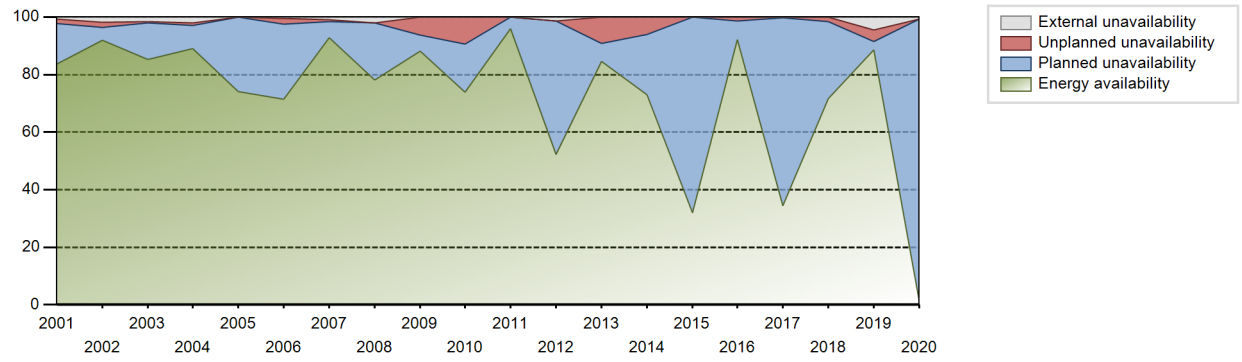


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1969						Data not provided					
1970						"					
1971						"					
1972	652.40	5071	210	35.36	35.36	35.37	57.73	0.00	0.00	64.64	0.00
1973	757.10	5181	210	41.16	41.16	41.16	59.14	35.36	22.52	36.33	0.00
1974	832.60	6938	156	60.54	60.54	60.93	79.20	0.00	0.00	39.46	0.00
1975	926.60	5825	200	52.95	52.95	52.89	66.50	26.82	19.40	27.64	0.00
1976	1156.60	7617	210	62.71	62.71	62.70	86.71	37.29	37.29	0.00	0.00
1977	994.80	6675	210	54.06	54.06	54.08	76.20	0.00	0.00	45.94	0.00
1978	941.00	6427	210	51.16	51.16	51.15	73.37	21.11	13.68	35.16	0.00
1979	965.90	7143	210	52.51	52.51	52.51	81.54	36.69	30.43	17.07	0.00
1980	893.90	5955	210	67.80	67.80	48.46	67.79	5.21	3.73	28.47	0.00
1981	793.80	5986	210	68.41	68.41	43.15	68.33	7.12	5.24	26.35	0.00
1982	1112.20	7872	210	89.91	89.91	60.46	89.86	6.48	6.23	3.86	0.00
1983	730.00	5396	200	41.66	41.66	41.67	61.60	8.55	3.89	54.45	0.00
1984	826.85	7688	200	89.58	90.33	47.07	87.52	4.89	4.65	5.02	0.75
1985	790.90	6194	170	64.60	64.60	53.15	70.71	6.20	4.27	31.13	0.00
1986	1090.23	7954	150	82.97	84.55	82.97	90.80	8.12	7.47	7.98	1.58
1987	193.38	1533	150	14.72	14.72	14.72	17.50	7.72	1.23	84.05	0.00
1988	1085.46	8010	150	82.38	83.80	82.38	91.19	6.81	6.13	10.07	1.42
1989	800.33	6177	150	61.42	61.57	60.91	70.51	15.36	11.18	27.26	0.15
1990	1045.17	7772	150	80.19	80.45	79.54	88.72	19.55	19.55	0.00	0.27
1991	566.89	6536	150	80.41	82.42	43.14	74.61	16.24	15.98	1.60	2.01
1992	762.34	5487	150	57.86	58.71	57.86	62.47	11.95	7.97	33.32	0.85
1993	967.68	7291	150	74.41	76.88	73.64	83.23	16.31	14.98	8.14	2.47
1994	280.62	2450	150	21.36	22.94	21.36	27.97	59.82	34.15	42.91	1.59
1995	1092.26	7893	150	83.12	91.02	83.12	90.10	8.98	8.98	0.00	7.89
1996	403.32	3872	150	30.61	32.27	30.61	44.08	39.27	20.87	46.86	1.66
1997	985.48	7347	150	75.00	75.91	75.00	83.87	11.06	9.44	14.65	0.91
1998	1162.62	8283	150	91.58	92.81	88.48	94.55	4.35	4.22	2.97	1.23
1999	852.60	6405	150	67.00	67.93	64.89	73.12	10.37	7.86	24.20	0.93
2000	1181.10	8337	150	91.63	91.63	89.64	94.91	1.70	1.59	6.78	0.00
2001	1084.22	7635	150	83.62	84.28	82.51	87.16	1.94	1.67	14.05	0.66
2002	1180.71	8394	150	91.97	93.76	89.86	95.82	2.00	1.91	4.33	1.79
2003	1100.38	7901	150	85.21	86.89	83.74	90.19	0.40	0.35	12.76	1.68
2004	1148.56	8111	150	88.97	90.93	87.17	92.34	1.10	1.01	8.06	1.96
2005	965.03	6552	150	74.16	74.20	73.44	74.79	0.00	0.00	25.80	0.04

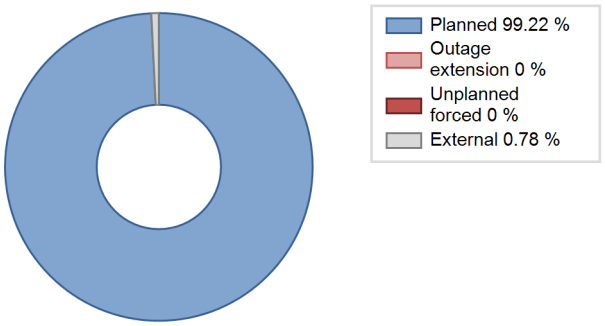
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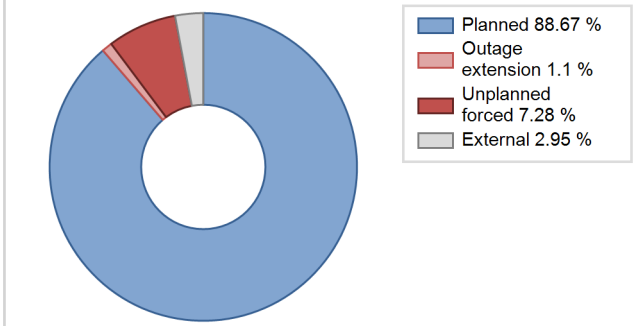
2006	938.72	6652	150	71.44	71.88	71.44	75.94	2.72	2.01	26.11	0.44
2007	1218.35	8400	150	92.72	93.55	92.72	95.89	0.75	0.70	5.74	0.83
2008	964.83	7045	150	78.19	80.17	73.23	80.20	0.00	0.00	19.83	1.97
2009	1205.65	7752	150	88.23	88.23	91.75	88.49	6.62	6.26	5.51	0.00
2010	976.75	6792	150	73.99	73.99	74.33	77.53	11.30	9.43	16.58	0.00
2011	1250.95	8437	150	95.98	95.98	95.20	96.31	0.00	0.00	4.02	0.00
2012	687.67	4750	150	52.15	53.57	52.19	54.08	0.00	0.00	46.43	1.42
2013	1120.51	7606	150	84.58	84.58	85.27	86.83	9.74	9.12	6.30	0.00
2014	960.40	6612	150	73.09	73.09	73.09	75.48	0.00	6.03	20.88	0.00
2015	427.55	2866	150	31.98	31.98	32.54	32.72	0.00	0.00	68.02	0.00
2016	1224.11	8317	150	92.15	92.15	92.90	94.68	1.54	1.44	6.41	0.00
2017	453.53	3703	150	34.52	34.52	34.52	42.27	0.69	0.24	65.24	0.00
2018	947.79	6449	150	71.58	71.58	72.13	73.62	2.12	1.55	26.87	0.00
2019	1163.97	8405	150	88.50	93.00	88.58	95.95	4.18	4.06	2.94	4.50
2020	16.62	179	150	1.26	2.03	1.26	2.04	0.00	0.00	97.97	0.77

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1969 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					304	
C. Inspection, maintenance or repair combined with refuelling	8605			1595	25	
D. Inspection, maintenance or repair without refuelling				198		
E. Testing of plant systems or components				6	4	
G. Major backfitting, refurbishment or upgrading activities without refuelling				67		
J. Grid limitation, failure or grid unavailability						41
L. Human factor related					0	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				2		
Z. Other				0	2	1
Subtotal	8605			1868	335	42
Total	**8605**			**2245**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1969 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		7
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		4
14. Safety Systems		5
15. Reactor Cooling Systems		60
16. Steam generation systems		14
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		119
32. Feedwater and Main Steam System		60
34. Miscellaneous Systems		1
41. Main Generator Systems		1
42. Electrical Power Supply Systems		29
Total		**314**

Highlights (2020)

Unit was shutdown on 8th January 2020 for Refueling, surveillance and in-service inspection. Subsequently, it was decided to take up extensive health assessment and accordingly unit has been taken under project mode from 1st April 2020.

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2020 Operating Experience

IN-2 TARAPUR-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	:	GE (GENERAL ELECTRIC CO.)
Turbine Supplier	:	GE (GENERAL ELECTRIC CO.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-1 (Mark 2)
Thermal power	:	530 MWth
Gross electrical power	:	160 MWe
Reference unit power (net)	:	150 MWe

Key Dates

Construction Date	:	1964-10-01
Grid Date	:	1969-05-05
Commercial Date	:	1969-10-28
Age at end of year	:	51 years

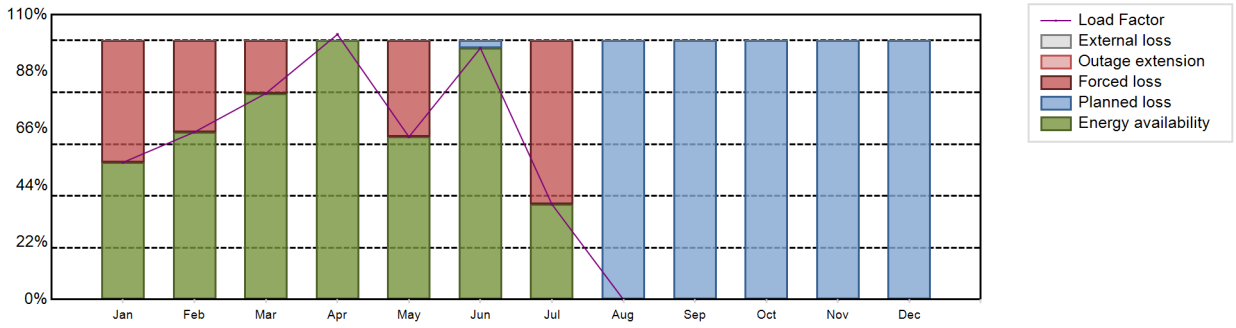
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	2.44
Refuelling frequency [month]	:	18
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	21600
Active core diameter [m]	:	2.416
Active core height/length [m]	:	3.66
Number of fissile fuel assemblies/bundles	:	284
Fuel linear heat generation rate [kW/m]	:	14.2
Number of control rod assemblies	:	69
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.03
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	3.06
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]	:	6.88
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 (2020)

Net Energy Production	:	542.06 GW(e).h	Forced Loss Rate (FLR)	:	29.35 %
Energy Availability Factor (EAF)	:	40.94 %	Unplanned Capability Loss Factor (UCL)	:	17.01 %
Unit Capability Factor (UCF)	:	40.94 %	Planned Unavailability Factor (PUF)	:	42.04 %
Load Factor (LF)	:	41.14 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	42.14 %	Total off-line time	:	5082 hours

Annual Summary



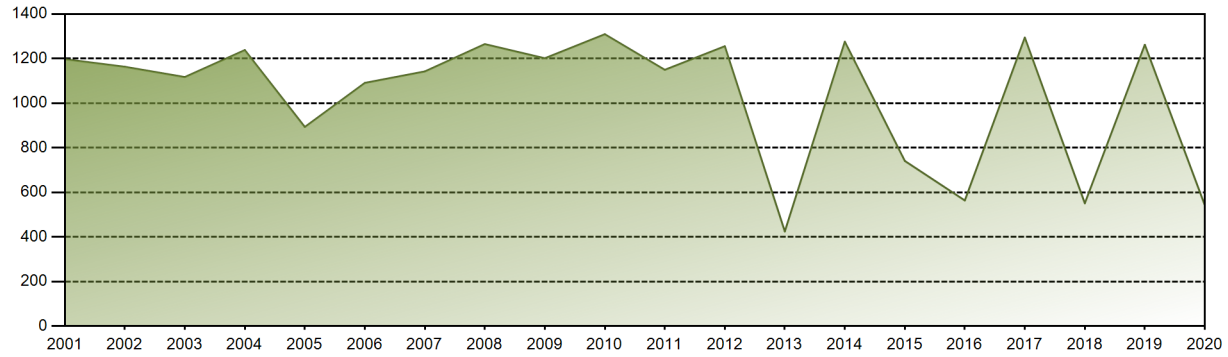
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	59.10	67.52	88.87	110.58	70.10	104.84	41.05	0.00	0.00	0.00	0.00	0.00	542.06
EAF [%]	52.96	64.68	79.63	100.00	62.81	97.07	36.78	0.00	0.00	0.00	0.00	0.00	40.94
UCF [%]	52.96	64.68	79.63	100.00	62.81	97.07	36.78	0.00	0.00	0.00	0.00	0.00	40.94
LF [%]	52.96	64.68	79.63	102.39	62.81	97.07	36.78	0.00	0.00	0.00	0.00	0.00	41.14
OF [%]	53.36	67.10	83.33	100.00	65.19	100.00	39.38	0.00	0.00	0.00	0.00	0.00	42.14
FLR [%]	47.04	35.32	20.37	0.00	37.19	0.00	63.22	0.00	0.00	0.00	0.00	0.00	29.35
UCL [%]	47.04	35.32	20.37	0.00	37.19	0.00	63.22	0.00	0.00	0.00	0.00	0.00	17.01
PUF [%]	0.00	0.00	0.00	0.00	0.00	2.93	0.00	100.00	100.00	100.00	100.00	100.00	42.04
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

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Historical Summary

Lifetime energy generation	:	46969.67 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	12.95 %
Cumulative Energy Availability Factor (EAF)	:	67.04 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	10.08 %
Cumulative Unit Capability Factor (UCF)	:	67.77 %	Cumulative Planned Unavailability Factor (PUF)	:	22.16 %
Cumulative Load Factor (LF)	:	63.74 %	Cumulative Externally cause unavailability (XUF)	:	0.72 %
Cumulative Operating Factor (OF)	:	74.55 %			

Electricity Production (net) [GWh]

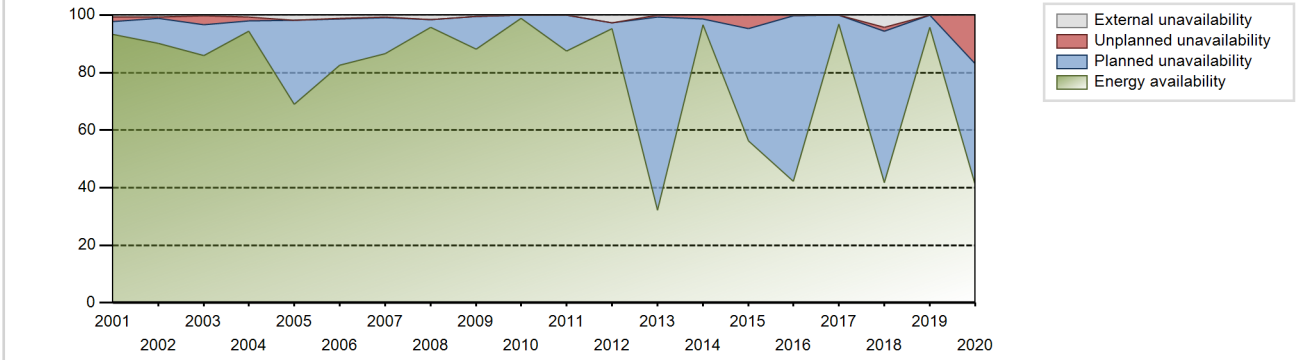


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1969						Data not provided					
1970						"					
1971						"					
1972	218.00	1987	210	11.82	11.82	11.82	22.62	0.00	0.00	88.18	0.00
1973	1249.60	7402	210	67.93	67.93	67.93	84.50	28.99	27.73	4.34	0.00
1974	597.00	4016	194	35.02	35.16	35.13	45.84	31.10	15.87	48.97	0.14
1975	925.80	5654	200	52.78	52.78	52.84	64.54	26.15	18.69	28.53	0.00
1976	1137.90	6534	210	61.68	61.68	61.69	74.39	18.30	13.81	24.51	0.00
1977	1161.50	7650	210	68.19	68.19	63.14	87.33	0.00	0.00	31.81	0.00
1978	1146.10	6678	210	62.33	62.33	62.30	76.23	24.42	20.13	17.54	0.00
1979	993.00	6216	210	53.90	53.90	53.98	70.96	29.03	22.05	24.05	0.00
1980	899.90	6883	210	78.38	78.38	48.78	78.36	2.86	2.31	19.32	0.00
1981	964.00	6748	210	77.08	77.08	52.40	77.03	2.79	2.21	20.71	0.00
1982	556.70	4844	210	55.40	55.40	30.26	55.30	17.80	12.00	32.60	0.00
1983	867.70	7519	200	49.51	49.51	49.53	85.83	20.76	12.97	37.51	0.00
1984	803.11	5615	200	69.60	70.59	45.71	63.92	2.33	1.68	27.73	0.98
1985	1070.89	8059	170	83.45	83.45	71.97	92.00	11.02	10.34	6.21	0.00
1986	769.51	5615	150	58.56	58.91	58.56	64.10	15.27	10.62	30.47	0.35
1987	1167.19	8221	150	88.83	91.46	88.83	93.85	5.24	5.06	3.48	2.63
1988	813.50	6077	150	61.74	62.06	61.74	69.18	10.62	7.38	30.56	0.32
1989	427.06	3052	150	34.84	34.84	32.50	34.84	65.16	65.16	0.00	0.00
1990	762.38	7827	150	58.74	58.74	58.02	89.35	35.35	32.12	9.14	0.00
1991	848.46	6265	150	75.03	76.40	64.57	71.52	23.60	23.60	0.00	1.37
1992	819.84	6076	150	62.22	62.79	62.22	69.17	37.21	37.21	0.00	0.57
1993	779.72	5750	150	59.34	60.72	59.34	65.64	9.73	6.55	32.73	1.38
1994	843.61	6722	150	64.20	64.87	64.20	76.74	31.31	29.57	5.57	0.67
1995	640.00	4911	150	48.71	55.63	48.71	56.06	16.92	11.33	33.04	6.93
1996	361.17	3203	150	27.41	30.43	27.41	36.46	48.71	28.91	40.66	3.02
1997	775.71	6978	150	59.03	59.61	59.03	79.66	28.06	23.25	17.14	0.57
1998	881.06	6522	150	67.82	71.24	67.05	74.45	5.20	3.91	24.85	3.42
1999	1103.52	7711	150	86.37	87.57	83.98	88.03	10.04	9.78	2.66	1.20
2000	1023.11	7162	150	78.99	79.03	77.65	81.53	0.80	0.64	20.34	0.03
2001	1197.42	8364	150	93.27	93.90	91.13	95.48	1.65	1.57	4.53	0.63
2002	1163.29	7978	150	90.17	90.78	88.53	91.07	0.63	0.57	8.65	0.61
2003	1117.12	7890	150	85.91	86.07	85.02	90.07	3.50	3.12	10.80	0.17
2004	1238.26	8455	150	94.50	95.25	93.98	96.25	1.34	1.30	3.46	0.74
2005	893.32	6359	150	68.93	70.68	67.99	72.59	0.00	0.00	29.32	1.75

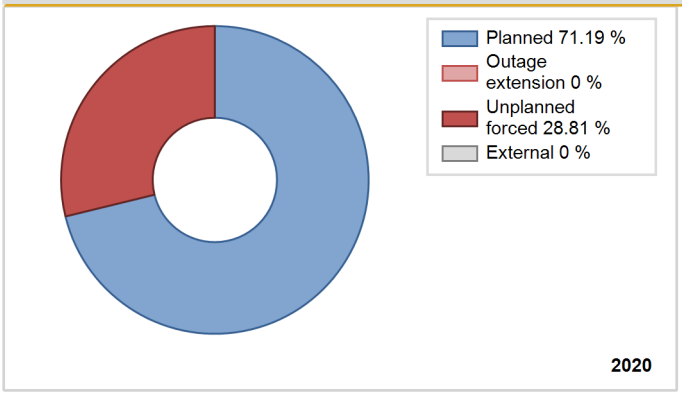
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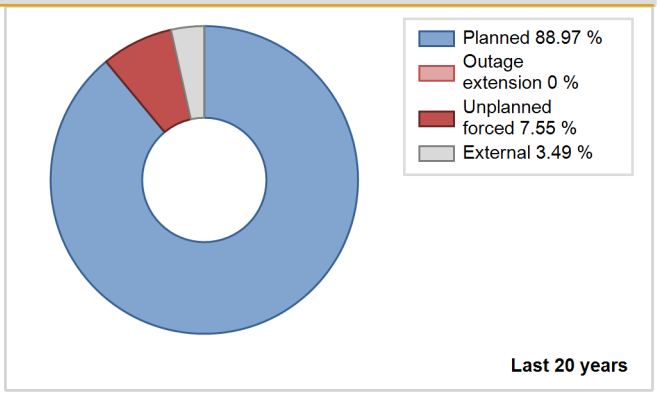
2006	1090.87	7439	150	82.65	83.87	83.02	84.92	0.26	0.22	15.91	1.22
2007	1142.36	7812	150	86.53	87.24	86.94	89.18	0.22	0.19	12.56	0.72
2008	1264.98	8462	150	95.82	97.35	96.01	96.33	0.00	0.00	2.65	1.52
2009	1201.41	7878	150	88.08	88.61	91.43	89.93	0.00	0.00	11.39	0.52
2010	1309.33	8760	150	98.87	98.87	99.64	100.00	0.00	0.00	1.13	0.00
2011	1149.62	7857	150	87.51	87.51	87.49	89.69	0.00	0.00	12.49	0.00
2012	1255.46	8723	150	95.28	98.06	95.28	99.31	0.00	0.00	1.94	2.77
2013	424.38	2982	150	32.26	32.26	32.30	34.04	2.07	0.68	67.06	0.00
2014	1275.95	8648	150	96.58	96.58	97.10	98.72	1.39	1.36	2.06	0.00
2015	740.83	5677	150	56.17	56.17	56.38	64.81	7.65	4.65	39.18	0.00
2016	563.58	3783	150	42.27	42.27	42.77	43.07	0.83	0.36	57.37	0.00
2017	1294.41	8561	150	96.95	96.95	98.51	97.73	0.00	0.00	3.05	0.00
2018	550.87	4388	150	41.68	46.01	41.92	50.09	2.91	1.38	52.61	4.33
2019	1262.16	8606	150	95.73	95.73	96.05	98.24	0.00	0.00	4.27	0.00
2020	542.06	3702	150	40.94	40.94	41.14	42.14	29.35	17.01	42.04	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			1969 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		1410			452	
C. Inspection, maintenance or repair combined with refuelling	3672			1402		
D. Inspection, maintenance or repair without refuelling				174		
E. Testing of plant systems or components				45	6	
F. Major backfitting, refurbishment or upgrading activities with refuelling				45		
G. Major backfitting, refurbishment or upgrading activities without refuelling				23		
H. Nuclear regulatory requirements				1	5	
J. Grid limitation, failure or grid unavailability						40
L. Human factor related					1	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				3		
Z. Other				2	1	1
Subtotal	3672	1410		1695	465	41
Total		**5082**			**2201**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1969 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		16
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		36
14. Safety Systems	576	15
15. Reactor Cooling Systems		62
16. Steam generation systems		12
31. Turbine and auxiliaries		51
32. Feedwater and Main Steam System		47
33. Circulating Water System	451	9
34. Miscellaneous Systems	383	26
41. Main Generator Systems		84
42. Electrical Power Supply Systems		93
Total	**1410**	**464**

Highlights (2020)

Unit was shutdown on 13th July for maintenance work. Subsequently, it was decided to carry out extensive health assessment. Therefore, unit was declared under project mode since 1st August 2020.

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2020 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

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	:	2000-05-12
Grid Date	:	2006-06-15
Commercial Date	:	2006-08-18
Age at end of year	:	14 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

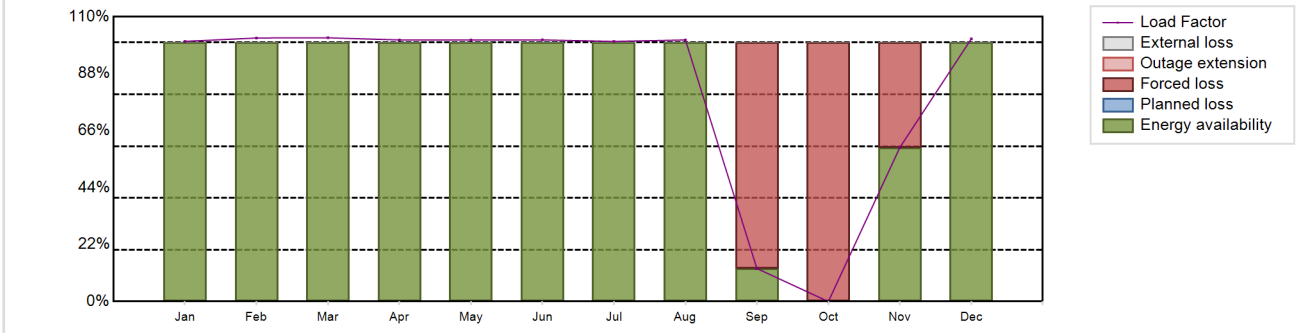
Operating coolant pressure [MPa]	:	0.7
Reactor outlet temperature [°C]	:	304
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	1.44
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	3525.17 GW(e).h
Energy Availability Factor (EAF)	:	81.06 %
Unit Capability Factor (UCF)	:	81.06 %
Load Factor (LF)	:	81.9 %
Operating Factor (OF)	:	81.28 %

Forced Loss Rate (FLR)	:	18.94 %
Unplanned Capability Loss Factor (UCL)	:	18.94 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1644 hours

Annual Summary



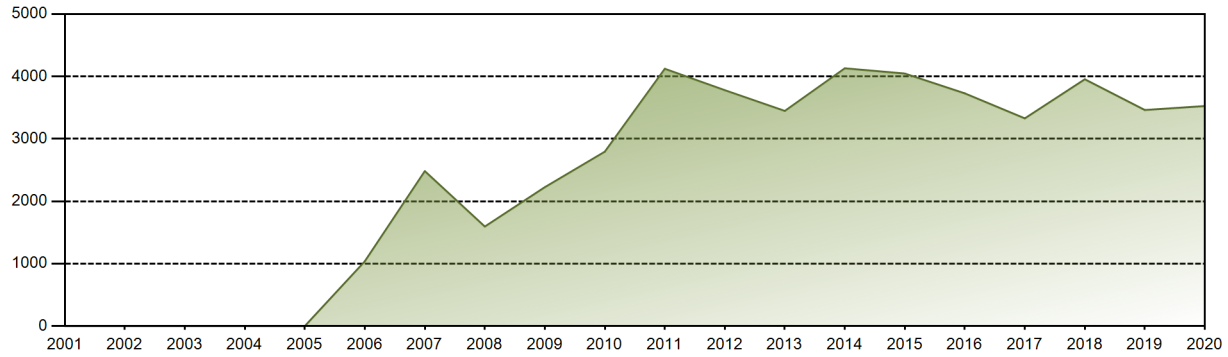
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	366.27	347.08	371.33	356.41	368.22	356.47	366.21	368.35	44.99	0.00	209.97	369.87	3525.17
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	12.75	0.00	59.52	100.00	81.06
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	12.75	0.00	59.52	100.00	81.06
LF [%]	100.47	101.77	101.86	101.02	101.00	101.04	100.45	101.04	12.75	0.00	59.52	101.46	81.90
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	14.31	0.00	60.69	100.00	81.28
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	87.25	100.00	40.48	0.00	18.94
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	87.25	100.00	40.48	0.00	18.94
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

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Historical Summary

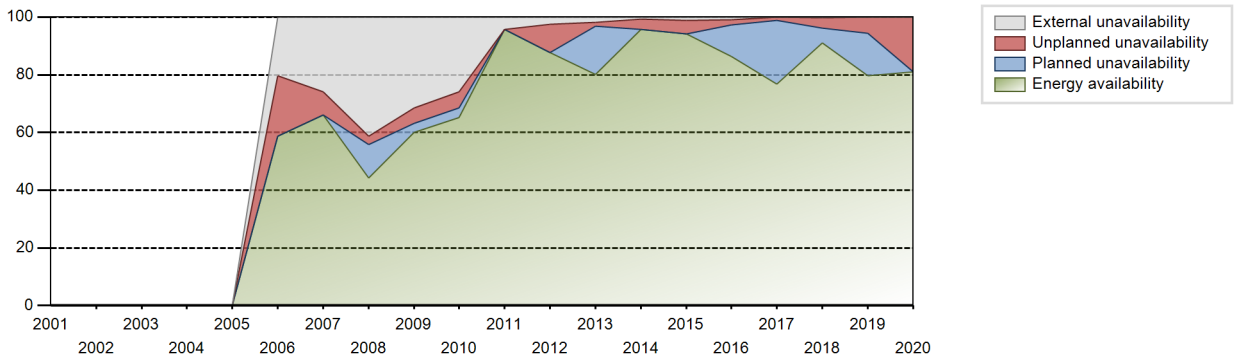
Lifetime energy generation	:	47642.78 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.62 %
Cumulative Energy Availability Factor (EAF)	:	78.4 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.51 %
Cumulative Unit Capability Factor (UCF)	:	88.37 %	Cumulative Planned Unavailability Factor (PUF)	:	6.12 %
Cumulative Load Factor (LF)	:	77.13 %	Cumulative Externally cause unavailability (XUF)	:	9.98 %
Cumulative Operating Factor (OF)	:	88.44 %			

Electricity Production (net) [GWh]



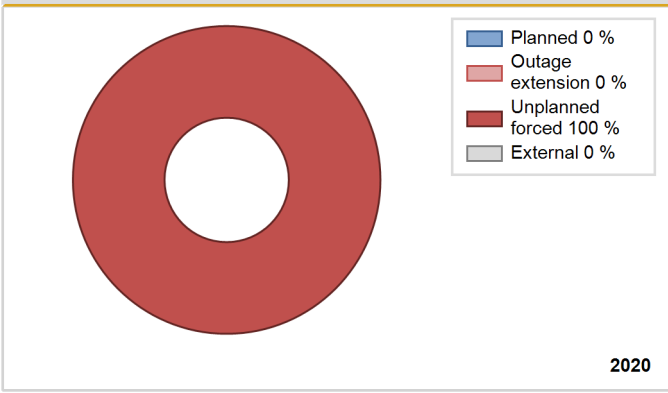
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2006	1037.77	3599	490	58.83	79.15	61.08	80.50	20.85	20.85	0.00	20.32
2007	2482.81	7967	490	66.18	92.12	57.84	90.95	7.88	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

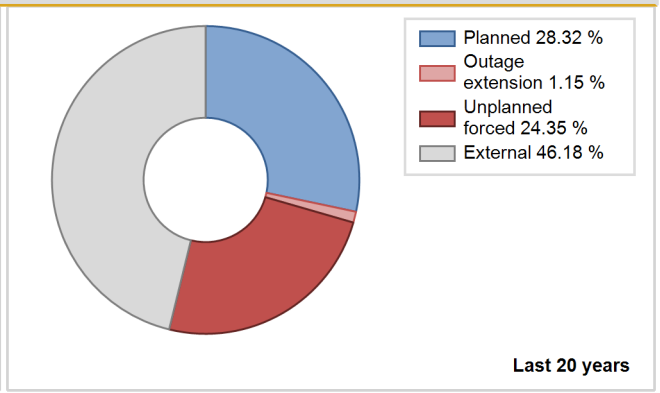
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2006 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		1644			455	
D. Inspection, maintenance or repair without refuelling				522	15	
E. Testing of plant systems or components				12	11	
J. Grid limitation, failure or grid unavailability						11
L. Human factor related					29	
P. Fire					2	
Subtotal		1644		534	512	11
Total		**1644**			**1057**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2006 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	1644	127
12. Reactor I&C Systems		133
14. Safety Systems		13
15. Reactor Cooling Systems		100
31. Turbine and auxiliaries		68
32. Feedwater and Main Steam System		10
33. Circulating Water System		6
34. Miscellaneous Systems		5
41. Main Generator Systems		15
42. Electrical Power Supply Systems		25
Total	**1644**	**502**

Highlights (2020)

Unit achieved an annual availability factor of 81.29% and annual capacity factor of 81.87%.

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2020 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	:	15 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

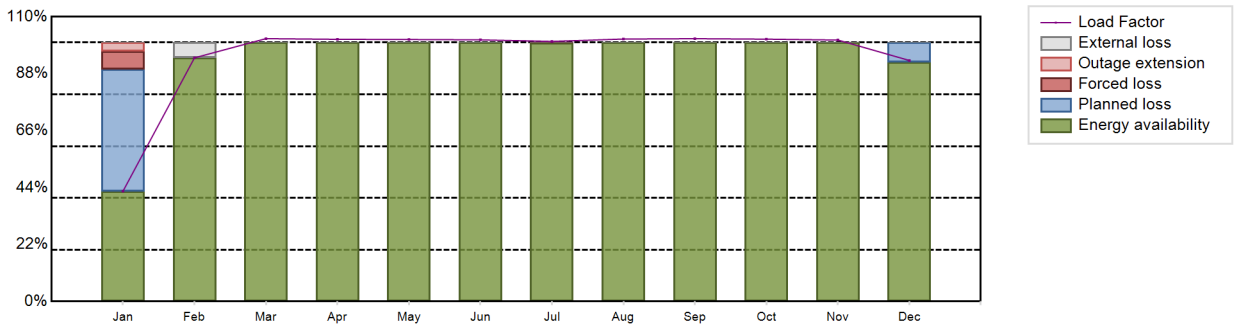
Operating coolant pressure [MPa]	:	11.6
Reactor outlet temperature [°C]	:	304
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	1.44
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4088.13 GW(e).h
Energy Availability Factor (EAF)	:	94.03 %
Unit Capability Factor (UCF)	:	94.49 %
Load Factor (LF)	:	94.98 %
Operating Factor (OF)	:	94.26 %

Forced Loss Rate (FLR)	:	0.63 %
Unplanned Capability Loss Factor (UCL)	:	0.89 %
Planned Unavailability Factor (PUF)	:	4.62 %
Externally cause unavailability (XUF)	:	0.47 %
Total off-line time	:	504 hours

Annual Summary



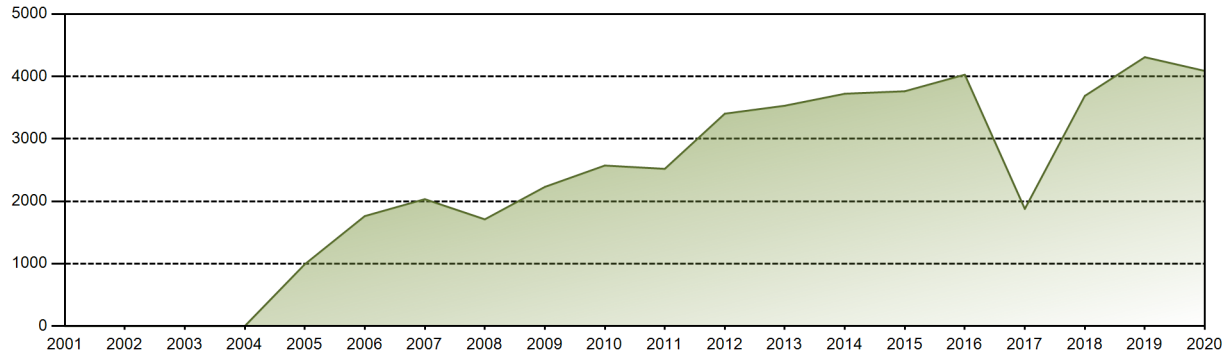
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	155.36	320.96	370.15	357.27	368.87	356.53	366.23	369.56	358.12	369.38	356.30	339.39	4088.13
EAF [%]	42.61	94.11	100.00	100.00	100.00	100.00	99.86	100.00	100.00	100.00	100.00	92.49	94.03
UCF [%]	42.61	100.00	100.00	100.00	100.00	100.00	99.86	100.00	100.00	100.00	100.00	92.49	94.49
LF [%]	42.61	94.11	101.53	101.27	101.18	101.06	100.46	101.37	101.51	101.32	100.99	93.10	94.98
OF [%]	45.43	94.11	100.00	100.00	100.00	100.00	99.87	100.00	100.00	100.00	100.00	92.47	94.26
FLR [%]	13.99	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.63
UCL [%]	10.41	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.89
PUF [%]	46.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.51	4.62
XUF [%]	0.00	5.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47

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Historical Summary

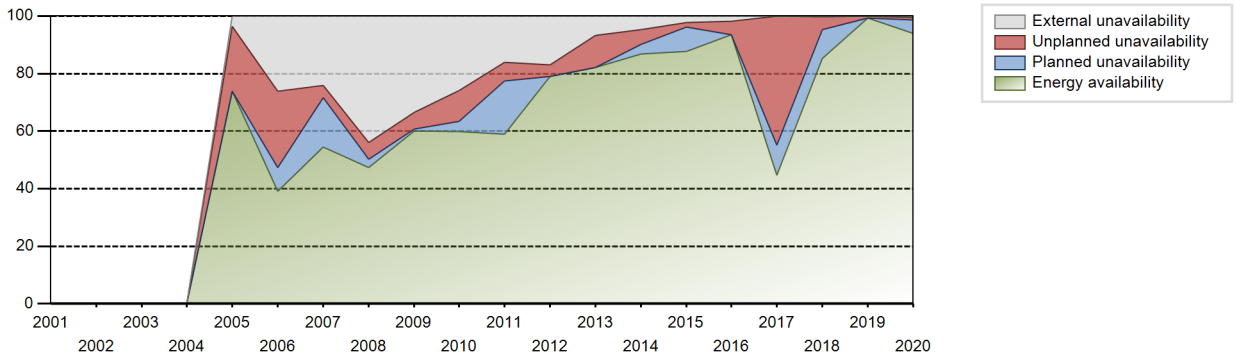
Lifetime energy generation	:	46233.5 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.36 %
Cumulative Energy Availability Factor (EAF)	:	71.54 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.39 %
Cumulative Unit Capability Factor (UCF)	:	84.85 %	Cumulative Planned Unavailability Factor (PUF)	:	5.75 %
Cumulative Load Factor (LF)	:	70.1 %	Cumulative Externally cause unavailability (XUF)	:	13.31 %
Cumulative Operating Factor (OF)	:	84.89 %			

Electricity Production (net) [GWh]



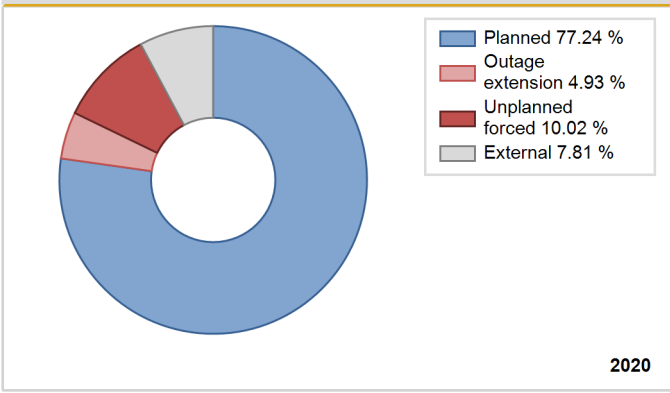
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2005	990.44	2770	490	73.84	77.37	65.69	76.03	22.63	22.63	0.00	3.54
2006	1762.12	5454	490	39.01	65.22	41.05	62.26	28.87	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

Key Factors in Last 20 Years [%]

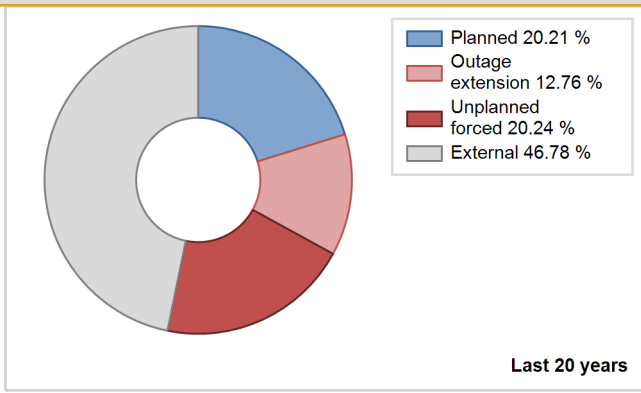


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2005 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		41			561	
D. Inspection, maintenance or repair without refuelling	396			434	274	
E. Testing of plant systems or components		26		21	2	
G. Major backfitting, refurbishment or upgrading activities without refuelling				47		
J. Grid limitation, failure or grid unavailability						31
L. Human factor related					23	
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.)						27
Z. Other			41		5	3
Subtotal	396	67	41	502	865	61
Total		**504**			**1428**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2005 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	26	72
12. Reactor I&C Systems	40	158
13. Reactor Auxiliary Systems		39
14. Safety Systems		17
15. Reactor Cooling Systems		19
16. Steam generation systems		6
21. Fuel Handling and Storage Facilities		63
31. Turbine and auxiliaries		23
32. Feedwater and Main Steam System		7
33. Circulating Water System		17
34. Miscellaneous Systems		8
35. All other I&C Systems		0
41. Main Generator Systems		95
42. Electrical Power Supply Systems	1	90
Total	**67**	**614**

Highlights (2020)

Unit achieved an annual availability factor of 94.27% and annual capacity factor of 94.83%.

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2020 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

Reactor type and model	:	PWR / VVER V-446
Thermal power	:	3000 MWth
Gross electrical power	:	1000 MWe
Reference unit power (net)	:	915 MWe

Key Dates

Construction Date	:	1975-05-01
Grid Date	:	2011-09-03
Commercial Date	:	2013-09-23
Age at end of year	:	9 years

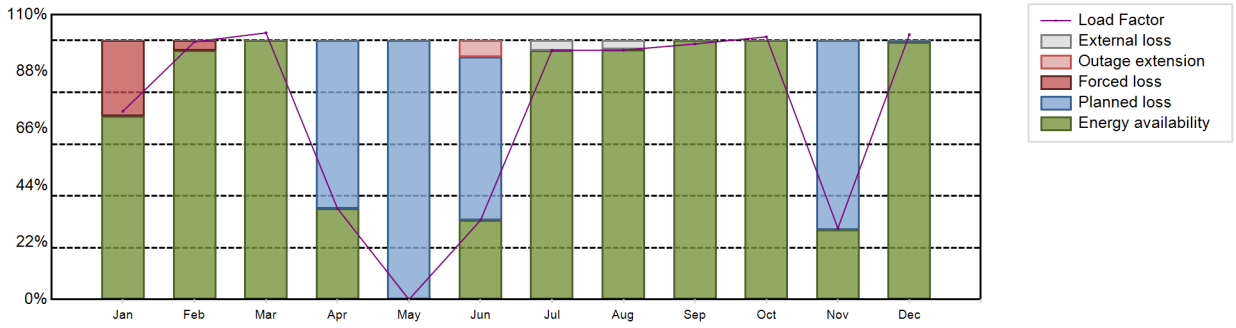
Design Characteristics

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 (2020)

Net Energy Production	:	5792.22 GW(e).h	Forced Loss Rate (FLR)	:	3.77 %
Energy Availability Factor (EAF)	:	71.05 %	Unplanned Capability Loss Factor (UCL)	:	3.32 %
Unit Capability Factor (UCF)	:	71.66 %	Planned Unavailability Factor (PUF)	:	25.02 %
Load Factor (LF)	:	72.07 %	Externally cause unavailability (XUF)	:	0.61 %
Operating Factor (OF)	:	72.28 %	Total off-line time	:	2435 hours

Annual Summary



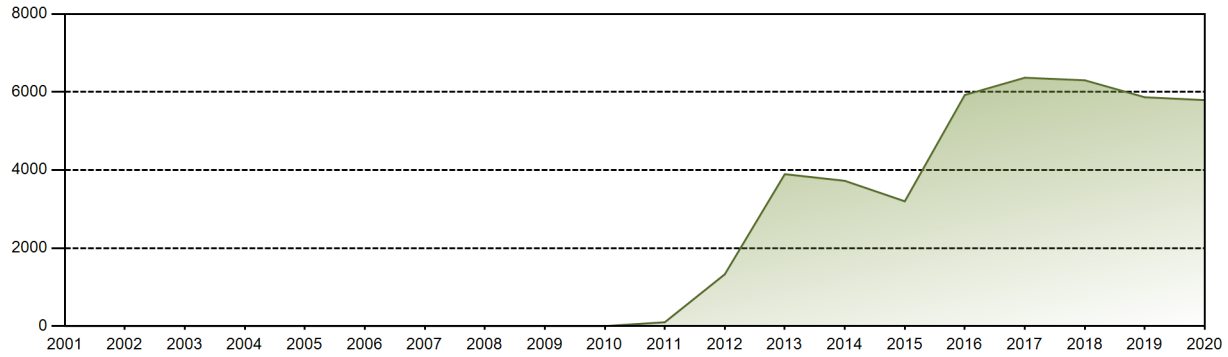
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	495.04	633.80	700.96	231.80	0.00	201.34	654.92	655.62	650.21	690.65	181.41	696.46	5792.22
EAF [%]	70.77	96.19	100.00	35.07	0.00	30.61	96.20	96.31	100.00	100.00	26.83	99.27	71.05
UCF [%]	70.77	96.19	100.00	35.07	0.00	30.61	100.00	99.69	100.00	100.00	26.83	99.27	71.66
LF [%]	72.72	99.52	102.97	35.18	0.00	30.56	96.20	96.31	98.70	101.45	27.54	102.31	72.07
OF [%]	72.85	96.84	100.00	38.06	0.00	31.39	100.00	100.00	100.00	100.00	26.94	99.87	72.28
FLR [%]	29.23	3.81	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	3.77
UCL [%]	29.23	3.81	0.00	0.00	0.00	6.30	0.00	0.31	0.00	0.00	0.00	0.00	3.32
PUF [%]	0.00	0.00	0.00	64.93	100.00	63.09	0.00	0.00	0.00	0.00	73.17	0.73	25.02
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	3.80	3.38	0.00	0.00	0.00	0.00	0.61

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Historical Summary

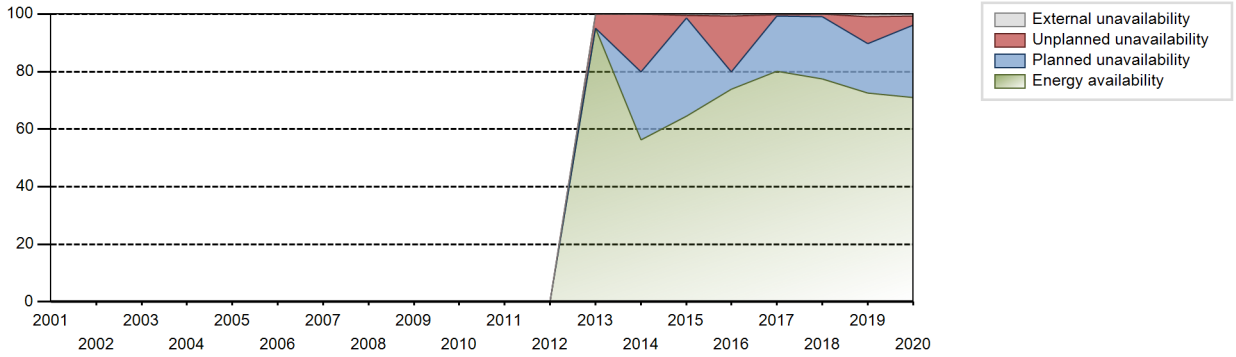
Lifetime energy generation	:	42712.13 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.45 %
Cumulative Energy Availability Factor (EAF)	:	71.67 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.64 %
Cumulative Unit Capability Factor (UCF)	:	72.11 %	Cumulative Planned Unavailability Factor (PUF)	:	20.25 %
Cumulative Load Factor (LF)	:	67.21 %	Cumulative Externally cause unavailability (XUF)	:	0.44 %
Cumulative Operating Factor (OF)	:	70.27 %			

Electricity Production (net) [GWh]

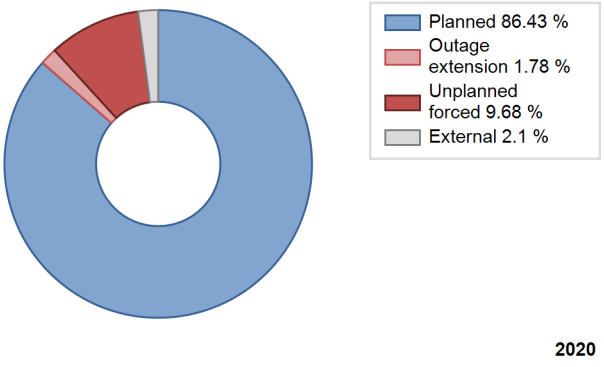


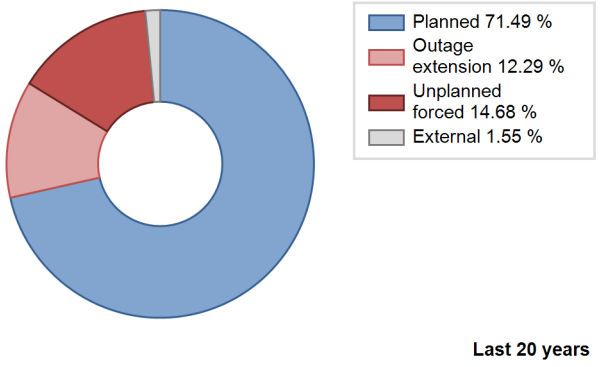
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2013	3893.67	4523	915	95.11	95.11	95.43	95.47	4.89	4.89	0.00	0.00
2014	3723.60	5181	915	56.36	56.40	46.46	59.14	8.50	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2013 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		224			558	
C. Inspection, maintenance or repair combined with refuelling	1634			1608		
D. Inspection, maintenance or repair without refuelling	527			144		
E. Testing of plant systems or components				2		
J. Grid limitation, failure or grid unavailability						13
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						258
L. Human factor related					25	
Z. Other		46			6	
Subtotal	2161	270		1754	589	271
Total	**2431**			**2614**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2013 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		18
15. Reactor Cooling Systems		108
16. Steam generation systems		12
31. Turbine and auxiliaries	224	114
32. Feedwater and Main Steam System		13
33. Circulating Water System		175
34. Miscellaneous Systems		4
41. Main Generator Systems		80
42. Electrical Power Supply Systems		7
Total	**224**	**531**

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2020 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	:	27 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

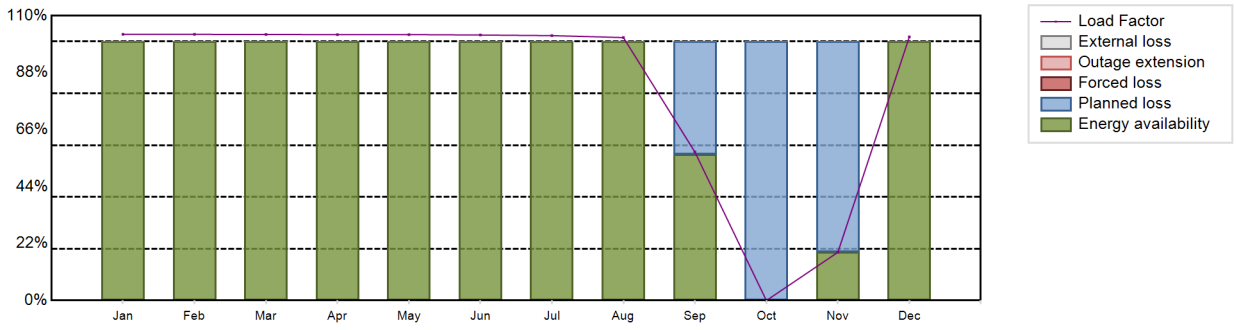
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	325
Number of SG	:	4
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	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	:	DS

Annual Production Results (2020)

Net Energy Production	:	8236.08 GW(e).h
Energy Availability Factor (EAF)	:	81.29 %
Unit Capability Factor (UCF)	:	81.29 %
Load Factor (LF)	:	83.2 %
Operating Factor (OF)	:	81.82 %
Equivalent non-electrical energy generated (NEG)	:	4.1 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	18.71 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1597 hours

Annual Summary



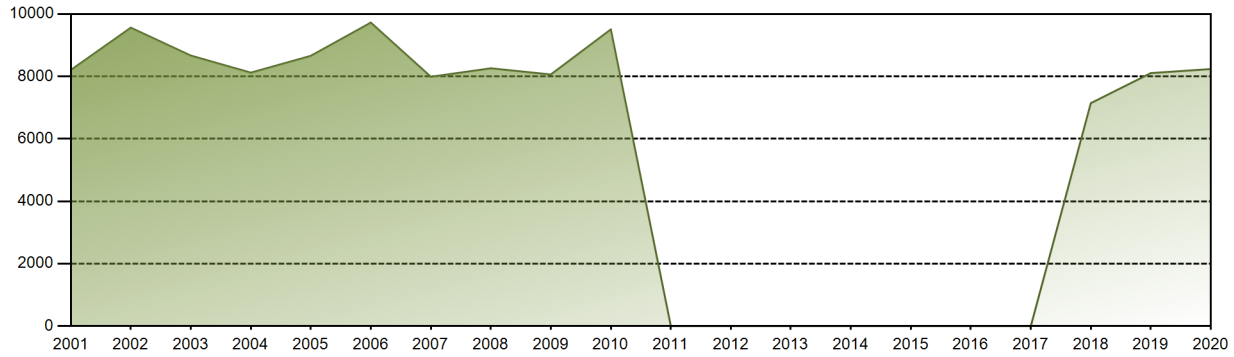
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	861.91	806.36	861.40	833.38	861.23	832.00	857.85	851.61	465.49	0.00	151.19	853.67	8236.09
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	56.36	0.00	18.69	100.00	81.29
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	56.36	0.00	18.69	100.00	81.29
LF [%]	102.79	102.80	102.73	102.70	102.71	102.53	102.31	101.56	57.37	0.00	18.63	101.81	83.20
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	56.81	0.00	24.72	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	0.00	0.00	0.00	0.00	43.64	100.00	81.31	0.00	18.71
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

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Historical Summary

Lifetime energy generation	:	172860.08 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.33 %
Cumulative Energy Availability Factor (EAF)	:	61.95 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.2 %
Cumulative Unit Capability Factor (UCF)	:	61.95 %	Cumulative Planned Unavailability Factor (PUF)	:	37.85 %
Cumulative Load Factor (LF)	:	62.91 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	62.23 %			

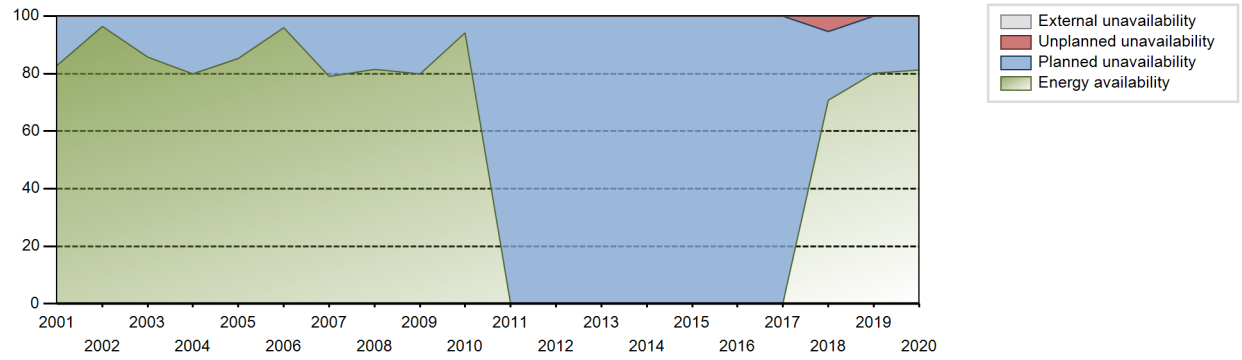
Electricity Production (net) [GWh]



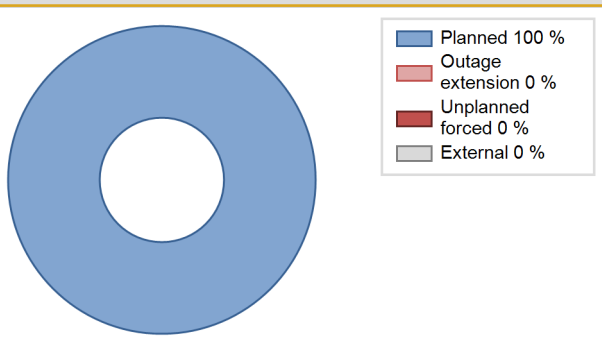
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1994	8795.82	7828	1127	96.91	96.91	97.39	97.00	0.00	0.00	3.09	0.00
1995	7356.33	6588	1127	74.14	74.14	74.51	75.21	0.00	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

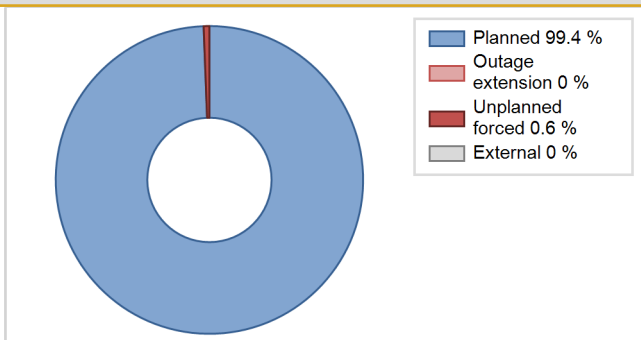
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1994 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					16	
C. Inspection, maintenance or repair combined with refuelling	1597			1017		
G. Major backfitting, refurbishment or upgrading activities without refuelling				2282		
Subtotal	1597			3299	16	
Total	**1597**			**3315**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1994 to 2020
	Hours Lost	Average hours lost per reactor-year
32. Feedwater and Main Steam System		16
Total		**16**

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2020 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

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	:	1992-07-15
Grid Date	:	1996-11-12
Commercial Date	:	1997-07-25
Age at end of year	:	24 years

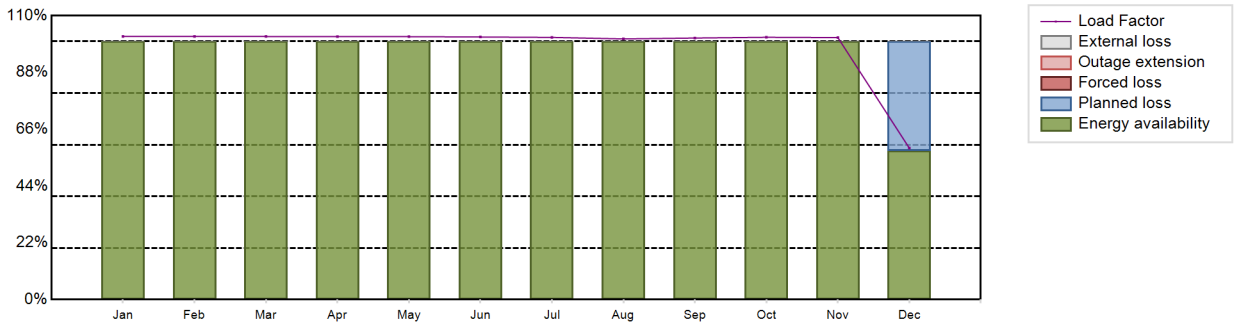
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.1
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	46
Average discharge burnup [MWd/t]	:	44000
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	:	DS

Annual Production Results (2020)

Net Energy Production	:	9703.45 GW(e).h
Energy Availability Factor (EAF)	:	96.42 %
Unit Capability Factor (UCF)	:	96.42 %
Load Factor (LF)	:	98.02 %
Operating Factor (OF)	:	96.46 %
Equivalent non-electrical energy generated (NEG)	:	1.39 GW(e).h
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	3.58 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	311 hours

Annual Summary



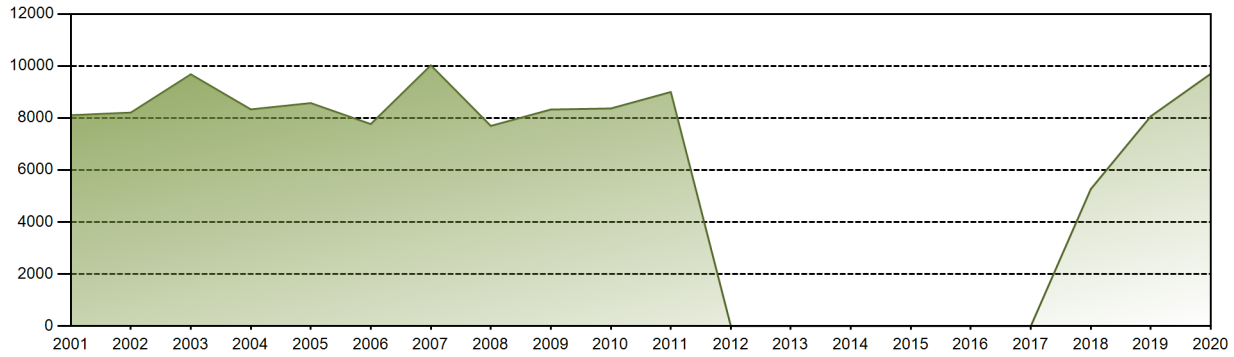
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	854.57	799.52	854.51	826.93	854.09	825.51	851.76	846.79	822.17	852.06	823.54	492.00	9703.45
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	57.76	96.42
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	57.76	96.42
LF [%]	101.92	101.93	101.91	101.91	101.86	101.73	101.58	100.99	101.32	101.62	101.49	58.68	98.02
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	58.20	96.46
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	42.24	3.58
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

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Historical Summary

Lifetime energy generation	:	148909.45 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.1 %
Cumulative Energy Availability Factor (EAF)	:	62.57 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.7 %
Cumulative Unit Capability Factor (UCF)	:	62.57 %	Cumulative Planned Unavailability Factor (PUF)	:	36.74 %
Cumulative Load Factor (LF)	:	63.46 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	62.83 %			

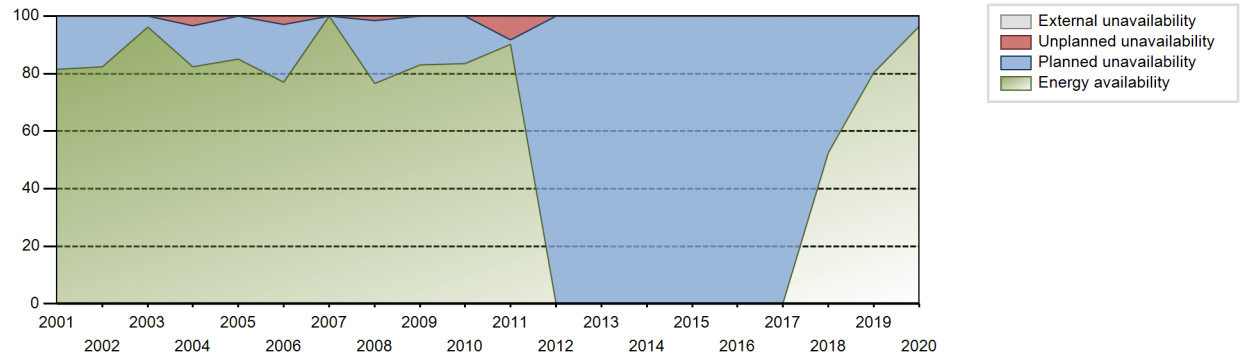
Electricity Production (net) [GWh]



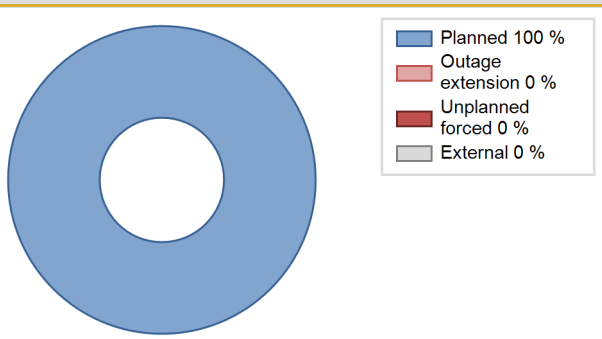
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1997	5841.01	5901	1127	99.99	99.99	100.73	100.00	0.00	0.00	0.01	0.00
1998	7634.53	6783	1127	76.75	76.75	77.33	77.43	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

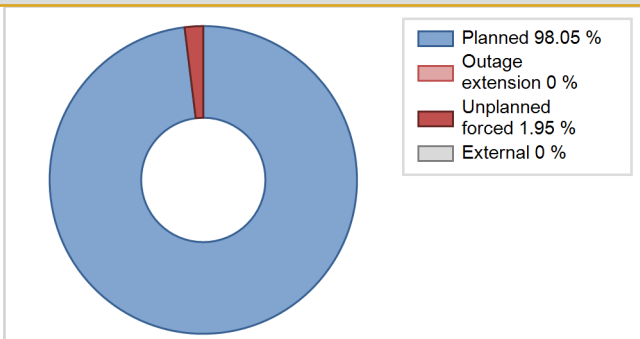
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1997 to 2020 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	311			914		
G. Major backfitting, refurbishment or upgrading activities without refuelling				2351		
Subtotal	311			3265	59	
Total	**311**			**3324**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1997 to 2020 Average hours lost per reactor-year
15. Reactor Cooling Systems		10
31. Turbine and auxiliaries		30
41. Main Generator Systems		19
Total		**59**

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2020 Operating Experience

JP-36 HAMAOKA-3 JAPAN



Status at end of year	:	**Operational**
Operator	:	CHUBU (CHUBU ELECTRIC POWER CO., INC.)
Owner	:	CHUBU (CHUBU ELECTRIC POWER CO., INC.)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1100 MWe
Reference unit power (net)	:	1056 MWe

Key Dates

Construction Date	:	1983-04-18
Grid Date	:	1987-01-20
Commercial Date	:	1987-08-28
Age at end of year	:	33 years

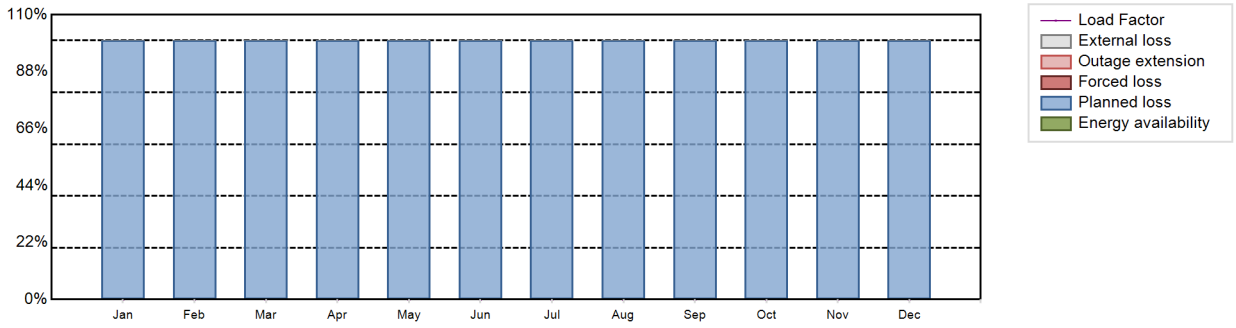
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.0
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	25
Average discharge burnup [MWd/t]	:	29500
Active core diameter [m]	:	4.75
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	18
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	6.93
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	:	3
HP cylinder inlet steam pressure [MPa]	:	6.55
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



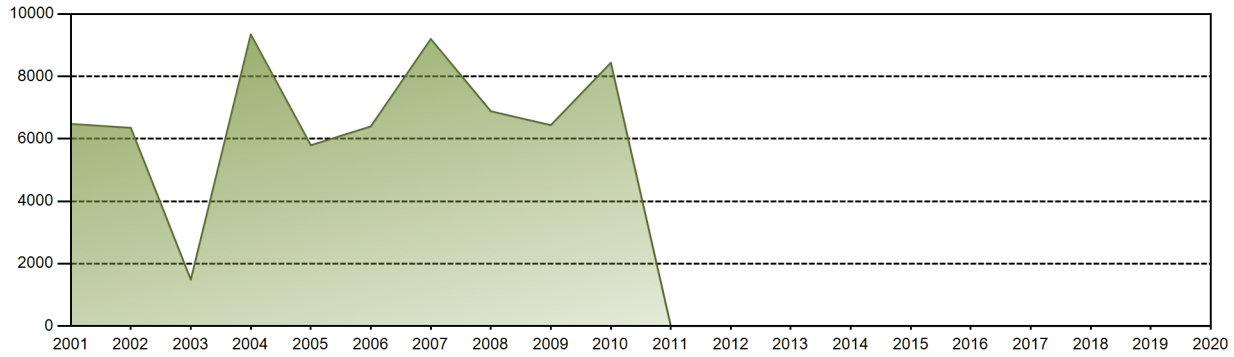
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	171104 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.8 %
Cumulative Energy Availability Factor (EAF)	:	54.73 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.15 %
Cumulative Unit Capability Factor (UCF)	:	54.82 %	Cumulative Planned Unavailability Factor (PUF)	:	40.02 %
Cumulative Load Factor (LF)	:	54.39 %	Cumulative Externally cause unavailability (XUF)	:	0.09 %
Cumulative Operating Factor (OF)	:	55.07 %			

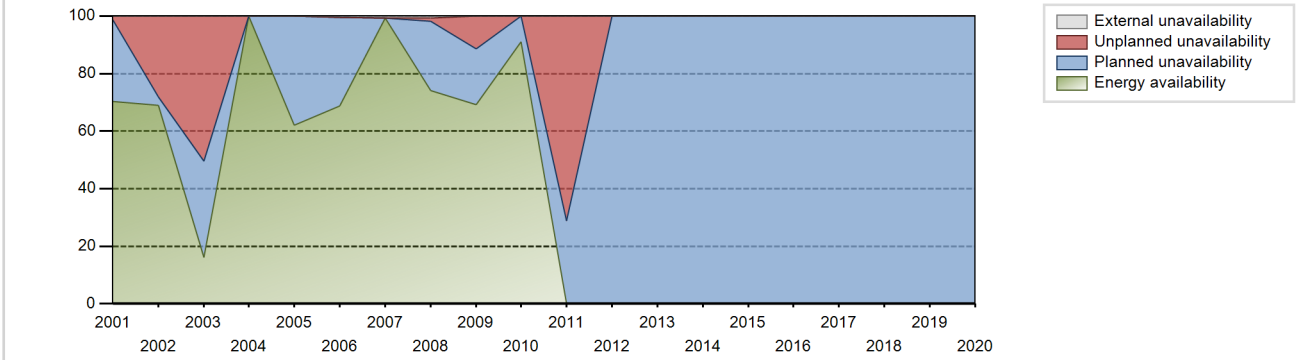
Electricity Production (net) [GWh]



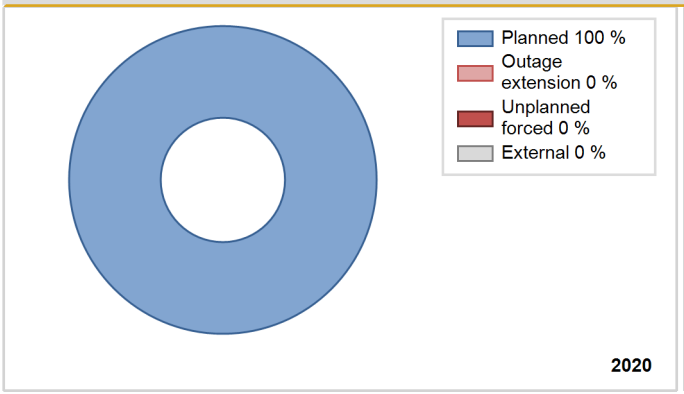
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	5586.64	6360	1066	99.37	99.37	98.37	100.00	0.00	0.00	0.63	0.00
1988	7066.77	6862	1066	75.79	75.79	75.47	78.12	0.00	0.00	24.21	0.00
1989	8541.99	8167	1066	92.38	92.38	91.47	93.23	7.24	7.21	0.41	0.00
1990	6601.27	6366	1056	71.36	71.36	71.36	72.67	0.00	0.00	28.64	0.00
1991	6763.14	6472	1056	73.47	73.50	73.11	73.88	0.00	0.00	26.50	0.03
1992	6585.40	6371	1056	71.37	71.69	70.99	72.53	0.00	0.00	28.31	0.32
1993	8767.99	8359	1056	95.33	95.33	94.78	95.42	0.00	0.00	4.67	0.00
1994	6490.47	6784	1056	77.43	77.43	70.16	77.44	0.00	0.00	22.57	0.00
1995	7725.72	7429	1056	84.11	84.65	83.52	84.81	0.00	0.00	15.35	0.53
1996	6891.56	6573	1056	74.72	74.82	74.30	74.83	0.00	0.00	25.18	0.09
1997	8109.71	7863	1056	88.32	88.32	87.67	89.76	1.32	1.19	10.50	0.00
1998	9200.69	8760	1056	100.00	100.00	99.46	100.00	0.00	0.00	0.00	0.00
1999	7618.28	7255	1056	82.81	82.81	82.35	82.82	0.00	0.00	17.19	0.00
2000	7705.98	7340	1056	83.56	83.56	83.08	83.56	0.00	0.00	16.44	0.00
2001	6476.81	6171	1056	70.42	70.44	70.02	70.45	1.91	1.37	28.19	0.02
2002	6350.93	6044	1056	68.99	68.99	68.65	69.00	28.89	28.02	2.99	0.00
2003	1486.62	1403	1056	16.14	16.14	16.07	16.02	45.91	50.41	33.45	0.00
2004	9342.48	8784	1056	100.00	100.00	100.72	100.00	0.00	0.00	0.00	0.00
2005	5793.39	5473	1056	62.12	62.18	62.63	62.48	0.00	0.00	37.82	0.05
2006	6396.90	6081	1056	68.72	69.19	69.15	69.42	0.00	0.00	30.81	0.47
2007	9196.54	8760	1056	99.19	99.99	99.42	100.00	0.00	0.00	0.01	0.80
2008	6882.87	6625	1056	74.05	74.81	74.20	75.42	1.48	1.12	24.07	0.76
2009	6437.10	6085	1056	69.22	69.22	69.59	69.46	0.00	11.43	19.35	0.00
2010	8434.81	7974	1056	90.98	90.98	91.18	91.03	0.00	0.00	9.02	0.00
2011	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	71.23	28.77	0.00
2012	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1056	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

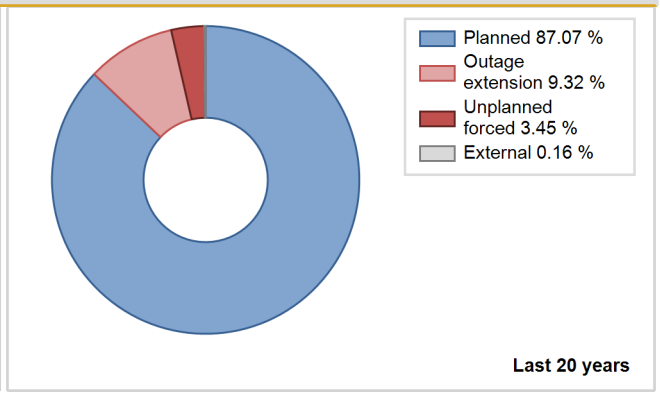
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 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				1085		
D. Inspection, maintenance or repair without refuelling				21	4	
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			2367		
H. Nuclear regulatory requirements					187	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)					30	
Z. Other					110	
Subtotal	8784			3473	468	
Total	**8784**			**3941**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		115
15. Reactor Cooling Systems		108
31. Turbine and auxiliaries		2
34. Miscellaneous Systems		17
35. All other I&C Systems		0
Total		**242**

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2020 Operating Experience

JP-49 HAMAOKA-4 JAPAN



Status at end of year	:	**Operational**
Operator	:	CHUBU (CHUBU ELECTRIC POWER CO., INC.)
Owner	:	CHUBU (CHUBU ELECTRIC POWER CO., INC.)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1137 MWe
Reference unit power (net)	:	1092 MWe

Key Dates

Construction Date	:	1989-10-13
Grid Date	:	1993-01-27
Commercial Date	:	1993-09-03
Age at end of year	:	27 years

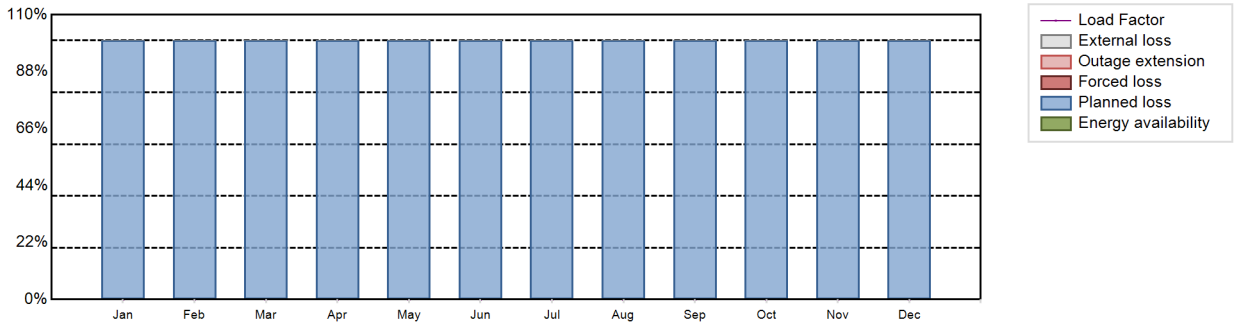
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.44
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	25
Average discharge burnup [MWd/t]	:	39500
Active core diameter [m]	:	4.75
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	18
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	6.93
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	:	3
HP cylinder inlet steam pressure [MPa]	:	6.55
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



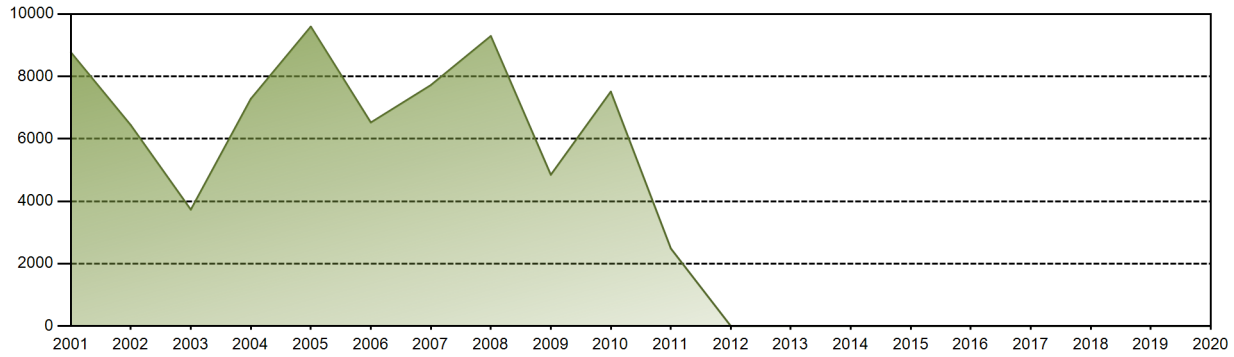
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	130349 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.98 %
Cumulative Energy Availability Factor (EAF)	:	51.66 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.78 %
Cumulative Unit Capability Factor (UCF)	:	52.09 %	Cumulative Planned Unavailability Factor (PUF)	:	44.12 %
Cumulative Load Factor (LF)	:	51.65 %	Cumulative Externally cause unavailability (XUF)	:	0.43 %
Cumulative Operating Factor (OF)	:	52 %			

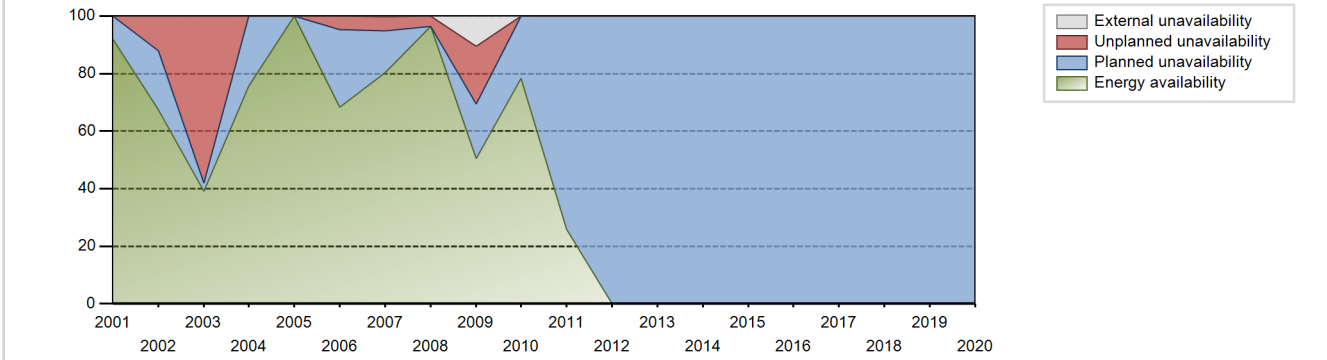
Electricity Production (net) [GWh]



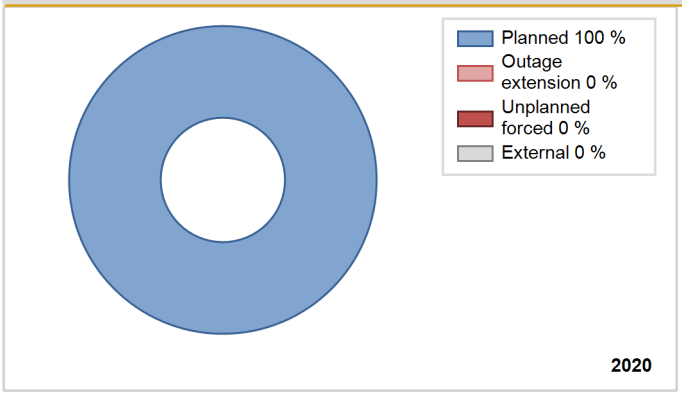
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	5877.56	6326	1092	99.93	99.93	99.65	100.00	0.00	0.00	0.07	0.00
1994	7110.42	6576	1092	74.66	74.90	74.33	75.07	0.00	0.00	25.10	0.24
1995	9545.99	8760	1092	100.00	100.00	99.79	100.00	0.00	0.00	0.00	0.00
1996	8301.28	7615	1092	86.68	86.68	86.54	86.69	0.00	0.00	13.32	0.00
1997	7882.99	7302	1092	82.61	83.07	82.41	83.36	0.00	0.00	16.93	0.46
1998	7154.09	6604	1092	74.92	74.95	74.79	75.39	0.00	0.00	25.05	0.03
1999	9545.08	8760	1092	99.95	99.95	99.78	100.00	0.00	0.00	0.05	0.00
2000	8233.65	7577	1092	85.97	86.26	85.84	86.26	0.00	0.00	13.74	0.29
2001	8773.52	8046	1092	91.85	91.85	91.72	91.85	0.00	0.00	8.15	0.00
2002	6436.42	5906	1092	67.42	67.42	67.28	67.42	0.00	12.05	20.53	0.00
2003	3729.78	3415	1092	39.09	39.11	38.99	38.98	0.00	58.07	2.82	0.02
2004	7279.71	6668	1092	75.76	75.79	75.89	75.91	0.00	0.02	24.19	0.03
2005	9595.62	8760	1092	99.99	100.00	100.31	100.00	0.00	0.00	0.00	0.01
2006	6523.51	6423	1092	68.23	68.24	68.20	73.32	6.58	4.80	26.95	0.01
2007	7720.91	7098	1092	80.45	80.65	80.71	81.03	0.52	4.96	14.39	0.19
2008	9293.57	8512	1092	96.47	96.48	96.89	96.90	3.52	3.52	0.01	0.01
2009	4847.54	4480	1092	50.48	60.89	50.68	51.14	24.79	20.08	19.03	10.41
2010	7512.95	6870	1092	78.33	78.38	78.54	78.42	0.00	0.00	21.62	0.05
2011	2486.88	2297	1092	26.00	26.00	26.00	26.22	0.00	0.00	74.00	0.00
2012	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1092	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

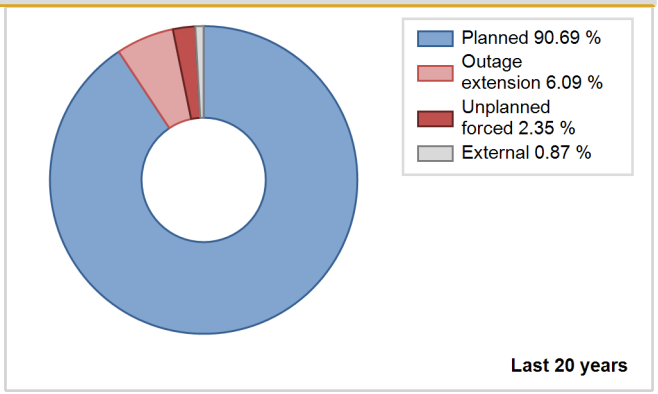
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1993 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					284	
C. Inspection, maintenance or repair combined with refuelling				753		
D. Inspection, maintenance or repair without refuelling				22		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			3129		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						33
Z. Other					39	
Subtotal	8784			3904	323	33
Total	**8784**			**4260**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1993 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		233
13. Reactor Auxiliary Systems		15
31. Turbine and auxiliaries		65
32. Feedwater and Main Steam System		10
Total		**323**

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2020 Operating Experience

JP-60 HAMAOKA-5 JAPAN



Status at end of year	:	**Operational**
Operator	:	CHUBU (CHUBU ELECTRIC POWER CO., INC.)
Owner	:	CHUBU (CHUBU ELECTRIC POWER CO., INC.)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / ABWR
Thermal power	:	3926 MWth
Gross electrical power	:	1380 MWe
Reference unit power (net)	:	1325 MWe

Key Dates

Construction Date	:	2000-07-12
Grid Date	:	2004-04-30
Commercial Date	:	2005-01-18
Age at end of year	:	16 years

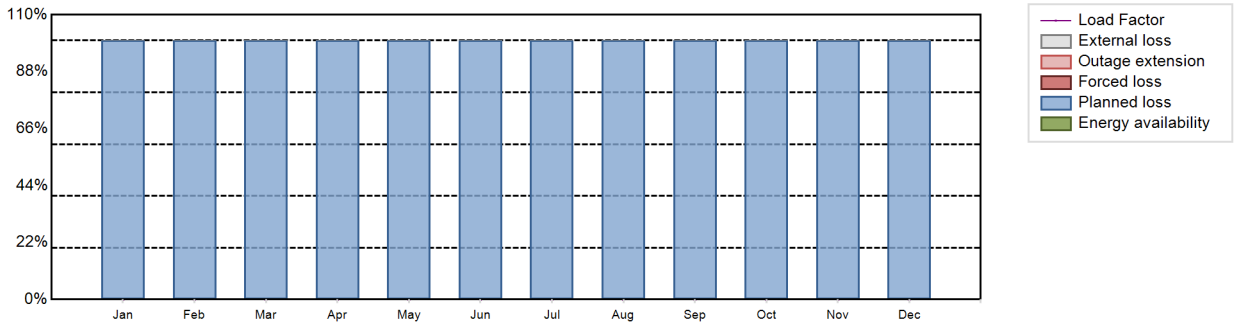
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.07
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]	:	0.31
Average fuel enrichment [% of U235]	:	3.7	**Secondary systems**		
Refuelling frequency [month]	:	13	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	25	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	45000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	5.16	HP cylinder inlet steam pressure [MPa]	:	6.69
Active core height/length [m]	:	3.71	Output voltage [kV]	:	22
Number of fissile fuel assemblies/bundles	:	872	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	16.5	Number of main condensate pumps	:	3
Number of control rod assemblies	:	205	Number of FW pumps for full power operation	:	2
Number of external reactor coolant loops	:	NA	Number of on-site safety related diesel generators	:	3
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

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	:	8784 hours

Annual Summary



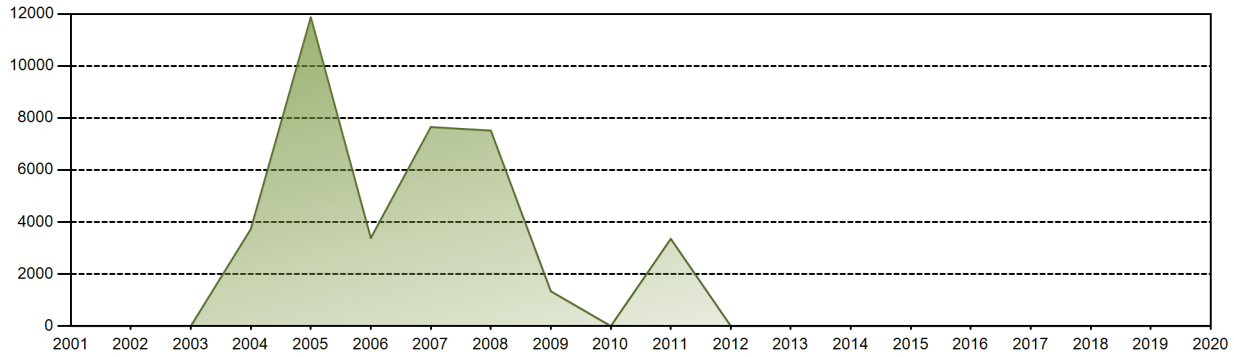
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

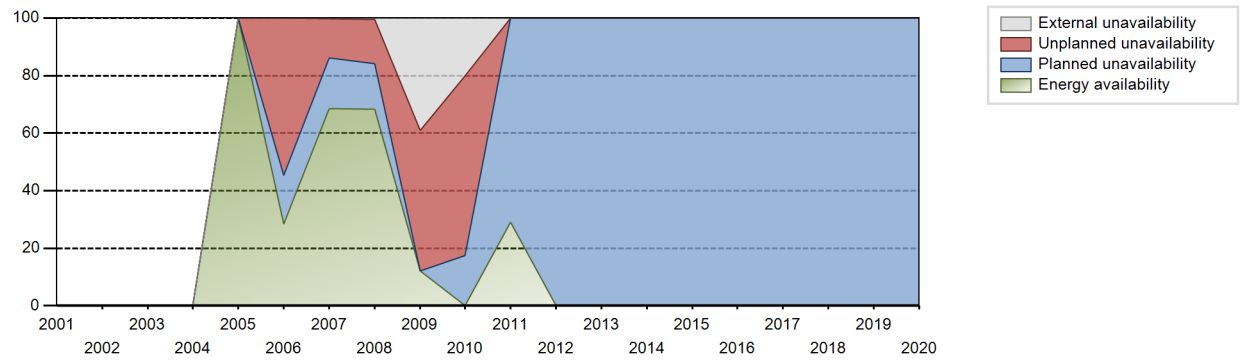
Lifetime energy generation	:	38950 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	24.69 %
Cumulative Energy Availability Factor (EAF)	:	18.37 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.74 %
Cumulative Unit Capability Factor (UCF)	:	21.88 %	Cumulative Planned Unavailability Factor (PUF)	:	66.38 %
Cumulative Load Factor (LF)	:	18.85 %	Cumulative Externally cause unavailability (XUF)	:	3.51 %
Cumulative Operating Factor (OF)	:	18.92 %			

Electricity Production (net) [GWh]



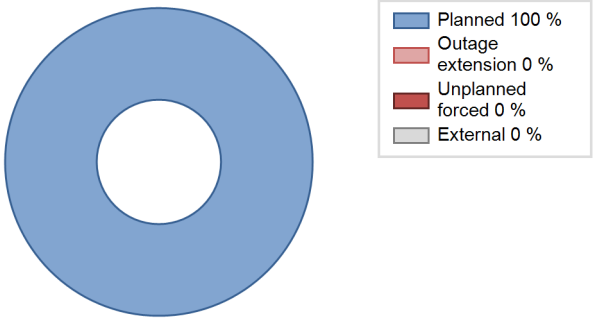
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2005	11870.42	8760	1325	100.00	100.00	102.23	100.00	0.00	0.00	0.00	0.00
2006	3385.19	2515	1325	28.51	28.51	29.17	28.71	65.74	54.69	16.81	0.00
2007	7652.74	6159	1212	68.64	68.83	71.01	70.31	16.47	13.58	17.60	0.18
2008	7516.25	6075	1212	68.33	68.80	70.60	69.16	0.00	15.32	15.89	0.47
2009	1338.27	1076	1212	12.17	51.29	12.60	12.28	48.71	48.70	0.00	39.12
2010	0.00	0	1212	0.00	20.00	0.00	0.00	0.00	62.47	17.53	20.00
2011	3353.43	2557	1325	29.11	29.11	29.10	29.19	0.00	0.00	70.89	0.00
2012	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1325	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

Key Factors in Last 20 Years [%]

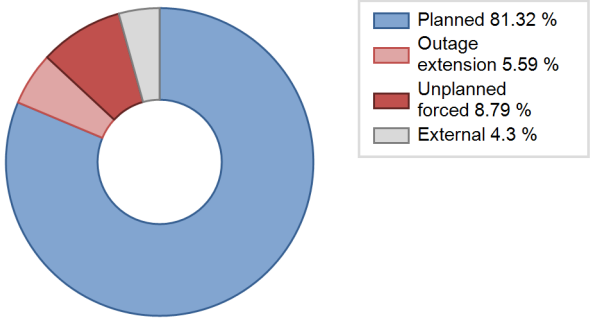


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2005 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					763	
C. Inspection, maintenance or repair combined with refuelling				293		
F. Major backfitting, refurbishment or upgrading activities with refuelling				146		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			5631		
H. Nuclear regulatory requirements					365	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						345
Subtotal	8784			6070	1128	345
Total	**8784**			**7543**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2005 to 2020 Average hours lost per reactor-year
31. Turbine and auxiliaries		763
Total		**763**

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2020 Operating Experience

JP-58 HIGASHI DORI-1 (TOHOKU) JAPAN



Status at end of year	:	**Operational**
Operator	:	TOHOKU (Tohoku Electric Power Co., Inc)
Owner	:	TOHOKU (Tohoku Electric Power Co., Inc)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	TOSHIBA (TOSHIBA CORPORATION)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1100 MWe
Reference unit power (net)	:	1067 MWe

Key Dates

Construction Date	:	2000-11-07
Grid Date	:	2005-03-09
Commercial Date	:	2005-12-08
Age at end of year	:	15 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]	:	3.7
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	25
Average discharge burnup [MWd/t]	:	45000
Active core diameter [m]	:	4.75
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	15.8
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

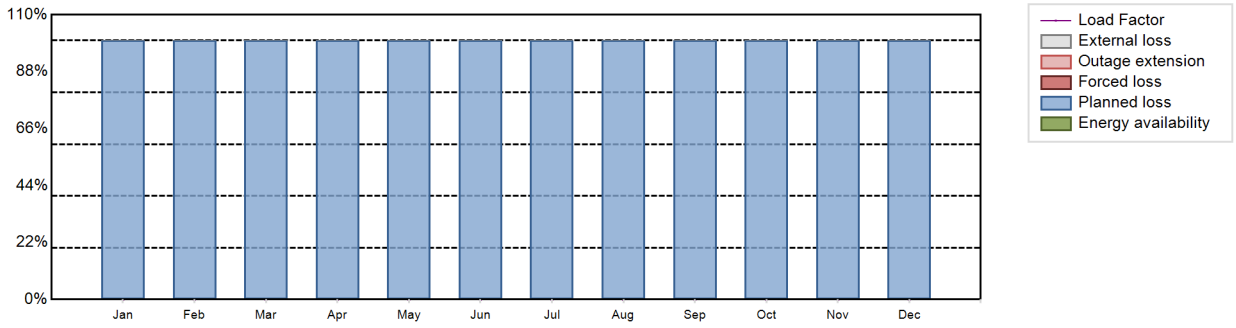
Operating coolant pressure [MPa]	:	6.93
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.43
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	6.55
Output voltage [kV]	:	19
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



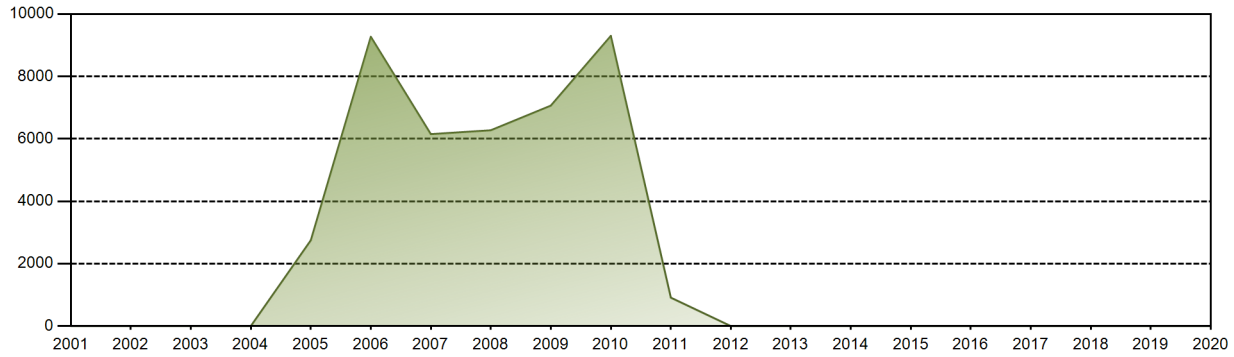
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

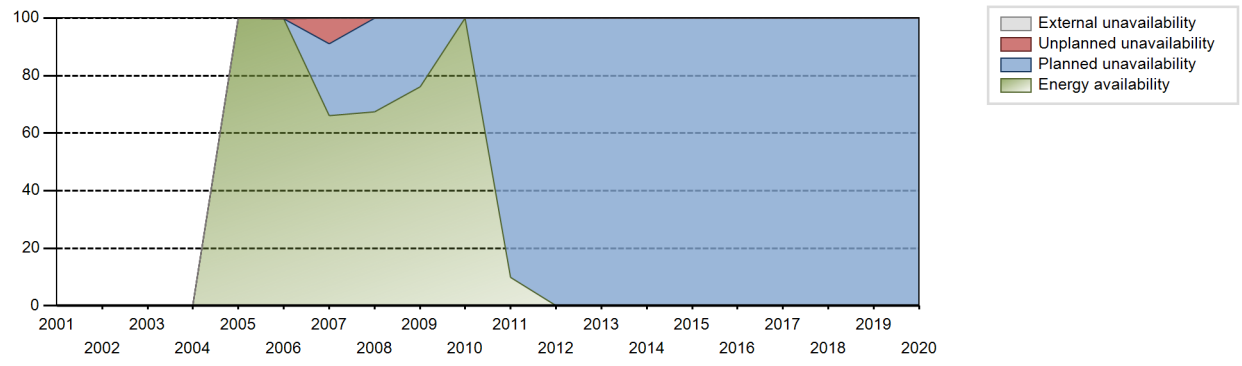
Lifetime energy generation	:	41897 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	28.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.59 %
Cumulative Unit Capability Factor (UCF)	:	28.35 %	Cumulative Planned Unavailability Factor (PUF)	:	71.05 %
Cumulative Load Factor (LF)	:	28.05 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	28.31 %			

Electricity Production (net) [GWh]



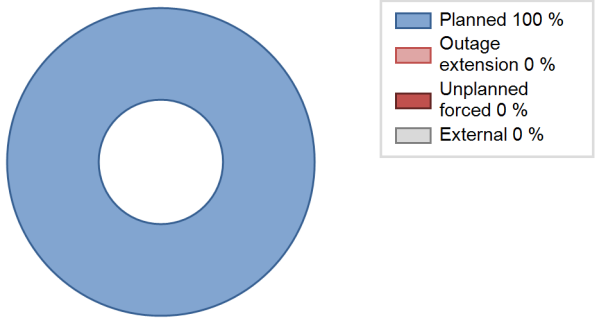
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2005	2749.61	3536	1067	100.00	100.00	76.90	77.42	0.00	0.00	0.00	0.00
2006	9269.32	8760	1067	99.74	100.00	99.17	100.00	0.00	0.00	0.00	0.26
2007	6150.83	5827	1067	66.18	66.18	65.81	66.52	0.00	8.93	24.90	0.00
2008	6274.76	5947	1067	67.31	67.31	66.95	67.70	0.00	0.00	32.69	0.00
2009	7064.53	6696	1067	76.03	76.07	75.58	76.44	0.00	0.00	23.93	0.03
2010	9298.98	8760	1067	100.00	100.00	99.49	100.00	0.00	0.00	0.00	0.00
2011	911.00	865	1067	9.81	9.81	9.75	9.87	0.00	0.00	90.19	0.00
2012	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

Key Factors in Last 20 Years [%]

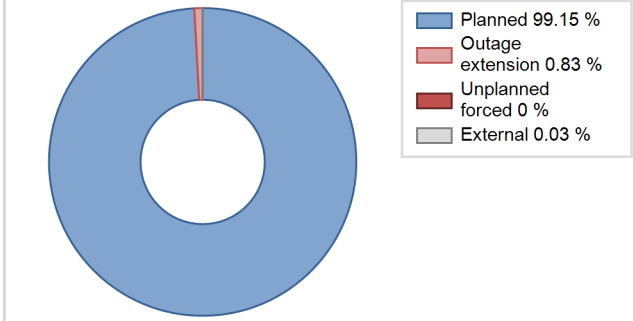


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2005 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling				649	52	
D. Inspection, maintenance or repair without refuelling				99		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			5510		
Subtotal	8784			6258	52	
Total	**8784**			**6310**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2005 to 2020
	Hours Lost	Average hours lost per reactor-year
Total		

Highlights (2020)

Implementation of safety measure for considering the new regulatory requirements.

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2020 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

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	:	1990-10-01
Grid Date	:	1994-03-29
Commercial Date	:	1994-12-15
Age at end of year	:	26 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]	:	4.8
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	48000
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

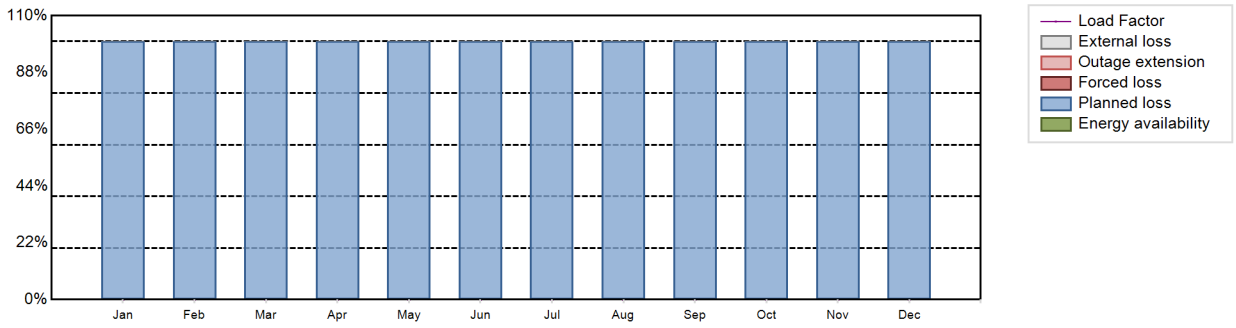
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.283
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	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	:	4
Non-electrical applications	:	DS

Annual Production Results (2020)

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 %
Equivalent non-electrical energy generated (NEG)	:	3.57 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



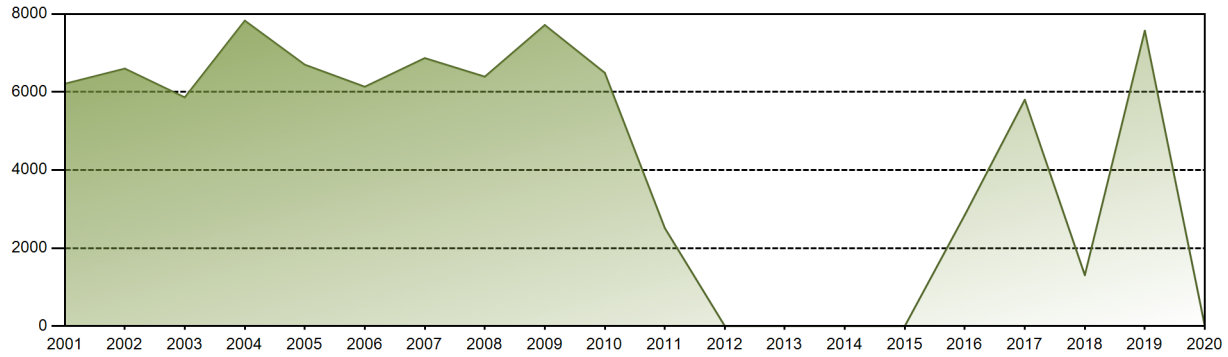
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	125606 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.78 %
Cumulative Energy Availability Factor (EAF)	:	66.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.76 %
Cumulative Unit Capability Factor (UCF)	:	66.3 %	Cumulative Planned Unavailability Factor (PUF)	:	32.95 %
Cumulative Load Factor (LF)	:	65.08 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	63.33 %			

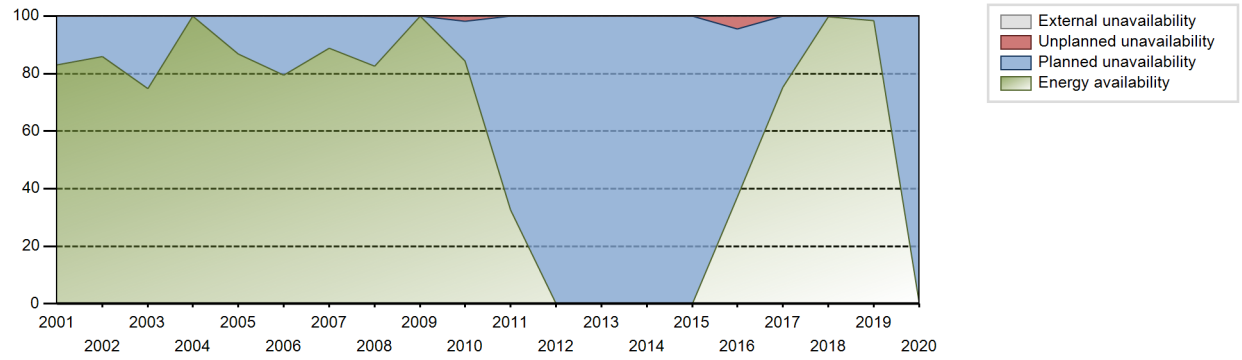
Electricity Production (net) [GWh]



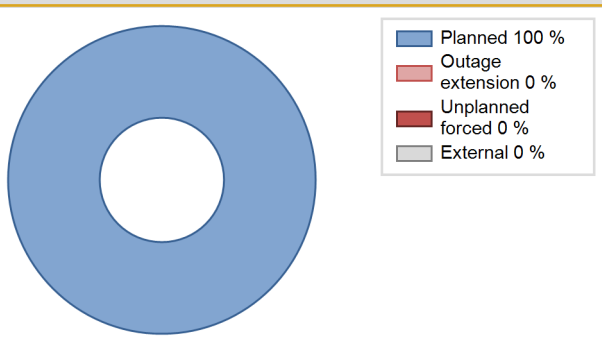
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1994	2195.52	3669	846	100.00	100.00	101.17	100.00	0.00	0.00	0.00	0.00
1995	7491.81	8760	846	99.99	99.99	101.09	100.00	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

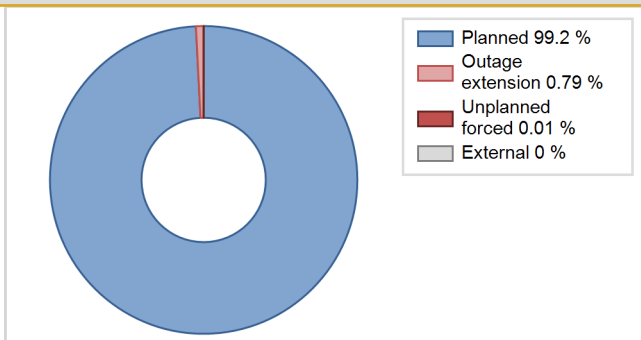
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1994 to 2020 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	8784			1212		
G. Major backfitting, refurbishment or upgrading activities without refuelling				1786		
M. Governmental requirements or court decisions						290
Z. Other					22	
Subtotal	8784			2998	69	290
Total	**8784**			**3357**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1994 to 2020 Average hours lost per reactor-year
15. Reactor Cooling Systems		16
41. Main Generator Systems		10
42. Electrical Power Supply Systems		38
Total		**64**

Highlights (2020)

Prolonged periodical inspection and refueling due to the court decision.

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2020 Operating Experience

JP-33 KASHIWAZAKI KARIWA-1 JAPAN



Status at end of year	:	**Operational**
Operator	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Owner	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	TOSHIBA (TOSHIBA CORPORATION)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1100 MWe
Reference unit power (net)	:	1067 MWe

Key Dates

Construction Date	:	1980-06-05
Grid Date	:	1985-02-13
Commercial Date	:	1985-09-18
Age at end of year	:	35 years

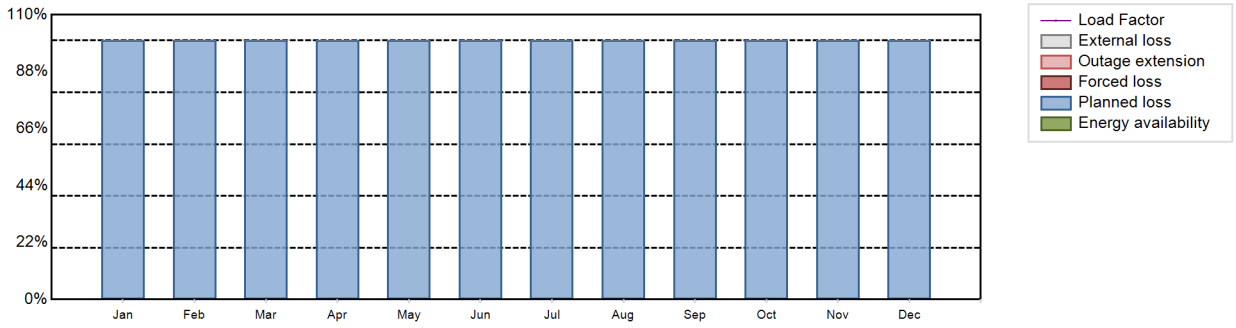
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.70
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	24
Average discharge burnup [MWd/t]	:	45000
Active core diameter [m]	:	4.75
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	18.6
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.07
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.28
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]	:	6.55
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



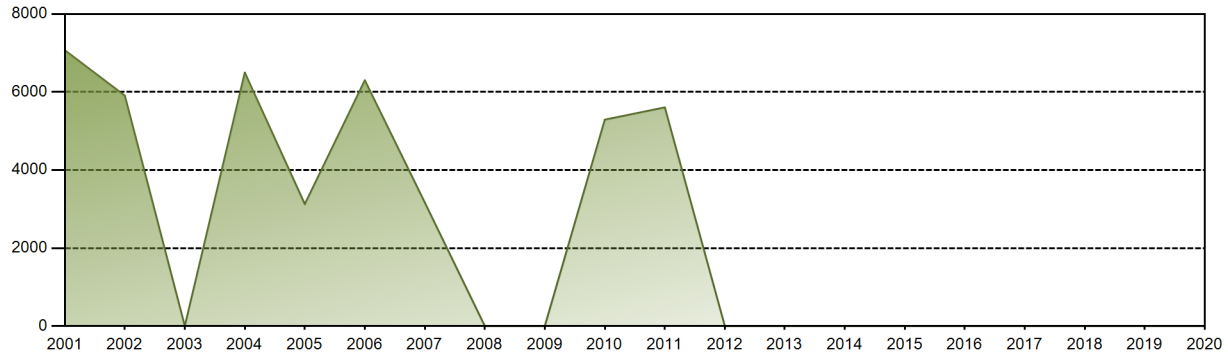
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	160133 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.09 %
Cumulative Energy Availability Factor (EAF)	:	48.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.56 %
Cumulative Unit Capability Factor (UCF)	:	49.11 %	Cumulative Planned Unavailability Factor (PUF)	:	47.33 %
Cumulative Load Factor (LF)	:	47.77 %	Cumulative Externally cause unavailability (XUF)	:	0.82 %
Cumulative Operating Factor (OF)	:	48.6 %			

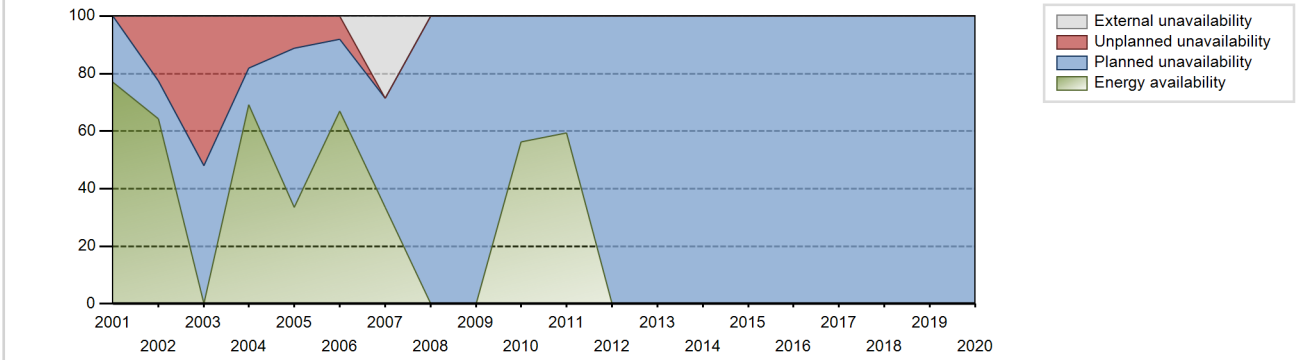
Electricity Production (net) [GWh]



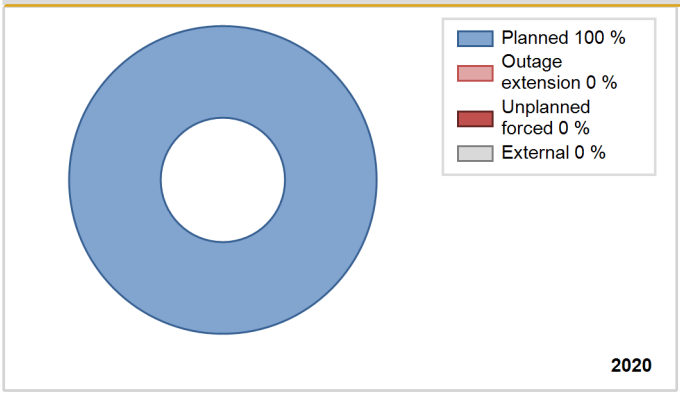
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	4960.19	5793	1067	100.00	100.00	98.80	100.00	0.00	0.00	0.00	0.00
1986	6703.73	6463	1067	73.03	73.03	71.72	73.78	0.00	0.00	26.97	0.00
1987	9195.47	8760	1067	100.00	100.00	98.38	100.00	0.00	0.00	0.00	0.00
1988	6959.75	6660	1067	75.04	75.04	74.26	75.82	0.00	0.00	24.96	0.00
1989	6442.33	6236	1067	69.67	69.67	68.92	71.19	0.00	0.00	30.33	0.00
1990	5987.40	5711	1067	64.97	64.97	64.06	65.19	0.00	0.00	35.03	0.00
1991	9031.56	8618	1067	97.86	97.86	96.63	98.38	0.00	0.00	2.14	0.00
1992	6958.10	6728	1067	75.37	75.84	74.24	76.59	2.17	1.68	22.48	0.47
1993	6874.29	6575	1067	74.74	74.74	73.55	75.06	0.00	0.00	25.26	0.00
1994	7020.25	6744	1067	76.11	76.11	75.11	76.99	0.00	0.00	23.89	0.00
1995	9235.21	8760	1067	99.99	99.99	98.80	100.00	0.00	0.00	0.01	0.00
1996	6814.36	6469	1067	73.64	73.64	72.71	73.65	0.00	0.00	26.36	0.00
1997	7899.88	7525	1067	85.68	85.68	84.52	85.90	0.25	0.22	14.10	0.00
1998	6176.21	5960	1067	67.36	67.36	66.08	68.04	14.53	11.46	21.18	0.00
1999	9198.85	8760	1067	99.68	99.75	98.42	100.00	0.25	0.25	0.00	0.06
2000	7714.74	7346	1067	83.62	83.63	82.31	83.63	0.00	0.00	16.37	0.00
2001	7070.55	6743	1067	76.91	76.92	75.65	76.97	0.00	0.00	23.08	0.01
2002	5906.21	5628	1067	64.23	64.23	63.19	64.25	11.79	22.56	13.21	0.00
2003	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	52.07	47.93	0.00
2004	6496.73	6171	1067	69.21	69.21	69.32	70.25	4.89	18.05	12.74	0.00
2005	3125.94	3051	1067	33.53	33.53	33.44	34.83	25.16	11.27	55.20	0.00
2006	6299.43	5899	1067	67.07	67.07	67.40	67.34	0.00	8.11	24.82	0.00
2007	3165.81	2952	1067	33.64	62.14	33.87	33.70	0.00	0.00	37.86	28.49
2008	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2010	5290.82	5022	1067	56.31	56.31	56.60	57.33	0.00	0.00	43.69	0.00
2011	5605.55	5208	1067	59.38	59.38	59.97	59.45	0.00	0.00	40.62	0.00
2012	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

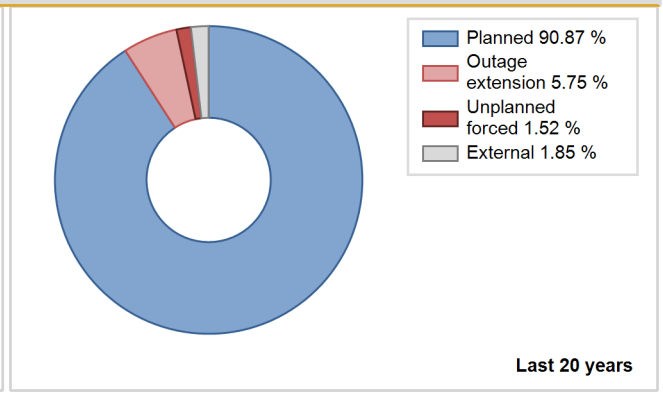
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	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				1215		
D. Inspection, maintenance or repair without refuelling				25		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			2924		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						71
Z. Other					52	
Subtotal	8784			4164	309	71
Total	**8784**			**4544**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		77
12. Reactor I&C Systems		130
15. Reactor Cooling Systems		31
32. Feedwater and Main Steam System		27
41. Main Generator Systems		6
Total		**271**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ichi Nuclear Power Stations.

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2020 Operating Experience

JP-39 KASHIWAZAKI KARIWA-2 JAPAN



Status at end of year	:	**Operational**
Operator	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Owner	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	TOSHIBA (TOSHIBA CORPORATION)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1100 MWe
Reference unit power (net)	:	1067 MWe

Key Dates

Construction Date	:	1985-11-18
Grid Date	:	1990-02-08
Commercial Date	:	1990-09-28
Age at end of year	:	30 years

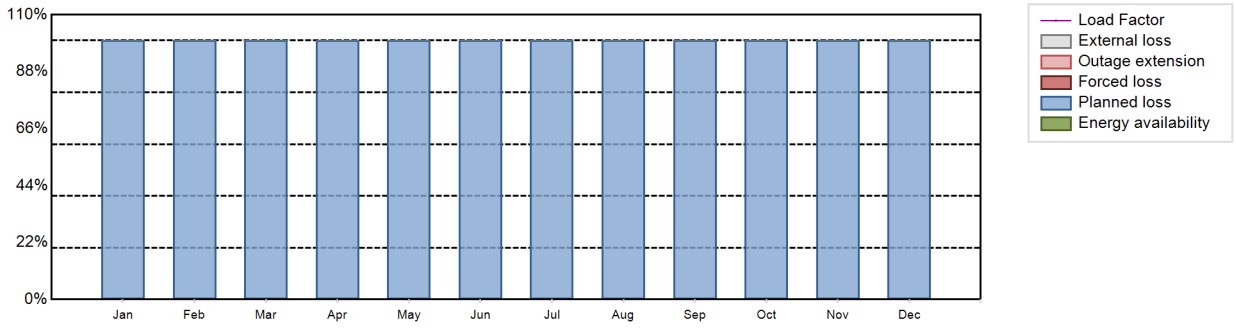
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.70
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	24
Average discharge burnup [MWd/t]	:	45000
Active core diameter [m]	:	4.75
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	18.6
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.07
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.31
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]	:	6.55
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



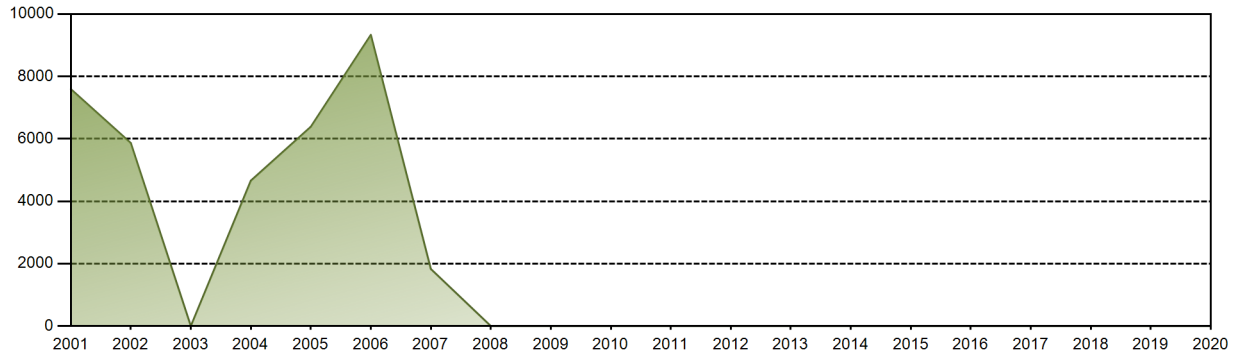
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	120879 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.48 %
Cumulative Energy Availability Factor (EAF)	:	41.64 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.62 %
Cumulative Unit Capability Factor (UCF)	:	41.65 %	Cumulative Planned Unavailability Factor (PUF)	:	53.73 %
Cumulative Load Factor (LF)	:	41.16 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	41.79 %			

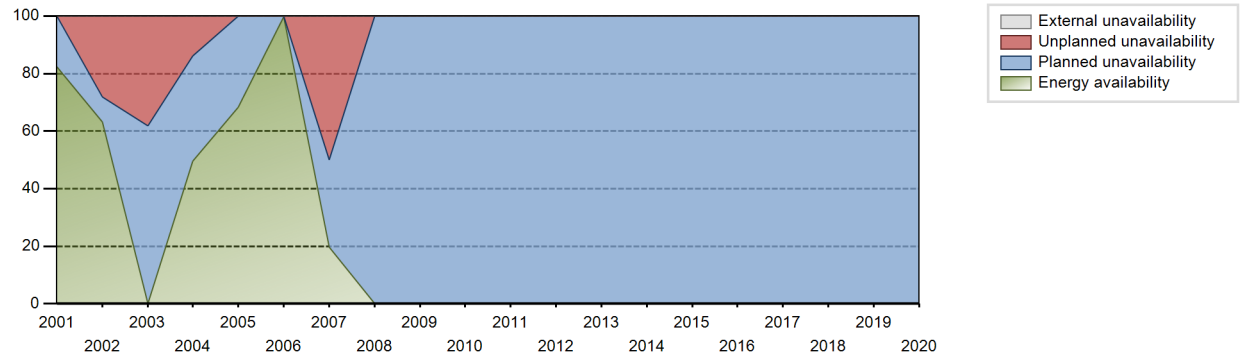
Electricity Production (net) [GWh]



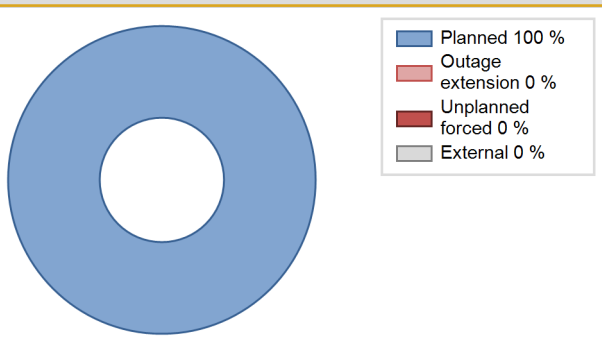
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	5386.27	6071	1067	100.00	100.00	98.64	100.00	0.00	0.00	0.00	0.00
1991	6642.43	6440	1067	72.39	72.39	71.07	73.52	3.01	2.24	25.37	0.00
1992	9046.85	8623	1067	97.93	97.94	96.53	98.17	2.00	2.00	0.06	0.01
1993	7212.57	6911	1067	78.27	78.48	77.17	78.89	0.00	0.00	21.52	0.21
1994	7291.14	6962	1067	79.05	79.05	78.01	79.47	0.00	0.00	20.95	0.00
1995	7696.75	7329	1067	83.43	83.43	82.35	83.66	0.00	0.00	16.57	0.00
1996	8811.08	8396	1067	95.24	95.25	94.01	95.58	0.00	0.00	4.75	0.01
1997	7284.36	6913	1067	79.08	79.08	77.93	78.92	2.76	2.24	18.68	0.00
1998	8142.05	7769	1067	88.43	88.43	87.11	88.69	0.00	0.00	11.57	0.00
1999	8208.83	7814	1067	89.15	89.20	87.82	89.20	0.00	0.00	10.80	0.05
2000	8140.00	7760	1067	88.25	88.27	86.85	88.34	3.73	3.42	8.30	0.02
2001	7595.48	7223	1067	82.45	82.45	81.26	82.45	0.00	0.00	17.55	0.00
2002	5866.21	5532	1067	63.12	63.12	62.76	63.15	30.77	28.05	8.82	0.00
2003	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	38.09	61.91	0.00
2004	4660.28	4361	1067	49.63	49.63	49.72	49.65	0.00	13.94	36.42	0.00
2005	6388.39	6035	1067	68.41	68.42	68.35	68.89	0.00	0.00	31.58	0.01
2006	9330.75	8760	1067	99.81	99.81	99.83	100.00	0.00	0.00	0.18	0.00
2007	1830.29	1786	1067	19.78	19.78	19.58	20.39	71.38	49.93	30.29	0.00
2008	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2010	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2011	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2012	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

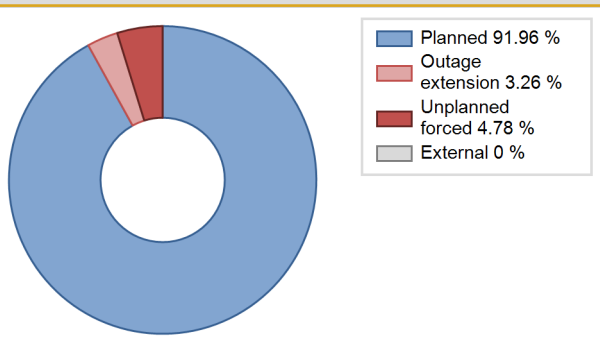
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1990 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					364	
C. Inspection, maintenance or repair combined with refuelling				936		
D. Inspection, maintenance or repair without refuelling				8		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			3799		
L. Human factor related					6	
Z. Other					42	
Subtotal	8784			4743	412	
Total	**8784**			**5155**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1990 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		2
13. Reactor Auxiliary Systems		7
15. Reactor Cooling Systems		193
31. Turbine and auxiliaries		167
Total		**369**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ichi Nuclear Power Stations.

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2020 Operating Experience

JP-52 KASHIWAZAKI KARIWA-3 JAPAN



Status at end of year	:	**Operational**
Operator	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Owner	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	TOSHIBA (TOSHIBA CORPORATION)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1100 MWe
Reference unit power (net)	:	1067 MWe

Key Dates

Construction Date	:	1989-03-07
Grid Date	:	1992-12-08
Commercial Date	:	1993-08-11
Age at end of year	:	28 years

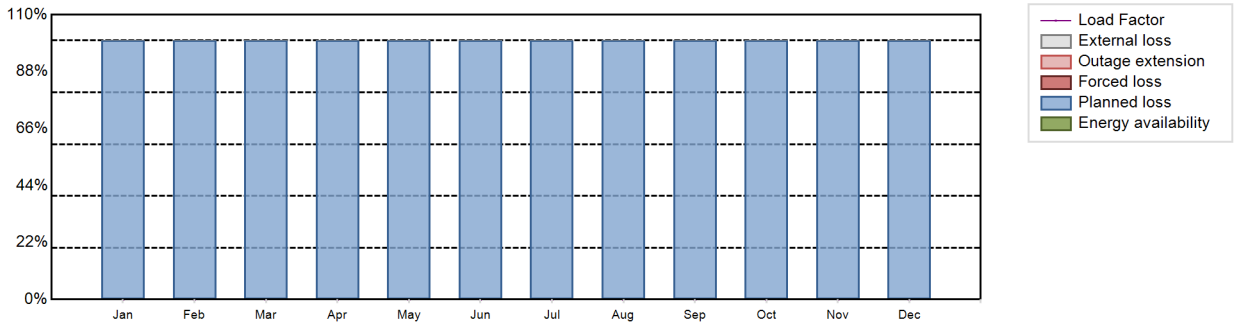
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.68
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	24
Average discharge burnup [MWd/t]	:	45000
Active core diameter [m]	:	4.75
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	18.6
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.07
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.31
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]	:	6.55
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



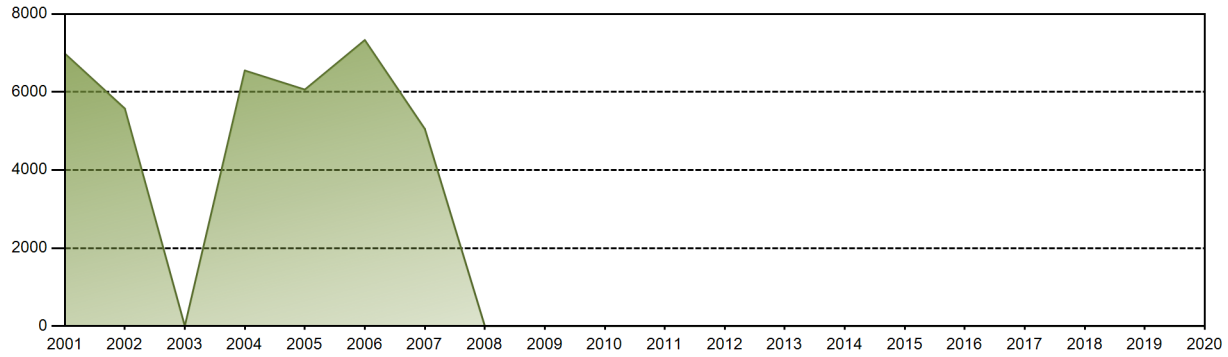
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	100277 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.53 %
Cumulative Energy Availability Factor (EAF)	:	38.39 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.99 %
Cumulative Unit Capability Factor (UCF)	:	39.04 %	Cumulative Planned Unavailability Factor (PUF)	:	56.97 %
Cumulative Load Factor (LF)	:	38.06 %	Cumulative Externally cause unavailability (XUF)	:	0.65 %
Cumulative Operating Factor (OF)	:	38.49 %			

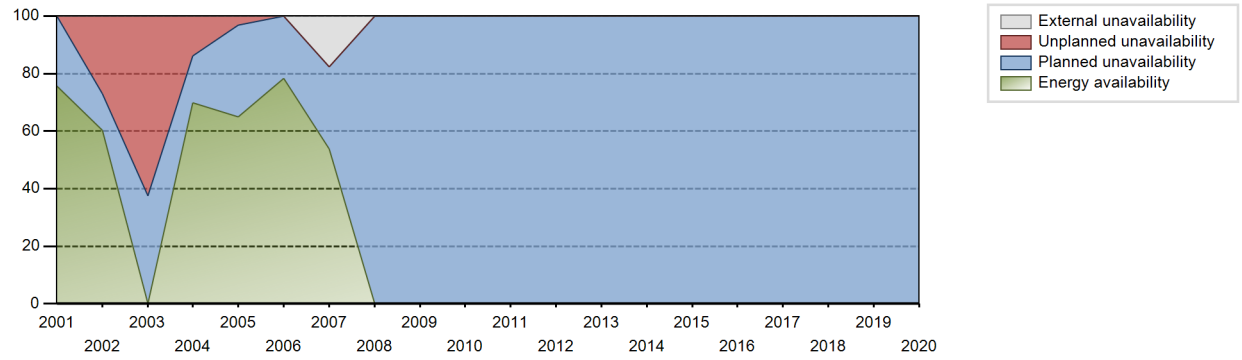
Electricity Production (net) [GWh]



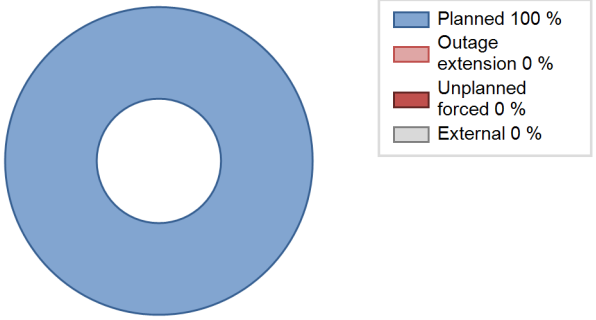
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	6488.42	6755	1067	100.00	100.00	98.92	100.00	0.00	0.00	0.00	0.00
1994	7264.43	6961	1067	78.92	78.92	77.72	79.46	0.00	0.00	21.08	0.00
1995	9253.86	8760	1067	100.00	100.00	99.00	100.00	0.00	0.00	0.00	0.00
1996	7921.58	7508	1067	85.47	85.47	84.52	85.47	0.00	0.00	14.53	0.00
1997	8016.22	7601	1067	86.76	86.76	85.76	86.77	0.00	0.00	13.24	0.00
1998	6748.02	6467	1067	73.09	73.09	72.20	73.82	3.78	2.87	24.03	0.00
1999	9028.26	8568	1067	97.68	97.75	96.59	97.81	0.00	0.00	2.25	0.07
2000	7945.09	7539	1067	85.82	85.82	84.77	85.83	0.00	0.00	14.18	0.00
2001	6985.69	6639	1067	75.76	75.77	74.74	75.79	0.00	0.00	24.23	0.00
2002	5575.54	5300	1067	60.35	60.35	59.65	60.50	0.21	26.98	12.67	0.00
2003	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	62.48	37.52	0.00
2004	6549.98	6093	1067	69.94	69.94	69.88	69.36	0.00	13.83	16.23	0.00
2005	6061.72	5772	1067	64.94	64.94	64.85	65.89	3.99	3.23	31.83	0.00
2006	7331.42	6924	1067	78.33	78.33	78.44	79.04	0.00	0.00	21.67	0.00
2007	5054.10	4714	1067	53.73	71.43	54.07	53.81	0.00	0.00	28.57	17.69
2008	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2010	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2011	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2012	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

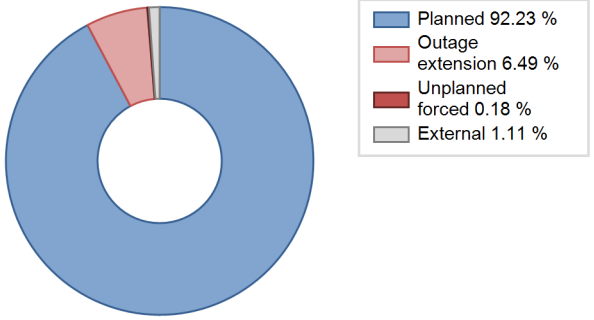
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1993 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					310	
C. Inspection, maintenance or repair combined with refuelling				842		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			4221		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						57
Z. Other					52	
Subtotal	8784			5063	362	57
Total	**8784**			**5482**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1993 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		290
15. Reactor Cooling Systems		21
Total		**311**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ichi Nuclear Power Stations.

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2020 Operating Experience

JP-53 KASHIWAZAKI KARIWA-4 JAPAN



Status at end of year	:	**Operational**
Operator	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Owner	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Reactor Supplier	:	HITACHI (HITACHI, LTD.)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1100 MWe
Reference unit power (net)	:	1067 MWe

Key Dates

Construction Date	:	1990-03-05
Grid Date	:	1993-12-21
Commercial Date	:	1994-08-11
Age at end of year	:	27 years

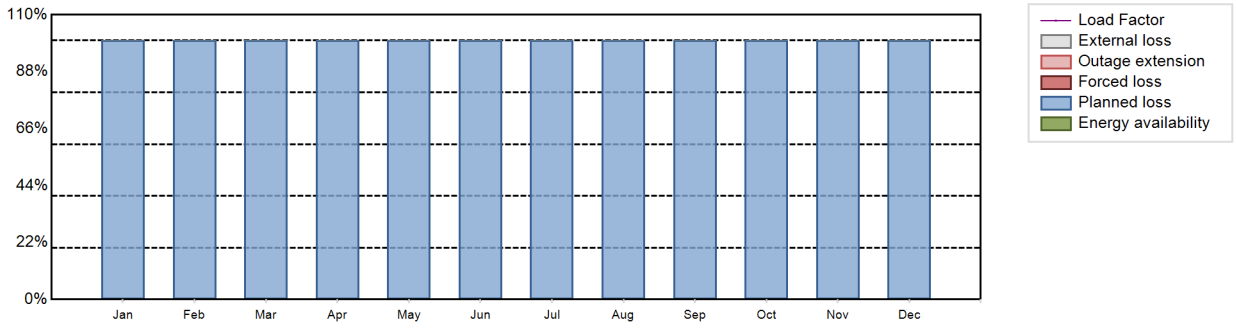
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.07
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]	:	0.31
Average fuel enrichment [% of U235]	:	3.70	**Secondary systems**		
Refuelling frequency [month]	:	13	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	24	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	45000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	4.75	HP cylinder inlet steam pressure [MPa]	:	6.55
Active core height/length [m]	:	3.71	Output voltage [kV]	:	19
Number of fissile fuel assemblies/bundles	:	764	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	:	185	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 (2020)

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	:	8784 hours

Annual Summary



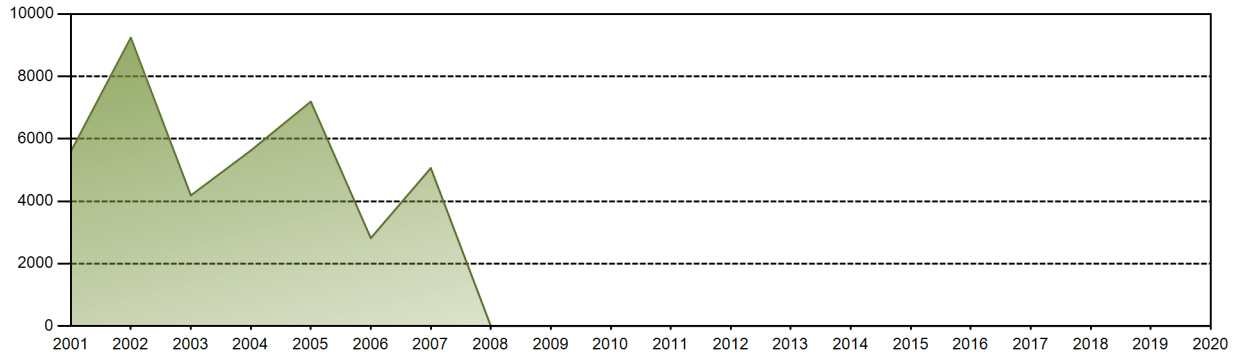
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	91851 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.24 %
Cumulative Energy Availability Factor (EAF)	:	36.6 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.02 %
Cumulative Unit Capability Factor (UCF)	:	38.38 %	Cumulative Planned Unavailability Factor (PUF)	:	58.6 %
Cumulative Load Factor (LF)	:	36.29 %	Cumulative Externally cause unavailability (XUF)	:	1.78 %
Cumulative Operating Factor (OF)	:	36.72 %			

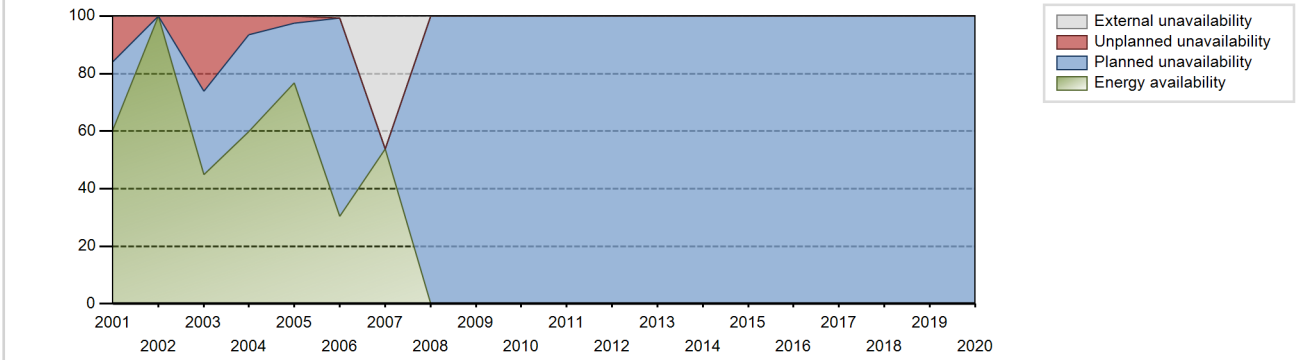
Electricity Production (net) [GWh]



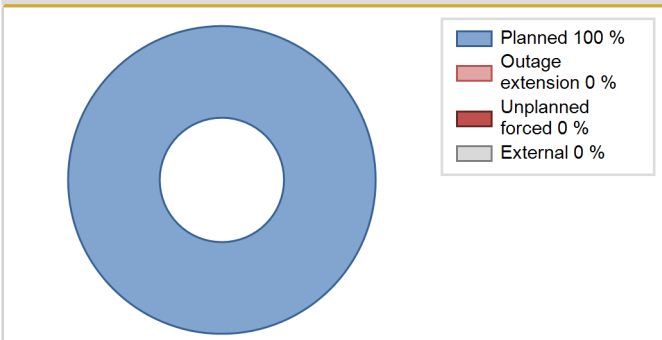
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1994	6040.10	6638	1067	99.76	99.76	98.76	100.00	0.00	0.00	0.24	0.00
1995	6182.46	5889	1067	66.99	66.99	66.14	67.23	12.76	9.80	23.22	0.00
1996	8067.98	7651	1067	87.05	87.05	86.08	87.10	0.00	0.00	12.95	0.00
1997	7516.71	7207	1067	81.53	81.67	80.42	82.27	7.22	6.36	11.98	0.14
1998	9258.69	8760	1067	99.99	99.99	99.06	100.00	0.00	0.00	0.01	0.00
1999	8141.74	7719	1067	88.09	88.09	87.11	88.12	0.00	0.00	11.91	0.00
2000	6918.93	6602	1067	75.13	75.14	73.82	75.16	14.59	12.83	12.02	0.02
2001	5591.43	5343	1067	60.60	60.60	59.82	60.99	20.74	15.86	23.53	0.00
2002	9239.86	8760	1067	99.91	99.96	98.85	100.00	0.00	0.00	0.04	0.06
2003	4185.83	3946	1067	44.96	45.05	44.78	45.05	0.00	25.92	29.03	0.09
2004	5623.72	5258	1067	59.86	59.87	60.00	59.86	0.00	6.56	33.57	0.00
2005	7192.00	6755	1067	76.79	76.79	76.95	77.11	0.00	2.37	20.83	0.00
2006	2816.50	2772	1067	30.41	31.04	30.13	31.64	0.00	0.00	68.96	0.63
2007	5061.67	4714	1067	53.81	99.99	54.15	53.81	0.00	0.00	0.01	46.18
2008	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2010	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2011	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2012	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

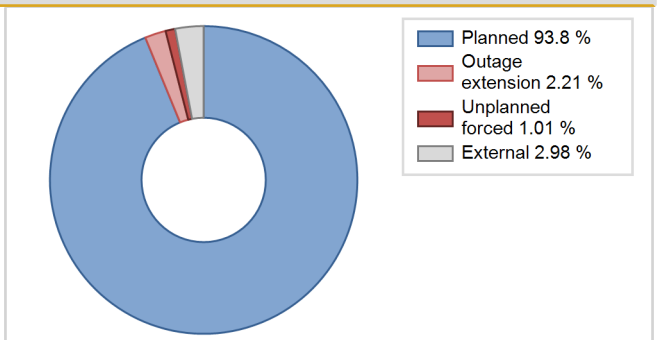
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1994 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					235	
C. Inspection, maintenance or repair combined with refuelling				832	11	
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			4384		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						156
Z. Other					24	
Subtotal	8784			5216	270	156
Total	**8784**			**5642**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1994 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		110
14. Safety Systems		11
31. Turbine and auxiliaries		19
41. Main Generator Systems		72
42. Electrical Power Supply Systems		33
Total		**245**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ichi Nuclear Power Stations.

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2020 Operating Experience

JP-40 KASHIWAZAKI KARIWA-5 JAPAN



Status at end of year	:	**Operational**
Operator	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Owner	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Reactor Supplier	:	HITACHI (HITACHI, LTD.)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1100 MWe
Reference unit power (net)	:	1067 MWe

Key Dates

Construction Date	:	1985-06-20
Grid Date	:	1989-09-12
Commercial Date	:	1990-04-10
Age at end of year	:	31 years

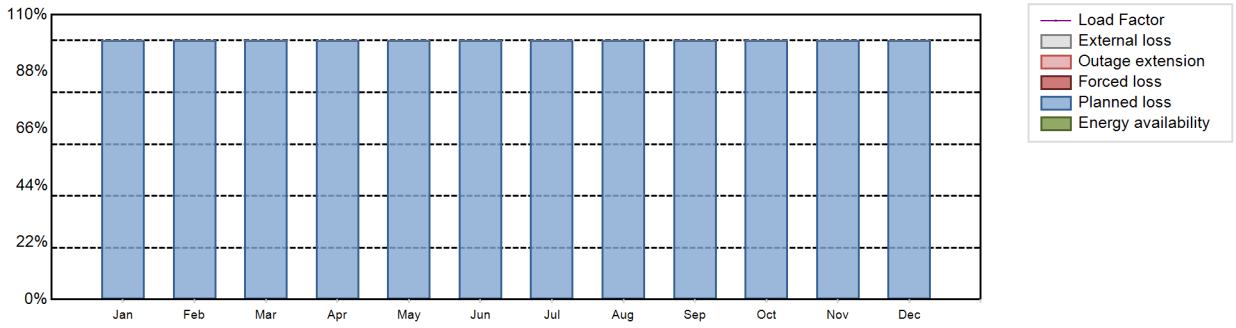
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.07
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]	:	0.31
Average fuel enrichment [% of U235]	:	3.68	**Secondary systems**		
Refuelling frequency [month]	:	13	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	24	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	45000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	4.75	HP cylinder inlet steam pressure [MPa]	:	6.55
Active core height/length [m]	:	3.71	Output voltage [kV]	:	19
Number of fissile fuel assemblies/bundles	:	764	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	:	185	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 (2020)

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	:	8784 hours

Annual Summary



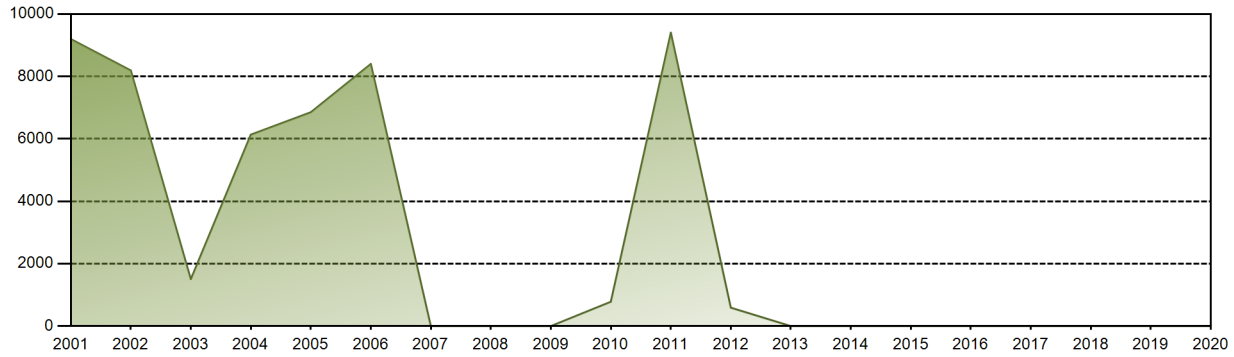
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	136968 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.15 %
Cumulative Energy Availability Factor (EAF)	:	47.32 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.25 %
Cumulative Unit Capability Factor (UCF)	:	48.99 %	Cumulative Planned Unavailability Factor (PUF)	:	48.76 %
Cumulative Load Factor (LF)	:	46.92 %	Cumulative Externally cause unavailability (XUF)	:	1.67 %
Cumulative Operating Factor (OF)	:	47.52 %			

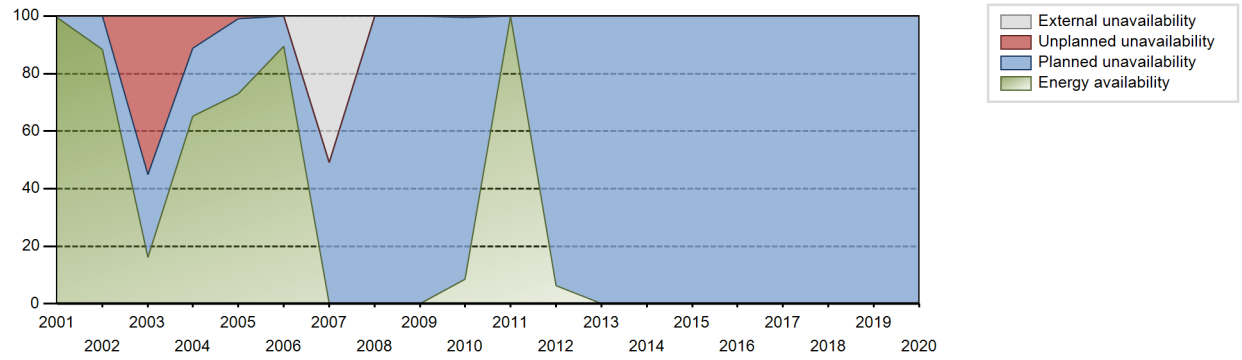
Electricity Production (net) [GWh]



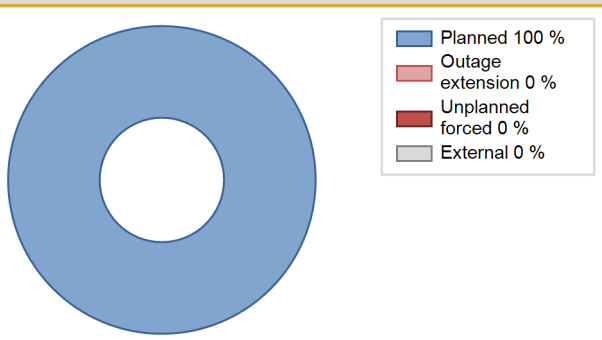
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	7910.63	7597	1067	100.00	100.00	98.74	100.00	0.00	0.00	0.00	0.00
1991	7093.33	6789	1067	76.70	76.70	75.89	77.50	0.00	0.00	23.30	0.00
1992	6977.48	6715	1067	75.46	75.50	74.45	76.45	0.00	0.00	24.50	0.04
1993	9238.24	8760	1067	99.89	99.90	98.84	100.00	0.00	0.00	0.10	0.01
1994	7154.70	6825	1067	77.50	77.50	76.55	77.91	0.00	0.00	22.50	0.00
1995	7508.33	7183	1067	81.46	81.46	80.33	82.00	1.95	1.62	16.92	0.00
1996	7905.83	7524	1067	85.64	85.64	84.35	85.66	0.00	0.00	14.36	0.00
1997	8919.12	8472	1067	96.63	96.63	95.42	96.71	0.00	0.00	3.37	0.00
1998	7352.55	6995	1067	79.63	79.63	78.66	79.85	0.00	0.00	20.37	0.00
1999	7771.81	7383	1067	84.27	84.27	83.15	84.28	0.00	0.00	15.73	0.00
2000	7042.75	6712	1067	76.30	76.40	75.14	76.41	0.00	0.00	23.60	0.11
2001	9198.56	8760	1067	99.61	99.61	98.41	100.00	0.00	0.00	0.39	0.00
2002	8191.05	7743	1067	88.31	88.31	87.63	88.39	0.00	0.00	11.69	0.00
2003	1503.10	1392	1067	16.07	16.07	16.08	15.89	0.00	55.08	28.85	0.00
2004	6134.80	5738	1067	65.26	65.26	65.46	65.32	0.01	11.17	23.57	0.00
2005	6852.88	6446	1067	72.99	72.99	73.32	73.58	0.15	0.95	26.06	0.00
2006	8400.48	7848	1067	89.45	89.45	89.87	89.59	0.00	0.00	10.55	0.00
2007	0.00	0	1067	0.00	50.96	0.00	0.00	0.00	0.00	49.04	50.96
2008	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2010	780.14	888	1067	8.55	8.55	8.35	10.14	5.20	0.47	90.98	0.00
2011	9402.07	8760	1067	99.99	99.99	100.59	100.00	0.00	0.00	0.01	0.00
2012	589.21	576	1067	6.37	6.51	6.29	6.56	0.00	0.00	93.49	0.14
2013	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1067	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

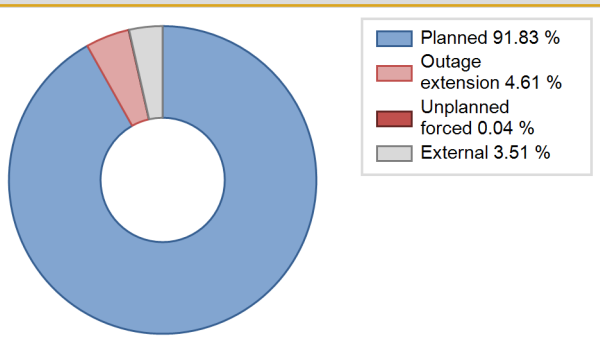
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1990 to 2020 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				905		
D. Inspection, maintenance or repair without refuelling				8		
F. Major backfitting, refurbishment or upgrading activities with refuelling				274		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			3185		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						149
Z. Other					33	
Subtotal	8784			4372	203	149
Total	**8784**			**4724**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1990 to 2020 Average hours lost per reactor-year
15. Reactor Cooling Systems		166
31. Turbine and auxiliaries		4
Total		**170**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ichi Nuclear Power Stations.

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2020 Operating Experience

JP-55 KASHIWAZAKI KARIWA-6 JAPAN



Status at end of year	:	**Operational**
Operator	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Owner	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	GE (GENERAL ELECTRIC CO.)

Reactor Unit Details

Reactor type and model	:	BWR / ABWR
Thermal power	:	3926 MWth
Gross electrical power	:	1356 MWe
Reference unit power (net)	:	1315 MWe

Key Dates

Construction Date	:	1992-11-03
Grid Date	:	1996-01-29
Commercial Date	:	1996-11-07
Age at end of year	:	24 years

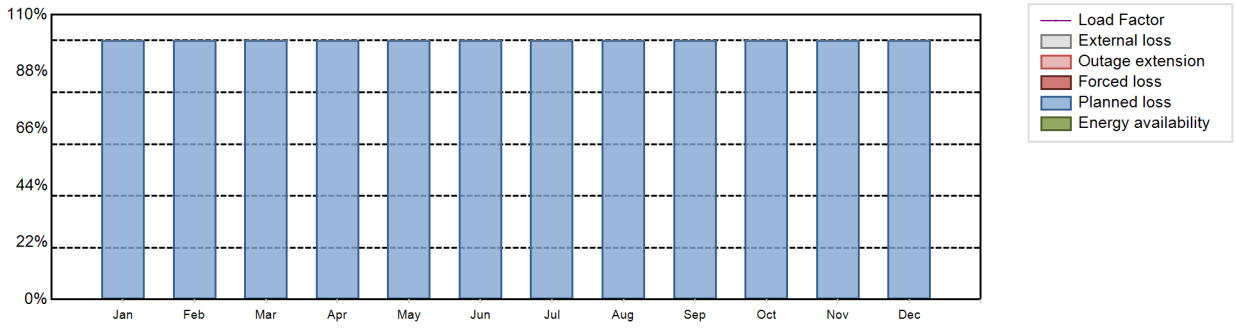
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.07
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]	:	0.31
Average fuel enrichment [% of U235]	:	3.75	**Secondary systems**		
Refuelling frequency [month]	:	13	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	24	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	45000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	5.16	HP cylinder inlet steam pressure [MPa]	:	6.69
Active core height/length [m]	:	3.71	Output voltage [kV]	:	27
Number of fissile fuel assemblies/bundles	:	872	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	18.8	Number of main condensate pumps	:	3
Number of control rod assemblies	:	205	Number of FW pumps for full power operation	:	2
Number of external reactor coolant loops	:	NA	Number of on-site safety related diesel generators	:	3
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

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	:	8784 hours

Annual Summary



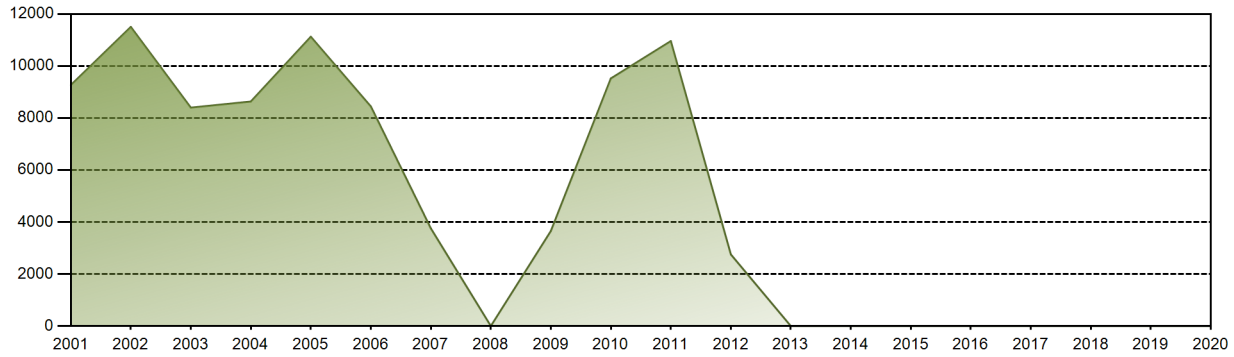
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	133581 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.74 %
Cumulative Energy Availability Factor (EAF)	:	46.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.56 %
Cumulative Unit Capability Factor (UCF)	:	47.8 %	Cumulative Planned Unavailability Factor (PUF)	:	50.64 %
Cumulative Load Factor (LF)	:	46.64 %	Cumulative Externally cause unavailability (XUF)	:	1.71 %
Cumulative Operating Factor (OF)	:	46.22 %			

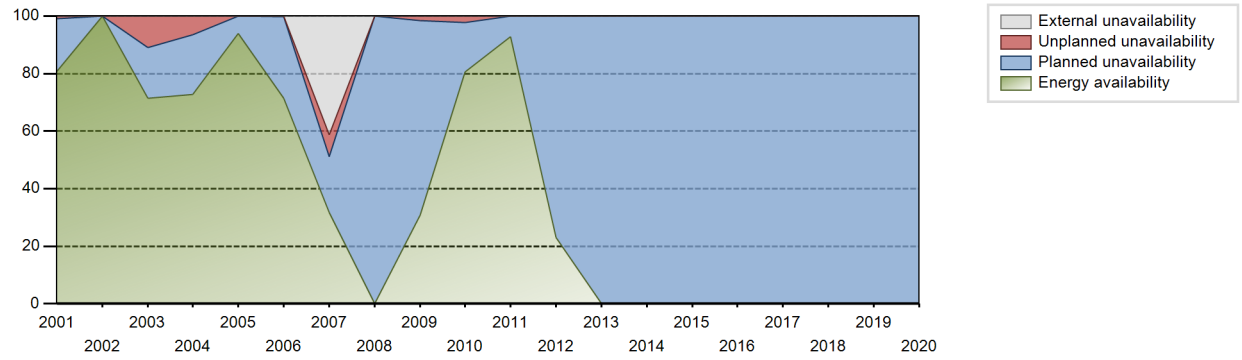
Electricity Production (net) [GWh]



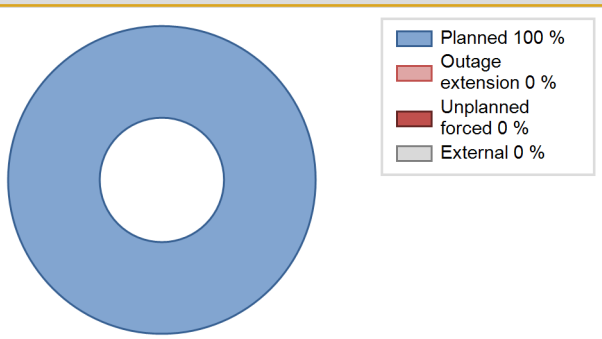
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1996	5663.21	5240	1315	100.00	100.00	99.77	100.00	0.00	0.00	0.00	0.00
1997	10161.45	7752	1315	88.44	88.44	88.21	88.49	0.00	0.00	11.56	0.00
1998	10702.27	8217	1315	93.26	93.26	92.91	93.80	1.32	1.25	5.49	0.00
1999	9710.40	7480	1315	84.76	84.76	84.30	85.39	2.80	2.45	12.80	0.00
2000	9411.59	7183	1315	81.76	81.76	81.48	81.77	4.49	3.84	14.39	0.00
2001	9269.97	7079	1315	80.74	80.74	80.47	80.81	1.17	0.95	18.30	0.00
2002	11504.14	8760	1315	100.00	100.00	99.87	100.00	0.00	0.00	0.00	0.00
2003	8401.23	6163	1315	71.53	71.53	72.93	70.35	0.00	10.92	17.55	0.00
2004	8635.19	6410	1315	72.69	72.69	74.76	72.97	0.41	6.55	20.76	0.00
2005	11126.45	8232	1315	93.88	93.88	96.59	93.97	0.00	0.00	6.12	0.00
2006	8446.71	6301	1315	71.41	71.41	73.33	71.93	0.25	0.18	28.41	0.00
2007	3758.17	2787	1315	31.64	73.01	32.62	31.82	9.34	7.52	19.47	41.37
2008	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	3653.77	2818	1315	30.88	30.88	31.72	32.17	5.10	1.66	67.46	0.00
2010	9522.09	7089	1315	80.65	80.65	82.66	80.92	2.75	2.28	17.08	0.00
2011	10960.32	8147	1315	92.74	92.74	95.15	93.00	0.00	0.00	7.26	0.00
2012	2756.33	2040	1315	23.13	23.13	23.86	23.22	0.00	0.00	76.87	0.00
2013	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

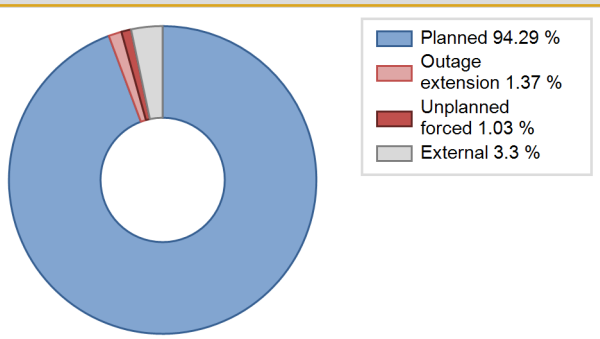
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1996 to 2020 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				647		
F. Major backfitting, refurbishment or upgrading activities with refuelling				281		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			3531		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						151
Z. Other					68	
Subtotal	8784			4459	139	151
Total	**8784**			**4749**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1996 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		14
12. Reactor I&C Systems		14
13. Reactor Auxiliary Systems		4
14. Safety Systems		44
32. Feedwater and Main Steam System		27
41. Main Generator Systems		9
42. Electrical Power Supply Systems		4
Total		**116**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ichi Nuclear Power Stations.

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2020 Operating Experience

JP-56 KASHIWAZAKI KARIWA-7 JAPAN



Status at end of year	:	**Operational**
Operator	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Owner	:	TEPCO (Tokyo Electric Power Company Holdings, Inc.)
Reactor Supplier	:	HITACHI (HITACHI, LTD.)
Turbine Supplier	:	GE (GENERAL ELECTRIC CO.)

Reactor Unit Details

Reactor type and model	:	BWR / ABWR
Thermal power	:	3926 MWth
Gross electrical power	:	1356 MWe
Reference unit power (net)	:	1315 MWe

Key Dates

Construction Date	:	1993-07-01
Grid Date	:	1996-12-17
Commercial Date	:	1997-07-02
Age at end of year	:	24 years

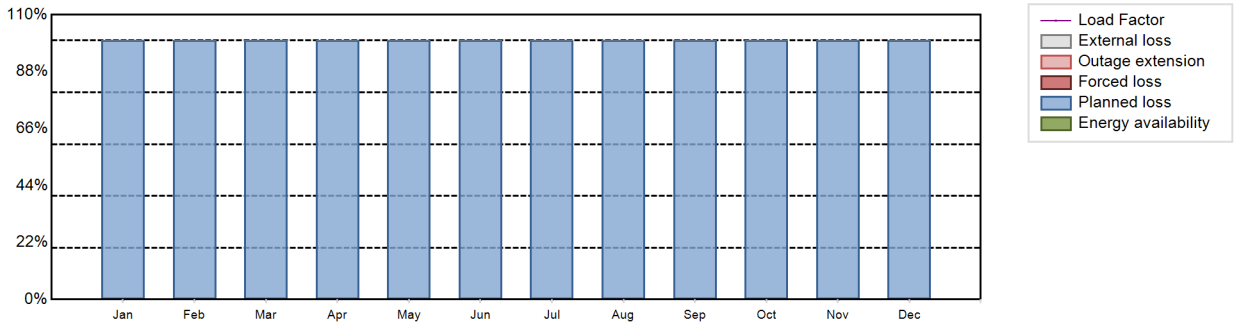
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.07
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]	:	0.31
Average fuel enrichment [% of U235]	:	3.75	**Secondary systems**		
Refuelling frequency [month]	:	13	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	24	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	45000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	5.16	HP cylinder inlet steam pressure [MPa]	:	6.69
Active core height/length [m]	:	3.71	Output voltage [kV]	:	27
Number of fissile fuel assemblies/bundles	:	872	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	18.8	Number of main condensate pumps	:	3
Number of control rod assemblies	:	205	Number of FW pumps for full power operation	:	2
Number of external reactor coolant loops	:	NA	Number of on-site safety related diesel generators	:	3
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

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	:	8784 hours

Annual Summary



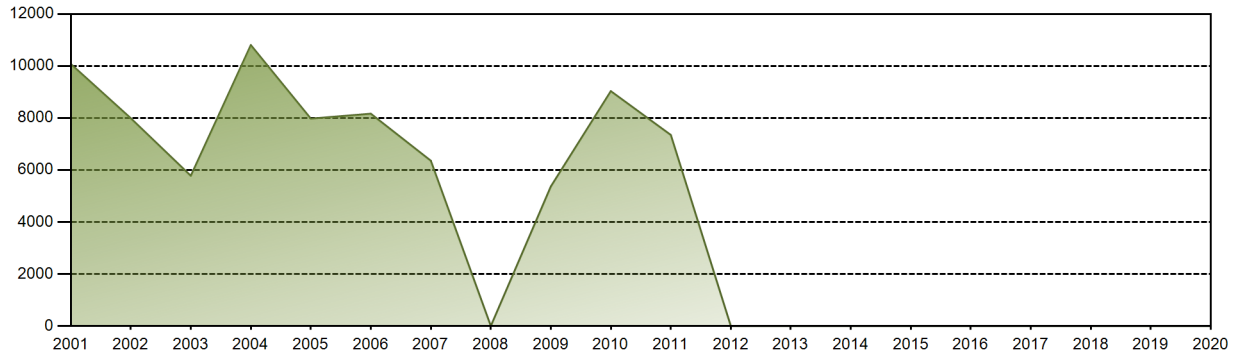
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	116411 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.77 %
Cumulative Energy Availability Factor (EAF)	:	41.74 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.79 %
Cumulative Unit Capability Factor (UCF)	:	43.31 %	Cumulative Planned Unavailability Factor (PUF)	:	54.9 %
Cumulative Load Factor (LF)	:	42.11 %	Cumulative Externally cause unavailability (XUF)	:	1.58 %
Cumulative Operating Factor (OF)	:	42.26 %			

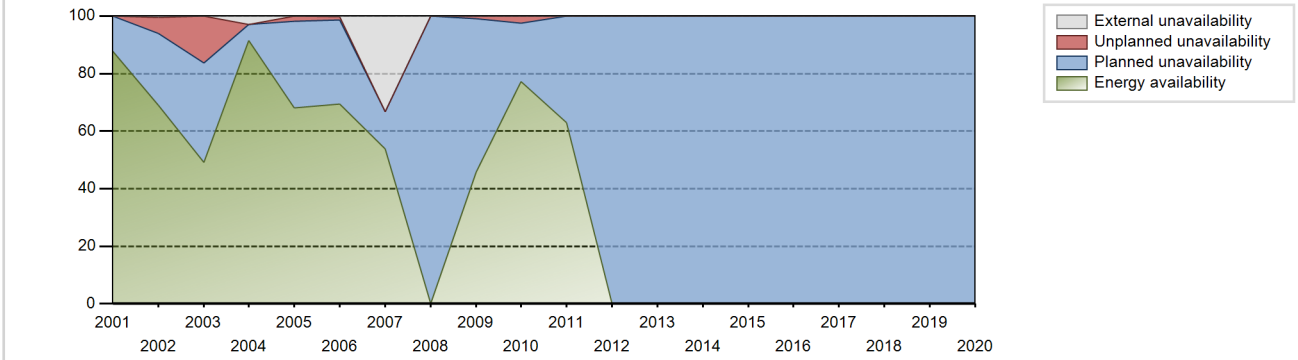
Electricity Production (net) [GWh]



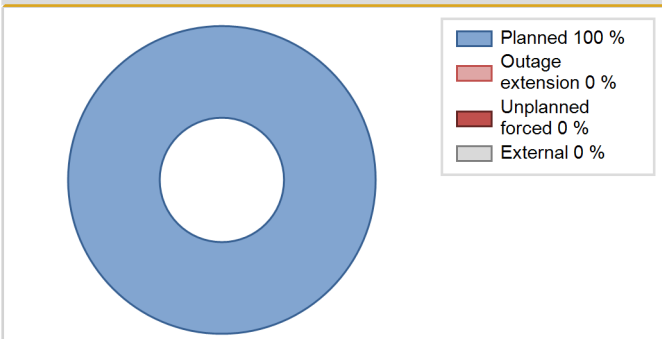
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1997	8127.93	6764	1315	100.00	100.00	99.76	100.00	0.00	0.00	0.00	0.00
1998	9715.61	7452	1315	84.66	84.66	84.34	85.07	0.00	0.00	15.34	0.00
1999	8445.43	6458	1315	73.66	73.66	73.31	73.72	15.86	13.88	12.45	0.00
2000	11240.18	8587	1315	97.62	97.62	97.31	97.76	0.00	0.00	2.38	0.00
2001	10078.37	7752	1315	87.76	87.76	87.49	88.49	0.00	0.00	12.24	0.00
2002	7989.96	6089	1315	68.95	69.51	69.36	69.51	0.00	5.50	24.99	0.56
2003	5778.49	4302	1315	49.19	49.19	50.16	49.11	0.00	16.37	34.44	0.00
2004	10805.16	8057	1315	91.59	94.46	93.54	91.72	0.00	0.00	5.54	2.87
2005	7977.49	6007	1315	68.00	68.00	69.25	68.57	0.00	1.92	30.08	0.00
2006	8166.24	6250	1315	69.53	69.86	70.89	71.35	1.39	0.98	29.15	0.33
2007	6358.57	4714	1315	53.82	87.12	55.20	53.81	0.00	0.00	12.88	33.31
2008	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	5366.30	4338	1315	45.84	45.84	46.58	49.52	2.13	1.00	53.16	0.00
2010	9033.86	7041	1315	77.23	77.23	78.42	80.38	3.07	2.45	20.33	0.00
2011	7348.67	5616	1315	62.90	62.90	63.79	64.11	0.04	0.03	37.07	0.00
2012	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1315	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

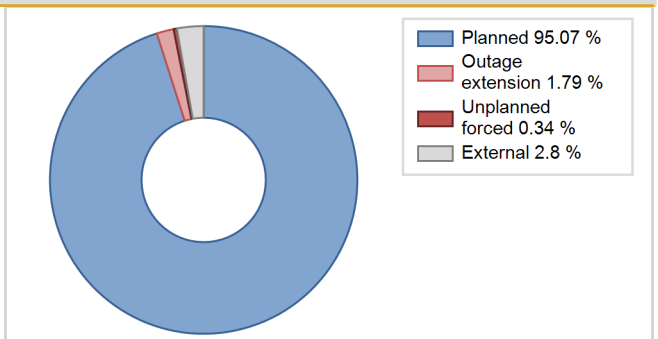
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1997 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					136	
C. Inspection, maintenance or repair combined with refuelling				795		
D. Inspection, maintenance or repair without refuelling				42		
F. Major backfitting, refurbishment or upgrading activities with refuelling				49		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			4005		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						138
Z. Other					17	
Subtotal	8784			4891	153	138
Total	**8784**			**5182**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1997 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		47
12. Reactor I&C Systems		41
15. Reactor Cooling Systems		48
Total		**136**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ichi and Dai-ni Nuclear Power Stations.

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2020 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

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	:	1972-08-07
Grid Date	:	1976-02-19
Commercial Date	:	1976-12-01
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]	:	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

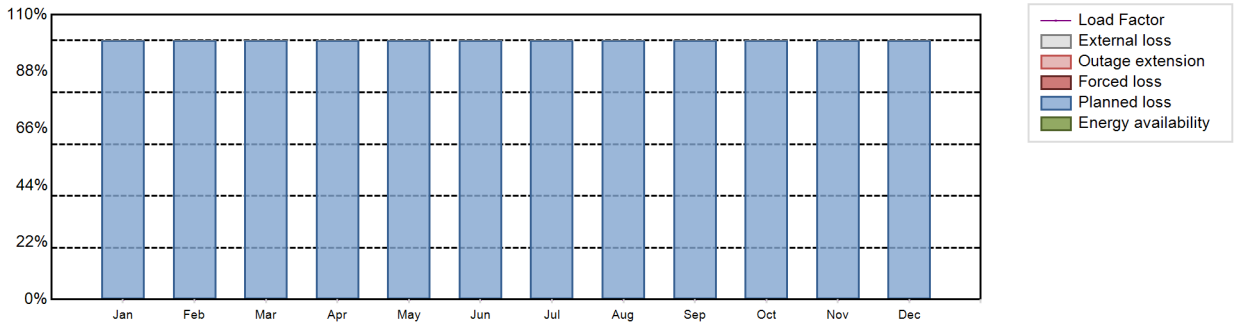
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	323
Number of SG	:	3
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.24
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	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	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



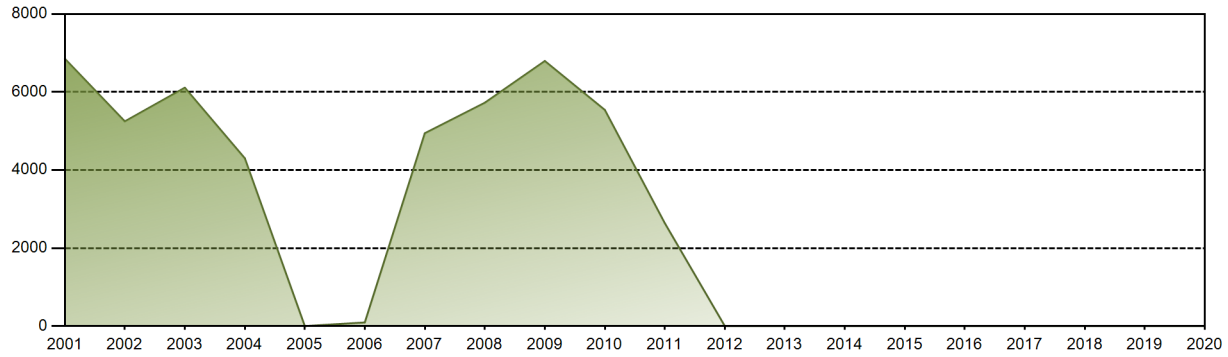
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	168850 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.89 %
Cumulative Energy Availability Factor (EAF)	:	55.42 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.34 %
Cumulative Unit Capability Factor (UCF)	:	55.44 %	Cumulative Planned Unavailability Factor (PUF)	:	43.23 %
Cumulative Load Factor (LF)	:	56.01 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	56.16 %			

Electricity Production (net) [GWh]

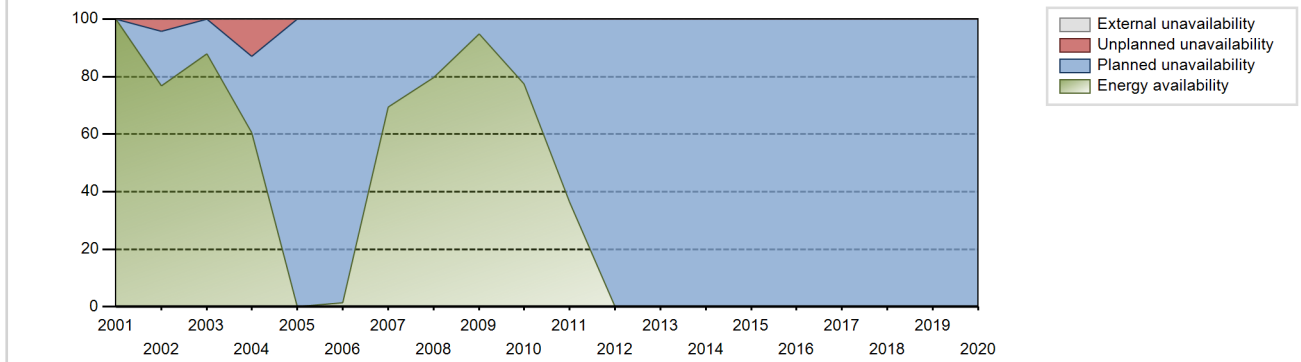


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	2615.00	5285	780	85.10	85.10	85.06	100.00	0.00	0.00	14.90	0.00
1977	4498.50	6159	780	65.85	65.85	65.84	70.31	1.27	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

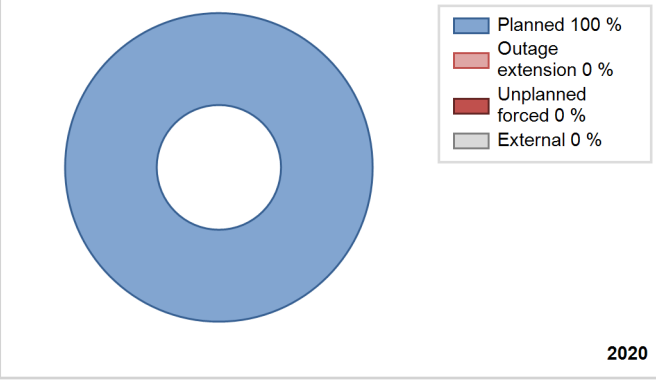
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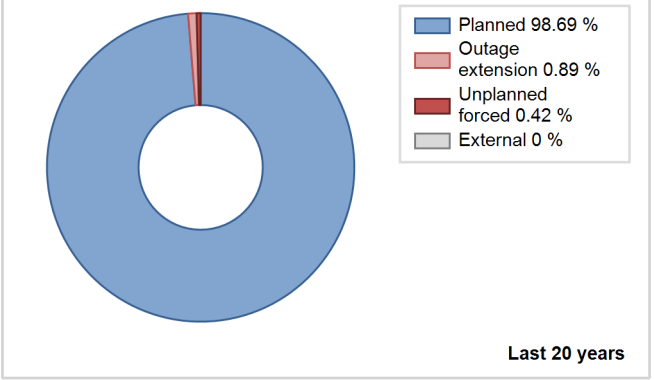
2013	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1976 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					99	
C. Inspection, maintenance or repair combined with refuelling				1855		
E. Testing of plant systems or components				0	3	
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			1884		
L. Human factor related					6	
Subtotal	8784			3739	108	
Total	**8784**			**3847**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1976 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		25
15. Reactor Cooling Systems		8
16. Steam generation systems		25
32. Feedwater and Main Steam System		46
34. Miscellaneous Systems		3
Total		**107**

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2020 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

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	:	1987-10-03
Grid Date	:	1991-06-07
Commercial Date	:	1991-12-18
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]	:	4.1
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	44000
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

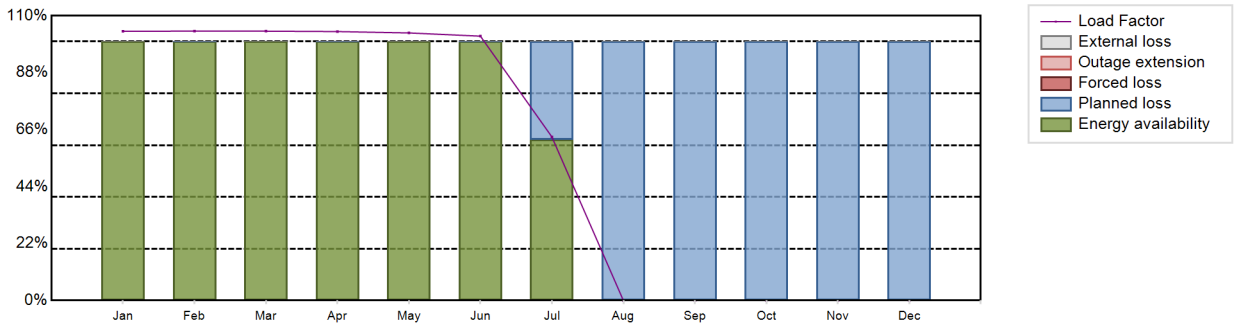
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	325
Number of SG	:	4
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.4
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	6
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	:	DS

Annual Production Results (2020)

Net Energy Production	:	5627.87 GW(e).h
Energy Availability Factor (EAF)	:	54.99 %
Unit Capability Factor (UCF)	:	54.99 %
Load Factor (LF)	:	56.85 %
Operating Factor (OF)	:	55.03 %
Equivalent non-electrical energy generated (NEG)	:	18.06 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	45.01 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	3950 hours

Annual Summary



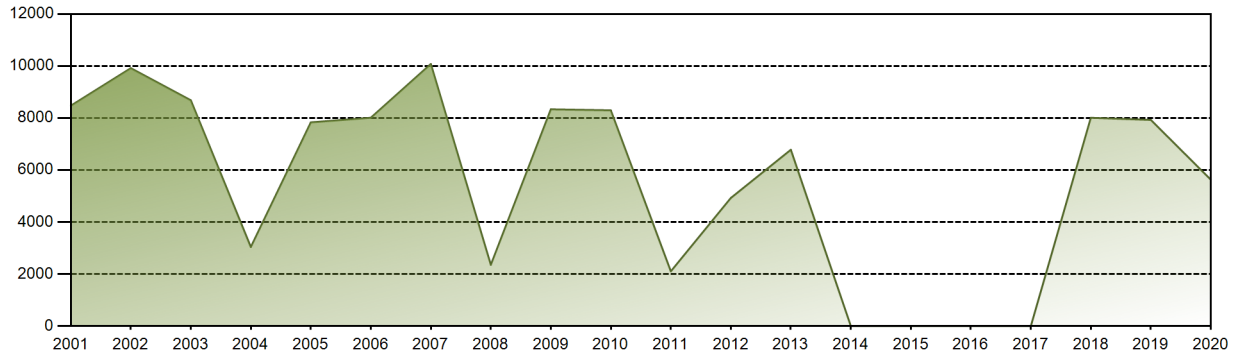
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	871.75	816.24	872.27	842.84	866.56	828.52	529.68	0.00	0.00	0.00	0.00	0.00	5627.87
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	62.16	0.00	0.00	0.00	0.00	0.00	54.99
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	62.16	0.00	0.00	0.00	0.00	0.00	54.99
LF [%]	103.97	104.06	104.03	103.87	103.35	102.10	63.17	0.00	0.00	0.00	0.00	0.00	56.85
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	62.63	0.00	0.00	0.00	0.00	0.00	55.03
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	0.00	0.00	0.00	0.00	0.00	37.84	100.00	100.00	100.00	100.00	100.00	45.01
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

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Historical Summary

Lifetime energy generation	:	189436.87 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.88 %
Cumulative Energy Availability Factor (EAF)	:	65.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.63 %
Cumulative Unit Capability Factor (UCF)	:	65.12 %	Cumulative Planned Unavailability Factor (PUF)	:	30.25 %
Cumulative Load Factor (LF)	:	65.96 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	65.38 %			

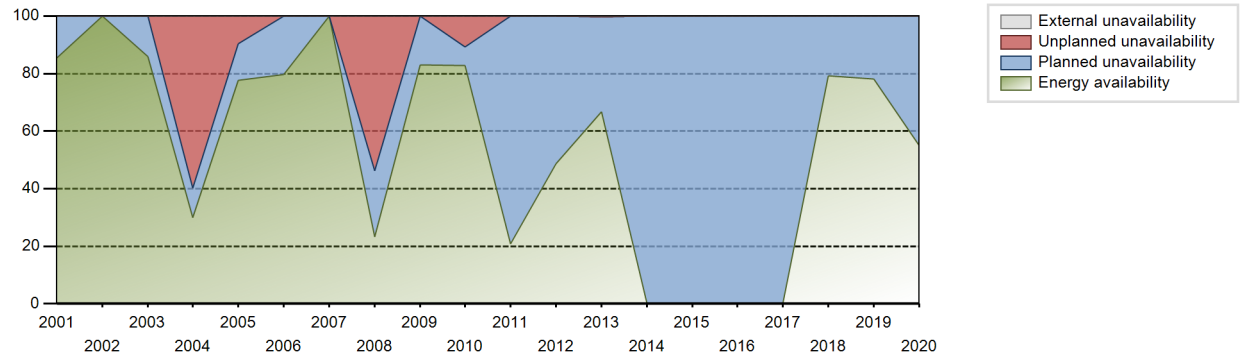
Electricity Production (net) [GWh]



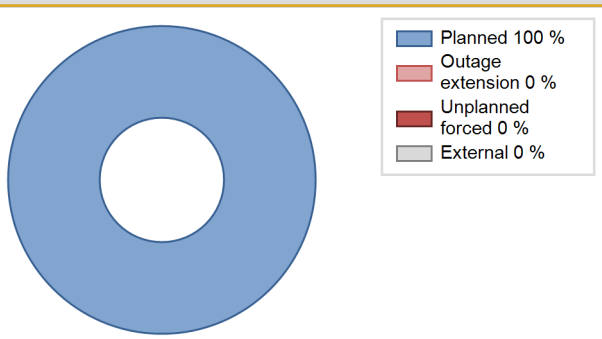
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1991	2524.41	3228	1127	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	9954.69	8784	1127	99.98	99.98	100.56	100.00	0.00	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

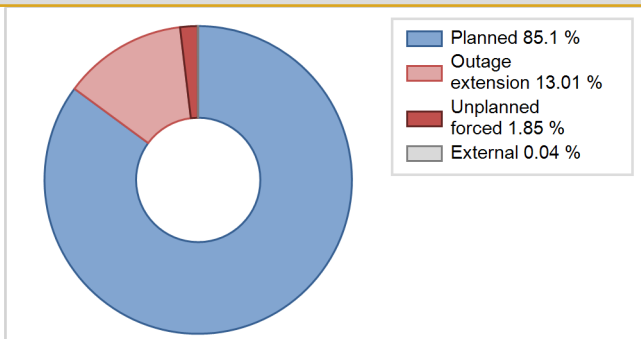
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1991 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					386	
C. Inspection, maintenance or repair combined with refuelling	3950			989		
F. Major backfitting, refurbishment or upgrading activities with refuelling				729		
G. Major backfitting, refurbishment or upgrading activities without refuelling				1017		
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					33	
Subtotal	3950			2735	419	
Total	**3950**			**3154**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1991 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		232
13. Reactor Auxiliary Systems		18
15. Reactor Cooling Systems		169
Total		**419**

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2020 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

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	:	1988-06-13
Grid Date	:	1992-06-19
Commercial Date	:	1993-02-02
Age at end of year	:	28 years

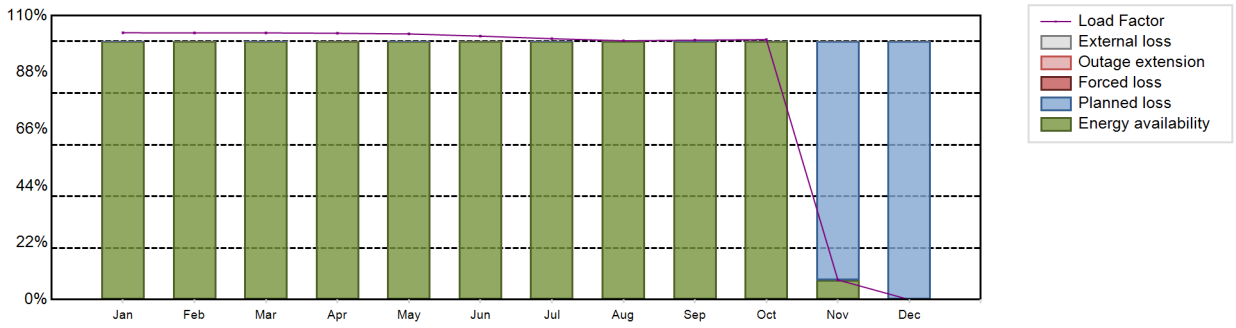
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.1
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	44000
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]	:	15.7
Reactor outlet temperature [°C]	:	325
Number of SG	:	4
Containment type	:	Confinement
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	:	3
HP cylinder inlet steam pressure [MPa]	:	6
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	:	DS

Annual Production Results (2020)

Net Energy Production	:	8481.35 GW(e).h
Energy Availability Factor (EAF)	:	83.95 %
Unit Capability Factor (UCF)	:	83.95 %
Load Factor (LF)	:	85.67 %
Operating Factor (OF)	:	83.99 %
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)	:	16.05 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1406 hours

Annual Summary



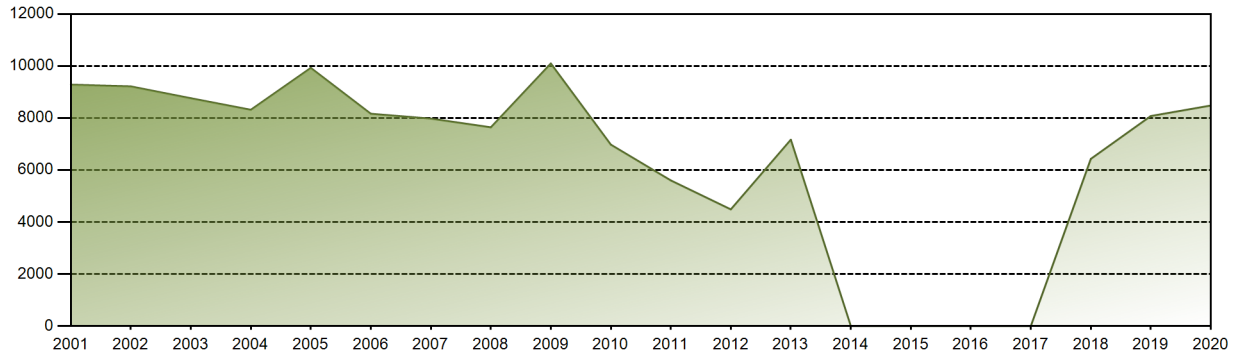
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	866.66	810.23	866.26	837.13	862.94	828.12	847.36	840.70	815.47	844.43	62.05	0.00	8481.35
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	7.56	0.00	83.95
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	7.56	0.00	83.95
LF [%]	103.36	103.29	103.31	103.17	102.92	102.06	101.06	100.26	100.50	100.71	7.65	0.00	85.67
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	8.06	0.00	83.99
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	0.00	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	92.44	100.00	16.05
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

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Historical Summary

Lifetime energy generation	:	192161.35 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.23 %
Cumulative Energy Availability Factor (EAF)	:	68.56 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.57 %
Cumulative Unit Capability Factor (UCF)	:	68.58 %	Cumulative Planned Unavailability Factor (PUF)	:	29.86 %
Cumulative Load Factor (LF)	:	69.67 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	68.75 %			

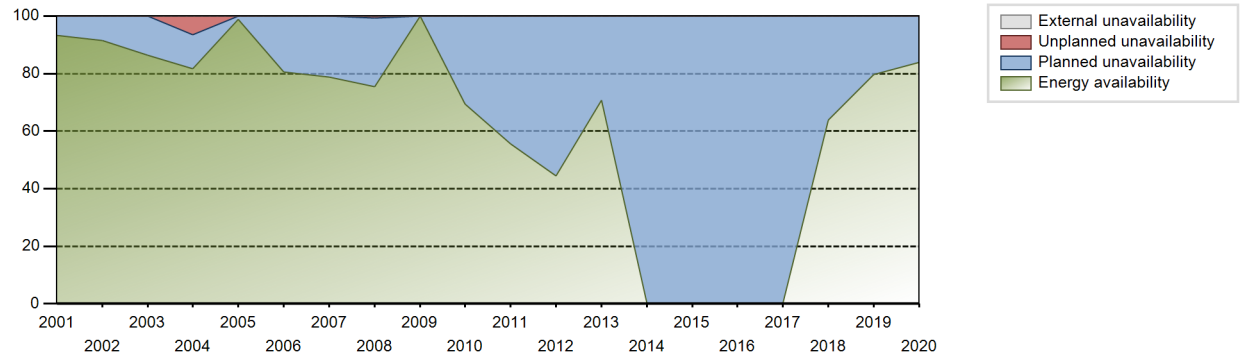
Electricity Production (net) [GWh]



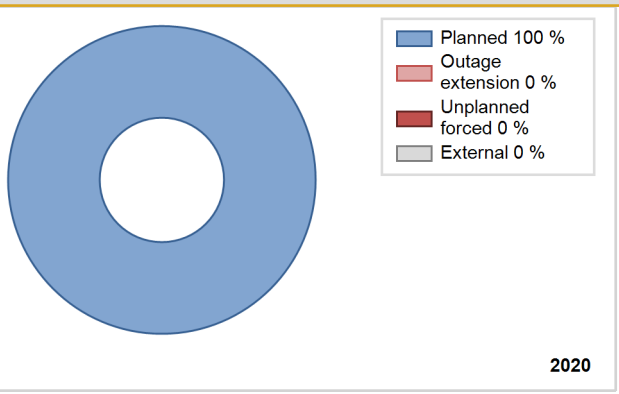
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	9923.46	8760	1127	99.98	99.98	100.51	100.00	0.00	0.00	0.02	0.00
1994	7851.52	7063	1127	79.68	79.68	79.53	80.63	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

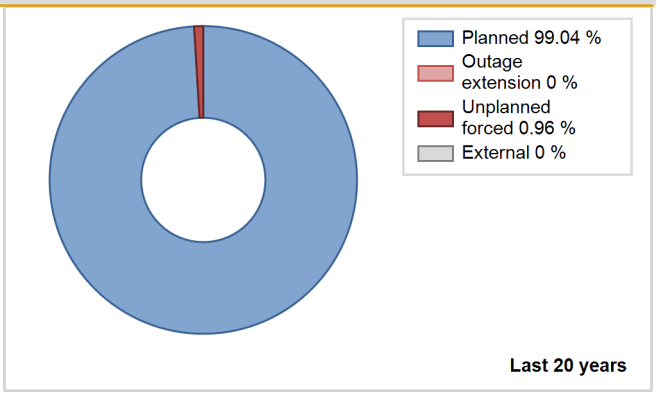
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1993 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					121	
C. Inspection, maintenance or repair combined with refuelling	1406			940		
F. Major backfitting, refurbishment or upgrading activities with refuelling				744		
G. Major backfitting, refurbishment or upgrading activities without refuelling				1007		
Z. Other					21	
Subtotal	1406			2691	142	
Total	**1406**			**2833**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1993 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
31. Turbine and auxiliaries		21
41. Main Generator Systems		118
Total		**141**

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2020 Operating Experience

JP-54 ONAGAWA-2 JAPAN



Status at end of year	:	**Operational**
Operator	:	TOHOKU (Tohoku Electric Power Co., Inc)
Owner	:	TOHOKU (Tohoku Electric Power Co., Inc)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	TOSHIBA (TOSHIBA CORPORATION)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	2436 MWth
Gross electrical power	:	825 MWe
Reference unit power (net)	:	796 MWe

Key Dates

Construction Date	:	1991-04-12
Grid Date	:	1994-12-23
Commercial Date	:	1995-07-28
Age at end of year	:	26 years

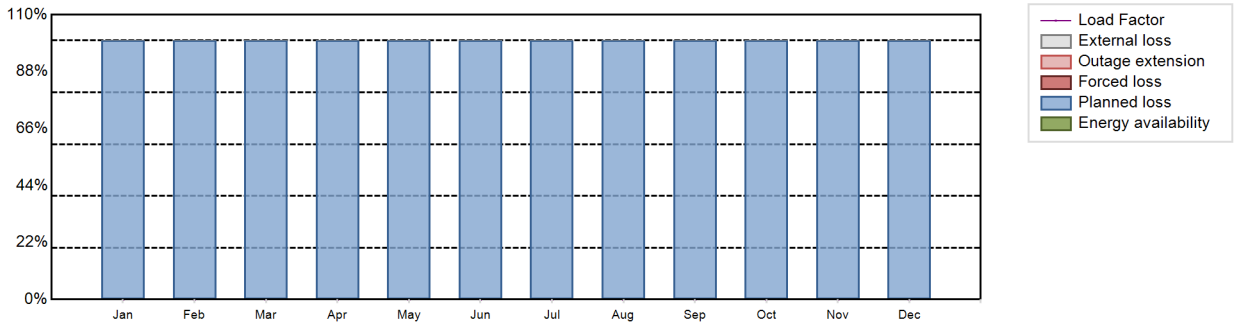
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	6.93
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]	:	3.7	**Secondary systems**		
Refuelling frequency [month]	:	13	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	25	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	45000	Number of LP cylinders per turbine	:	2
Active core diameter [m]	:	4.07	HP cylinder inlet steam pressure [MPa]	:	6.55
Active core height/length [m]	:	3.71	Output voltage [kV]	:	17
Number of fissile fuel assemblies/bundles	:	560	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	15.9	Number of main condensate pumps	:	6
Number of control rod assemblies	:	137	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 (2020)

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	:	8784 hours

Annual Summary



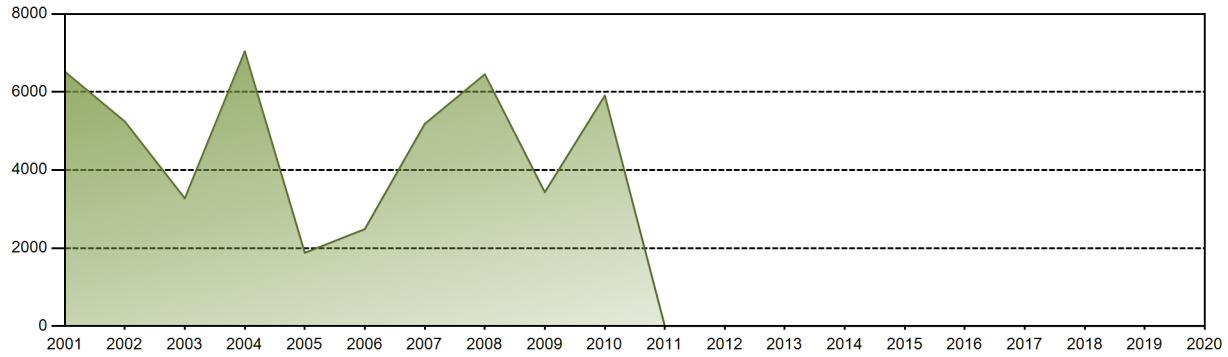
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	81165 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.56 %
Cumulative Energy Availability Factor (EAF)	:	44.8 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.34 %
Cumulative Unit Capability Factor (UCF)	:	48.28 %	Cumulative Planned Unavailability Factor (PUF)	:	47.39 %
Cumulative Load Factor (LF)	:	44.9 %	Cumulative Externally cause unavailability (XUF)	:	3.47 %
Cumulative Operating Factor (OF)	:	44.96 %			

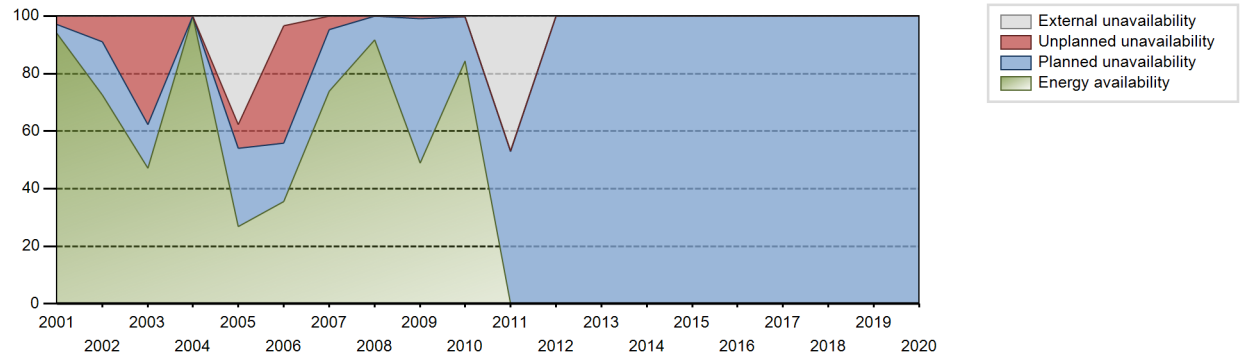
Electricity Production (net) [GWh]



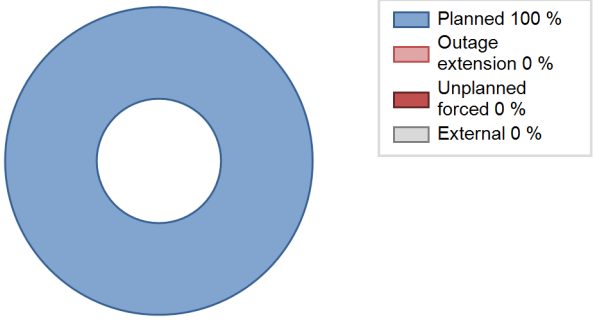
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1995	4496.61	6510	796	95.35	95.35	94.74	95.59	4.55	4.55	0.10	0.00
1996	5175.27	6545	796	74.44	74.44	74.02	74.51	2.69	2.06	23.50	0.00
1997	6931.60	8760	796	99.91	99.92	99.41	100.00	0.00	0.00	0.08	0.01
1998	5647.72	7185	796	81.11	81.12	80.99	82.02	2.63	2.19	16.69	0.00
1999	5841.18	7383	796	84.23	84.23	83.77	84.28	0.00	0.00	15.77	0.00
2000	5858.59	7402	796	84.25	84.25	83.79	84.27	0.00	0.00	15.75	0.00
2001	6521.16	8238	796	93.96	93.96	93.52	94.04	2.96	2.87	3.17	0.00
2002	5242.91	6368	796	72.44	72.44	75.19	72.69	3.21	8.96	18.60	0.00
2003	3272.36	4139	796	47.17	47.28	46.93	47.25	0.00	37.62	15.11	0.11
2004	7040.38	8784	796	100.00	100.00	100.69	100.00	0.00	0.00	0.00	0.00
2005	1877.27	2367	796	26.78	64.46	26.92	27.02	0.00	8.20	27.34	37.68
2006	2484.73	3188	796	35.56	38.88	35.63	36.39	33.66	40.74	20.37	3.33
2007	5184.62	6491	796	73.83	73.83	74.35	74.10	1.47	4.65	21.51	0.00
2008	6453.43	8086	796	91.76	91.76	92.30	92.05	0.00	0.11	8.13	0.00
2009	3430.26	4330	796	48.98	49.01	49.19	49.43	0.00	0.87	50.11	0.04
2010	5905.54	7417	796	84.40	84.62	84.69	84.67	0.00	0.00	15.38	0.22
2011	0.00	0	796	0.00	46.95	0.00	0.00	0.00	0.17	52.88	46.95
2012	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

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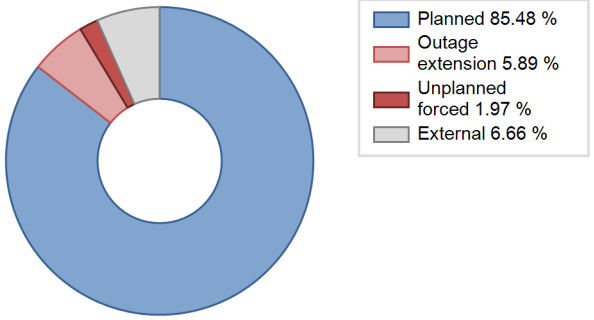
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1995 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					370	
C. Inspection, maintenance or repair combined with refuelling				900	4	
D. Inspection, maintenance or repair without refuelling				24		
E. Testing of plant systems or components					7	
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			3222		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						303
Subtotal	8784			4146	381	303
Total	**8784**			**4830**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1995 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		34
12. Reactor I&C Systems		71
13. Reactor Auxiliary Systems		61
15. Reactor Cooling Systems		156
31. Turbine and auxiliaries		13
32. Feedwater and Main Steam System		29
34. Miscellaneous Systems		4
Total		**368**

Highlights (2020)

Implementation of safety measure for considering the new regulatory requirements.

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2020 Operating Experience

JP-57 ONAGAWA-3 JAPAN



Status at end of year	:	**Operational**
Operator	:	TOHOKU (Tohoku Electric Power Co., Inc)
Owner	:	TOHOKU (Tohoku Electric Power Co., Inc)
Reactor Supplier	:	TOSHIBA (TOSHIBA CORPORATION)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	2436 MWth
Gross electrical power	:	825 MWe
Reference unit power (net)	:	796 MWe

Key Dates

Construction Date	:	1998-01-23
Grid Date	:	2001-05-30
Commercial Date	:	2002-01-30
Age at end of year	:	19 years

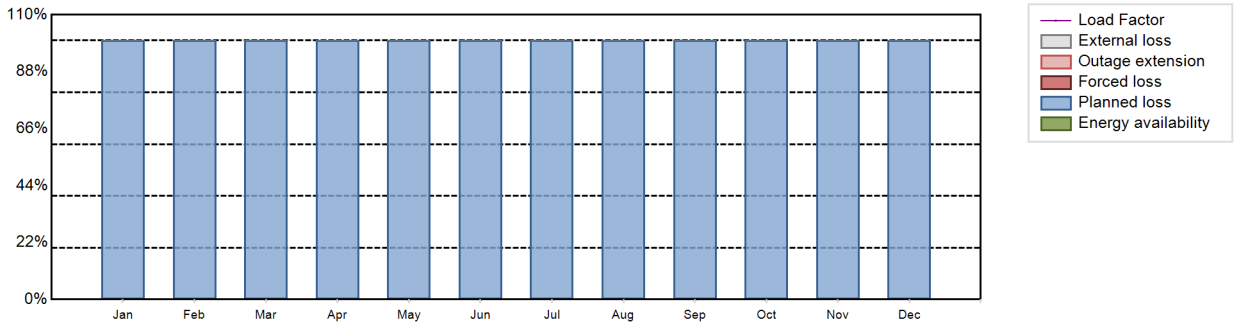
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.7
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	25
Average discharge burnup [MWd/t]	:	45000
Active core diameter [m]	:	4.07
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	560
Fuel linear heat generation rate [kW/m]	:	15.9
Number of control rod assemblies	:	137
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	6.93
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]	:	1500
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	6.55
Output voltage [kV]	:	20
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



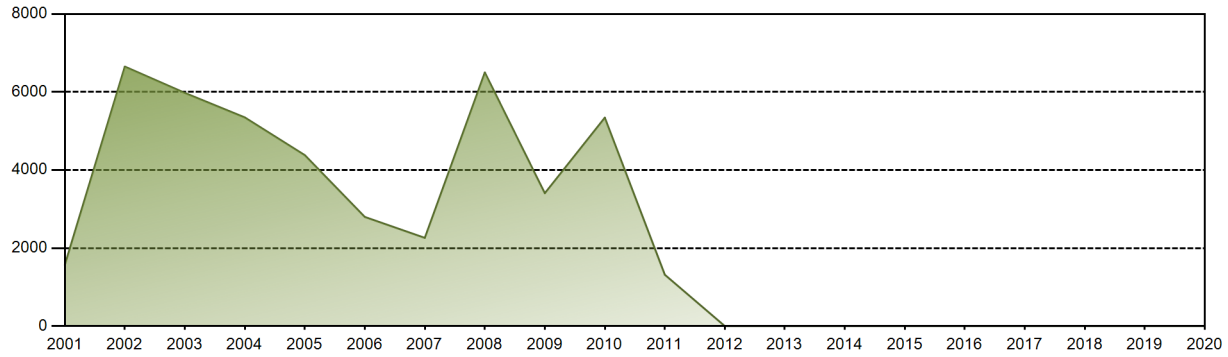
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

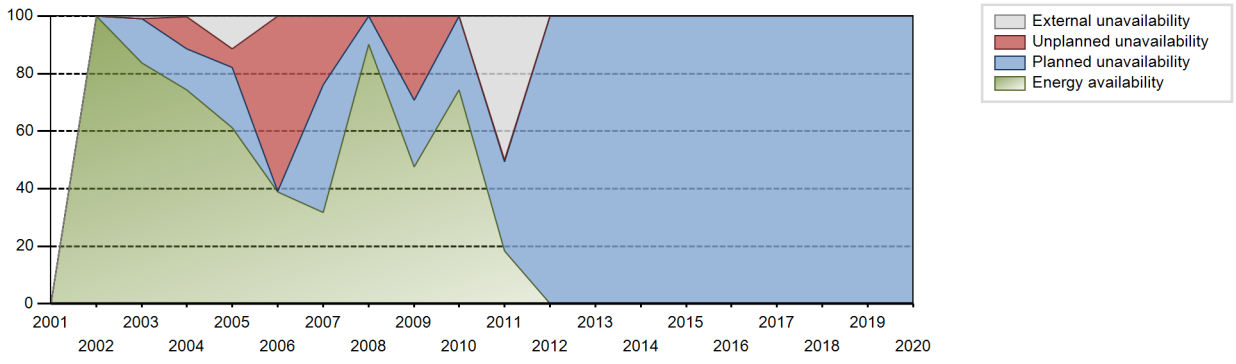
Lifetime energy generation	:	43740 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.85 %
Cumulative Energy Availability Factor (EAF)	:	32.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7 %
Cumulative Unit Capability Factor (UCF)	:	35.64 %	Cumulative Planned Unavailability Factor (PUF)	:	57.35 %
Cumulative Load Factor (LF)	:	33.3 %	Cumulative Externally cause unavailability (XUF)	:	3.3 %
Cumulative Operating Factor (OF)	:	32.6 %			

Electricity Production (net) [GWh]



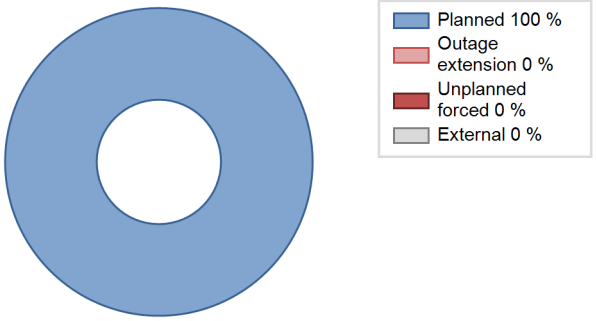
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	6652.52	8064	796	100.00	100.00	103.64	100.00	0.00	0.00	0.00	0.00
2003	5978.24	7332	796	83.70	84.66	85.73	83.70	0.00	0.00	15.34	0.96
2004	5348.70	6548	796	74.41	74.56	76.50	74.54	0.00	11.18	14.26	0.15
2005	4381.83	5460	796	61.22	72.69	62.84	62.33	1.50	6.31	20.99	11.48
2006	2798.13	3476	796	38.96	38.96	40.13	39.68	50.01	60.86	0.18	0.00
2007	2261.42	2887	796	31.70	31.70	32.43	32.96	15.96	24.00	44.30	0.00
2008	6502.19	7921	796	90.12	90.12	92.99	90.18	0.00	0.00	9.88	0.00
2009	3405.82	4202	796	47.48	47.48	48.84	47.97	5.35	29.31	23.21	0.00
2010	5342.77	6540	796	74.22	74.22	76.62	74.66	0.17	0.13	25.65	0.00
2011	1315.85	1671	796	18.37	68.34	18.87	19.08	1.02	0.70	30.96	49.97
2012	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	796	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

Key Factors in Last 20 Years [%]

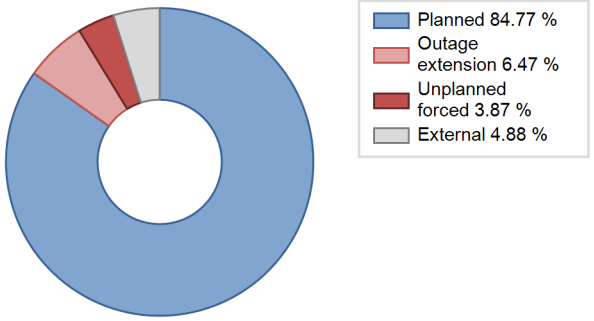


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2002 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					123	
C. Inspection, maintenance or repair combined with refuelling				745	109	
E. Testing of plant systems or components					245	
F. Major backfitting, refurbishment or upgrading activities with refuelling				151		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			4384		
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						304
Z. Other					155	
Subtotal	8784			5280	632	304
Total	**8784**			**6216**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2002 to 2020 Average hours lost per reactor-year
13. Reactor Auxiliary Systems		32
31. Turbine and auxiliaries		25
32. Feedwater and Main Steam System		255
34. Miscellaneous Systems		57
Total		**369**

Highlights (2020)

Implementation of safety measure for considering the new regulatory requirements.

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2020 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	:	37 years

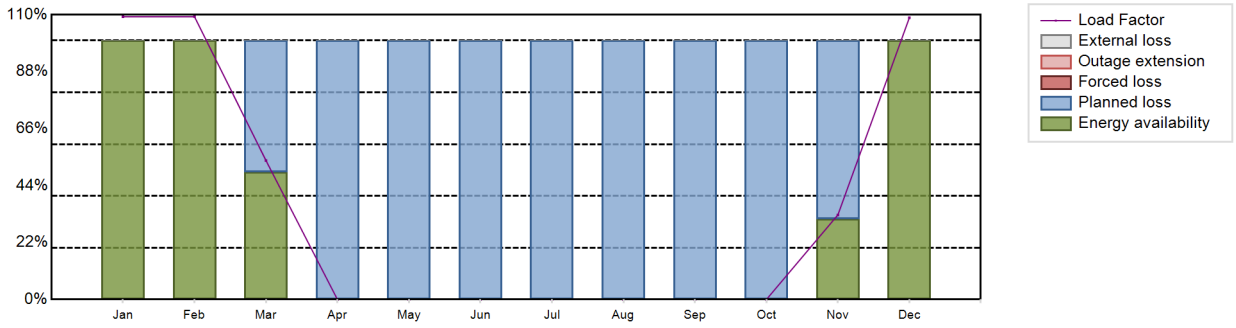
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.8
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 (2020)

Net Energy Production	:	2552.25 GW(e).h
Energy Availability Factor (EAF)	:	31.58 %
Unit Capability Factor (UCF)	:	31.58 %
Load Factor (LF)	:	34.34 %
Operating Factor (OF)	:	32.08 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	68.42 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	5966 hours

Annual Summary



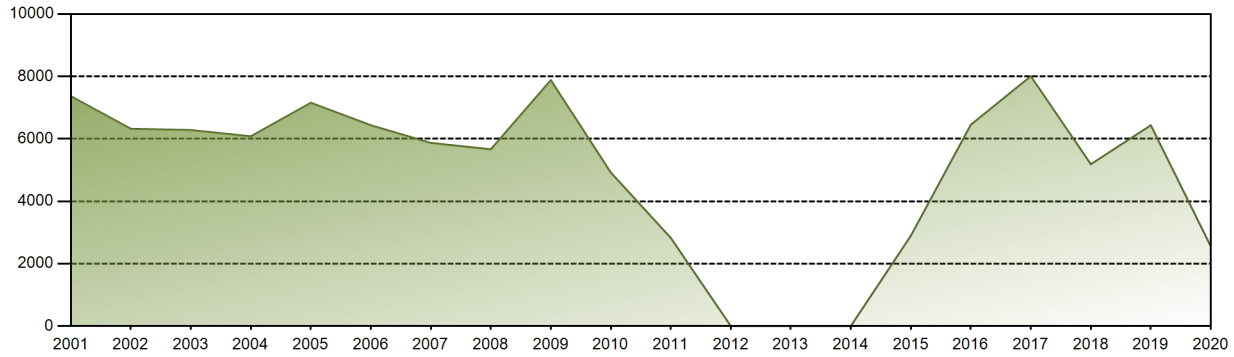
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	687.23	643.16	337.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	199.00	684.95	2552.25
EAF [%]	100.00	100.00	49.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.20	100.00	31.58
UCF [%]	100.00	100.00	49.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.20	100.00	31.58
LF [%]	109.18	109.23	53.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.67	108.82	34.34
OF [%]	100.00	100.00	49.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.81	100.00	32.08
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	50.84	100.00	100.00	100.00	100.00	100.00	100.00	100.00	68.80	0.00	68.42
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

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Historical Summary

Lifetime energy generation	:	204288.25 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.56 %
Cumulative Energy Availability Factor (EAF)	:	71.15 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.76 %
Cumulative Unit Capability Factor (UCF)	:	71.15 %	Cumulative Planned Unavailability Factor (PUF)	:	28.09 %
Cumulative Load Factor (LF)	:	73.25 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	71.67 %			

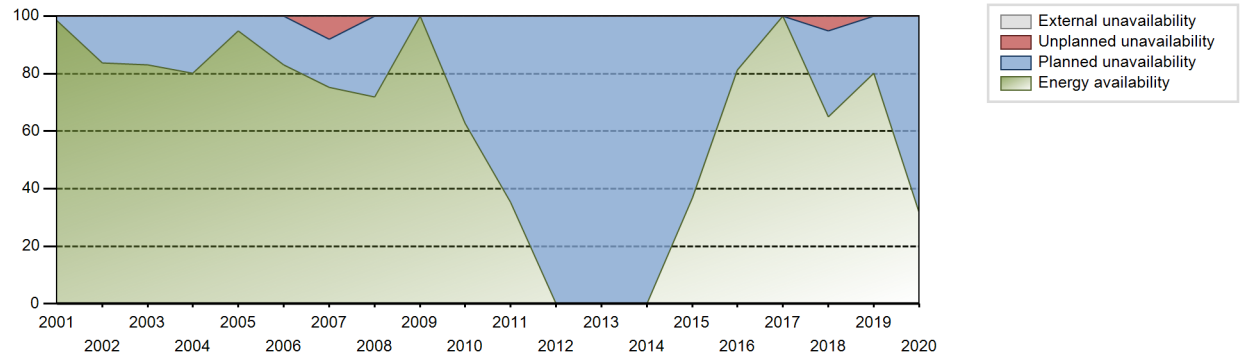
Electricity Production (net) [GWh]



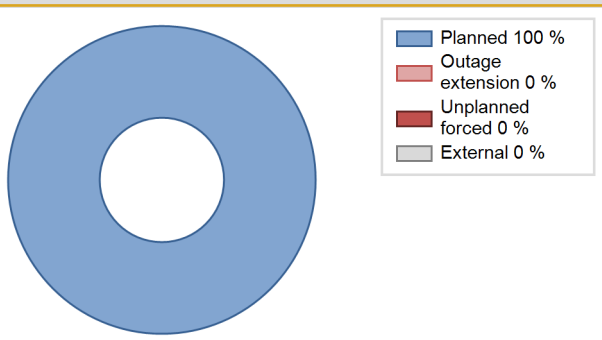
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	6069.77	7487	846	100.00	100.00	101.06	100.00	0.00	0.00	0.00	0.00
1985	5890.27	6964	846	78.68	78.68	79.48	79.50	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

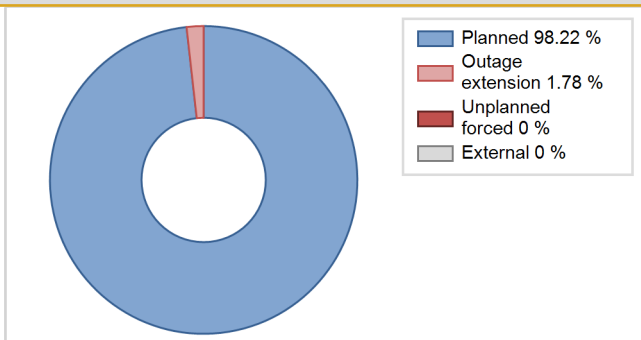
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 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	5966			1482		
G. Major backfitting, refurbishment or upgrading activities without refuelling				990		
Subtotal	5966			2472	64	
Total	**5966**			**2536**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		12
12. Reactor I&C Systems		1
13. Reactor Auxiliary Systems		7
16. Steam generation systems		19
31. Turbine and auxiliaries		6
32. Feedwater and Main Steam System		18
Total		**63**

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2020 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	:	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]	:	4.8
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

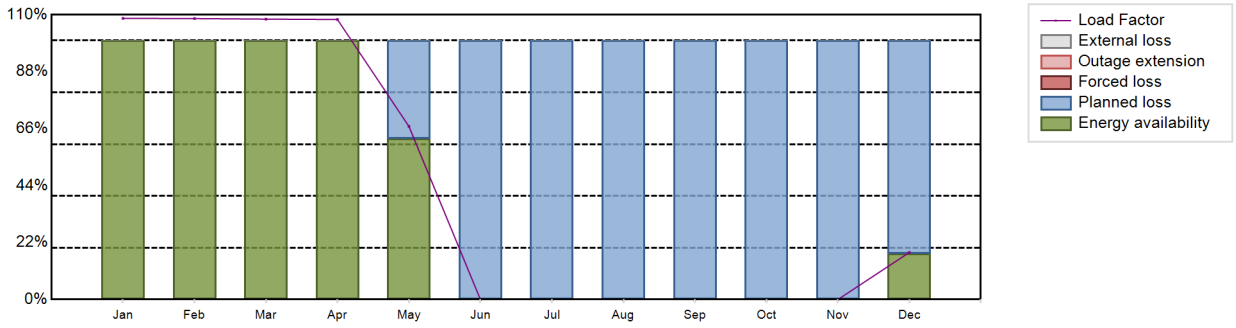
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.22
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	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 (2020)

Net Energy Production	:	3197.98 GW(e).h
Energy Availability Factor (EAF)	:	39.82 %
Unit Capability Factor (UCF)	:	39.82 %
Load Factor (LF)	:	43.03 %
Operating Factor (OF)	:	40.28 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	60.18 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	5246 hours

Annual Summary



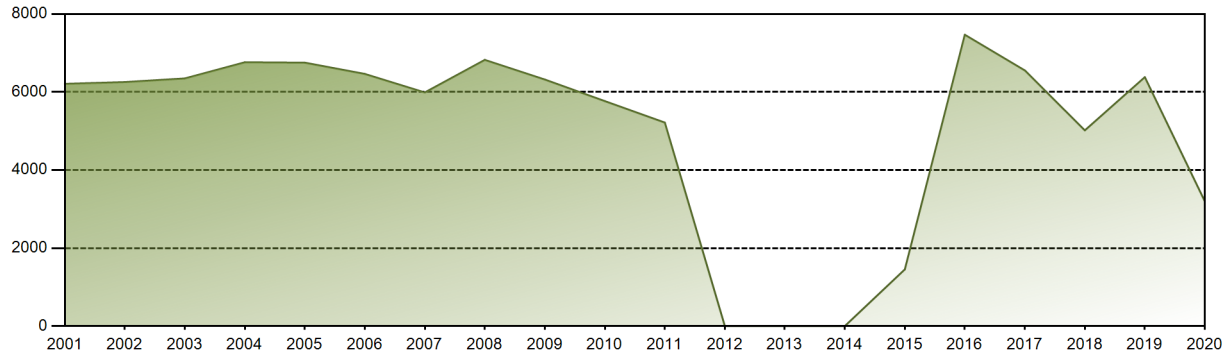
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	683.55	638.89	681.61	658.64	420.81	0.00	0.00	0.00	0.00	0.00	0.00	114.47	3197.98
EAF [%]	100.00	100.00	100.00	100.00	62.07	0.00	0.00	0.00	0.00	0.00	0.00	17.72	39.82
UCF [%]	100.00	100.00	100.00	100.00	62.07	0.00	0.00	0.00	0.00	0.00	0.00	17.72	39.82
LF [%]	108.60	108.50	108.29	108.13	66.86	0.00	0.00	0.00	0.00	0.00	0.00	18.19	43.03
OF [%]	100.00	100.00	100.00	100.00	62.50	0.00	0.00	0.00	0.00	0.00	0.00	22.72	40.28
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	37.93	100.00	100.00	100.00	100.00	100.00	100.00	82.28	60.18
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

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Historical Summary

Lifetime energy generation	:	191241.98 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.04 %
Cumulative Energy Availability Factor (EAF)	:	72.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.03 %
Cumulative Unit Capability Factor (UCF)	:	72.29 %	Cumulative Planned Unavailability Factor (PUF)	:	27.68 %
Cumulative Load Factor (LF)	:	74.02 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	72.71 %			

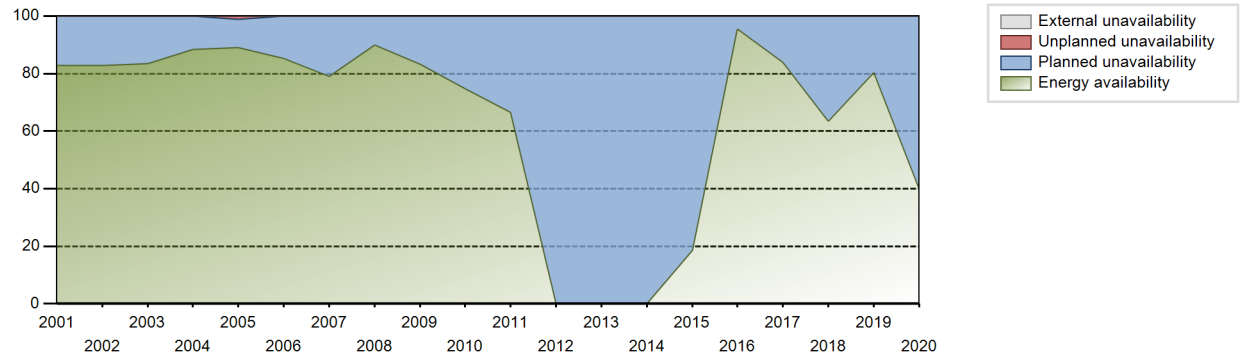
Electricity Production (net) [GWh]



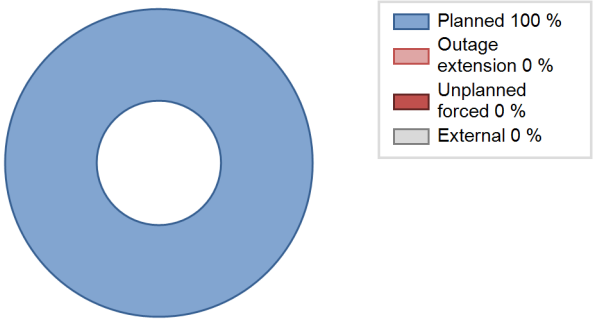
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	2816.07	4327	846	100.00	100.00	101.22	100.00	0.00	0.00	0.00	0.00
1986	5996.37	7112	846	80.14	80.14	80.91	81.19	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

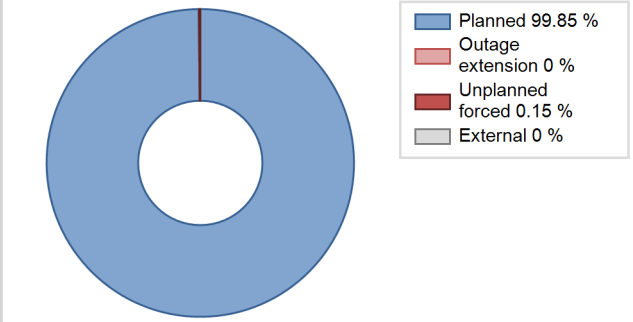
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	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	5246			1441		
G. Major backfitting, refurbishment or upgrading activities without refuelling				977		
Subtotal	5246			2418	3	
Total	**5246**			**2421**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
32. Feedwater and Main Steam System		3
Total		**3**

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2020 Operating Experience

JP-48 SHIKA-1 JAPAN



Status at end of year	:	**Operational**
Operator	:	HOKURIKU (HOKURIKU ELECTRIC POWER CO.)
Owner	:	HOKURIKU (HOKURIKU ELECTRIC POWER CO.)
Reactor Supplier	:	HITACHI (HITACHI, LTD.)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	1593 MWth
Gross electrical power	:	540 MWe
Reference unit power (net)	:	505 MWe

Key Dates

Construction Date	:	1989-07-01
Grid Date	:	1993-01-12
Commercial Date	:	1993-07-30
Age at end of year	:	27 years

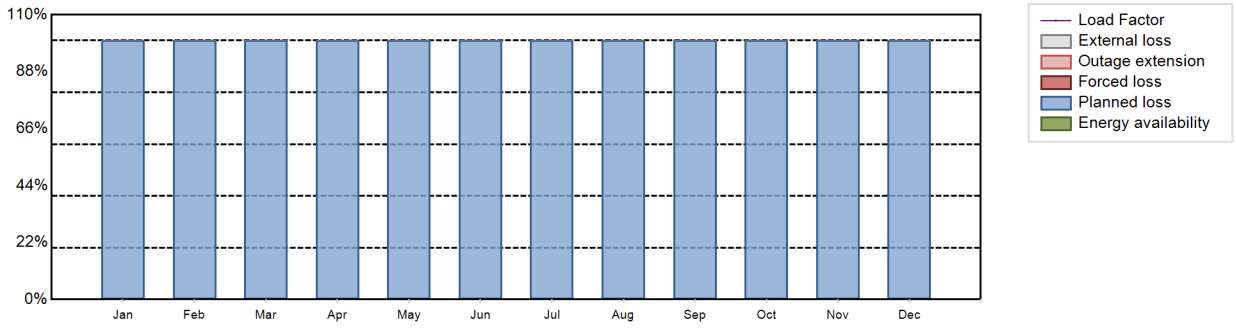
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	6.93
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]	:	0.427
Average fuel enrichment [% of U235]	:	3.8	**Secondary systems**		
Refuelling frequency [month]	:	15	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	25	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	45000	Number of LP cylinders per turbine	:	2
Active core diameter [m]	:	3.30	HP cylinder inlet steam pressure [MPa]	:	6.55
Active core height/length [m]	:	3.71	Output voltage [kV]	:	20
Number of fissile fuel assemblies/bundles	:	368	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	16	Number of main condensate pumps	:	6
Number of control rod assemblies	:	89	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 (2020)

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	:	8784 hours

Annual Summary



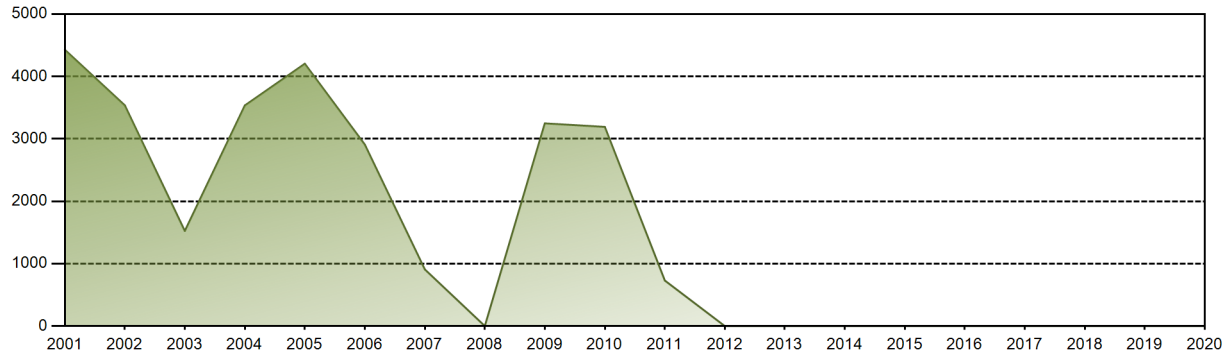
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	56333 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.15 %
Cumulative Energy Availability Factor (EAF)	:	45.67 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.53 %
Cumulative Unit Capability Factor (UCF)	:	45.67 %	Cumulative Planned Unavailability Factor (PUF)	:	50.8 %
Cumulative Load Factor (LF)	:	45.62 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	45.58 %			

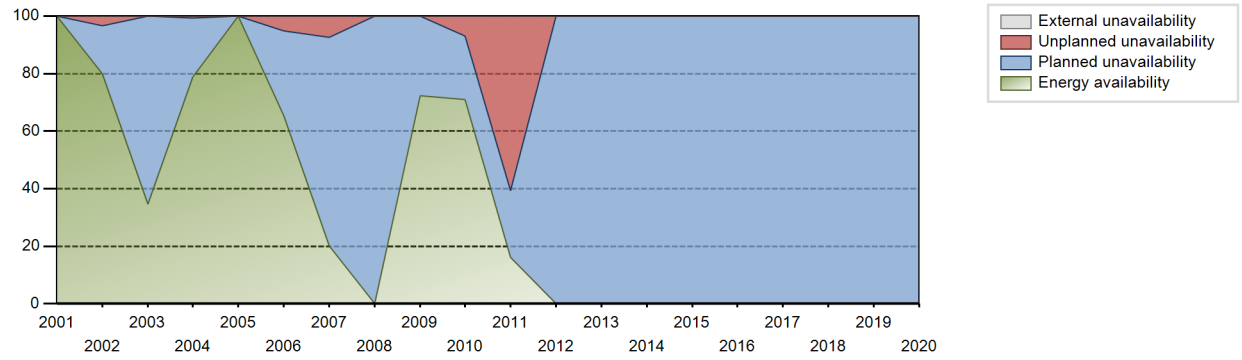
Electricity Production (net) [GWh]



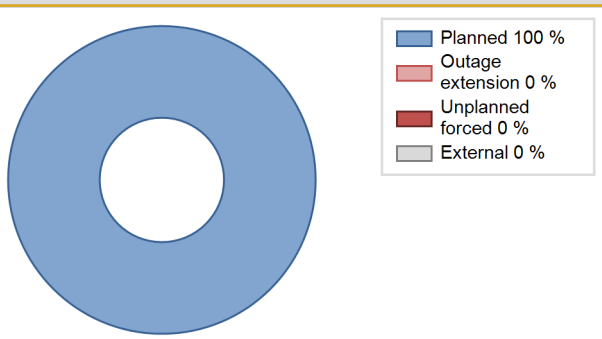
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	2834.34	6576	505	99.72	99.72	99.82	100.00	0.00	0.00	0.28	0.00
1994	3312.39	6584	505	75.02	75.02	74.88	75.16	5.32	4.21	20.77	0.00
1995	3497.23	6974	505	79.05	79.05	79.05	79.61	0.00	0.00	20.95	0.00
1996	3454.70	6848	505	77.91	77.91	77.88	77.96	4.07	3.31	18.78	0.00
1997	4431.84	8760	505	99.98	99.98	100.18	100.00	0.00	0.00	0.02	0.00
1998	3530.63	7047	505	80.04	80.04	79.81	80.45	2.22	1.82	18.15	0.00
1999	3325.67	6607	505	75.42	75.42	75.18	75.42	4.34	3.42	21.16	0.00
2000	3763.08	7462	505	84.89	84.89	84.83	84.95	0.00	0.00	15.11	0.00
2001	4427.41	8760	505	99.97	99.97	100.08	100.00	0.00	0.00	0.03	0.00
2002	3537.07	7010	505	80.01	80.01	79.96	80.02	4.02	3.35	16.64	0.00
2003	1523.80	3029	505	34.56	34.56	34.45	34.58	0.00	0.00	65.44	0.00
2004	3534.94	6958	505	78.75	78.75	79.69	79.21	0.88	0.70	20.55	0.00
2005	4203.80	8226	505	99.99	99.99	95.03	93.90	0.00	0.00	0.01	0.00
2006	2908.09	5777	505	65.34	65.34	65.74	65.95	7.22	5.09	29.57	0.00
2007	908.38	1778	505	20.23	20.23	20.53	20.30	26.87	7.43	72.33	0.00
2008	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2009	3247.93	6367	505	72.28	72.28	73.42	72.68	0.00	0.00	27.72	0.00
2010	3191.56	6287	505	71.09	71.09	72.15	71.77	8.51	6.96	21.95	0.00
2011	729.57	1416	505	16.11	16.11	16.49	16.16	79.00	60.60	23.29	0.00
2012	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	505	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

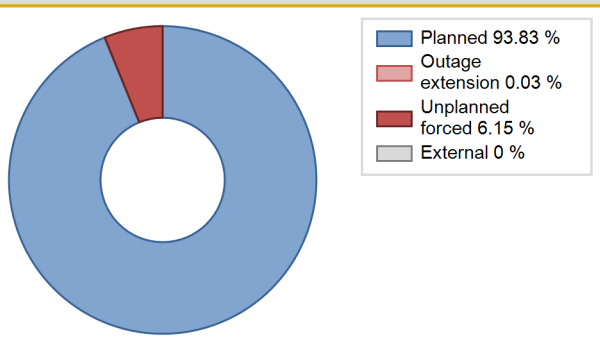
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1993 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					285	
C. Inspection, maintenance or repair combined with refuelling				1186		
D. Inspection, maintenance or repair without refuelling				325		
E. Testing of plant systems or components				76		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			2928		
H. Nuclear regulatory requirements					25	
J. Grid limitation, failure or grid unavailability						23
Subtotal	8784			4515	310	23
Total	**8784**			**4848**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1993 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		10
15. Reactor Cooling Systems		243
31. Turbine and auxiliaries		7
41. Main Generator Systems		16
42. Electrical Power Supply Systems		11
Total		**287**

Highlights (2020)

Implementation of safety mesures for considering the Accident of Fukushima Dai-ichi and Dai-ni Nuclear Power Stations.

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2020 Operating Experience

JP-59 SHIKA-2 JAPAN



Status at end of year	:	**Operational**
Operator	:	HOKURIKU (HOKURIKU ELECTRIC POWER CO.)
Owner	:	HOKURIKU (HOKURIKU ELECTRIC POWER CO.)
Reactor Supplier	:	HITACHI (HITACHI, LTD.)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / ABWR
Thermal power	:	3926 MWth
Gross electrical power	:	1206 MWe
Reference unit power (net)	:	1108 MWe

Key Dates

Construction Date	:	2001-08-20
Grid Date	:	2005-07-04
Commercial Date	:	2006-03-15
Age at end of year	:	15 years

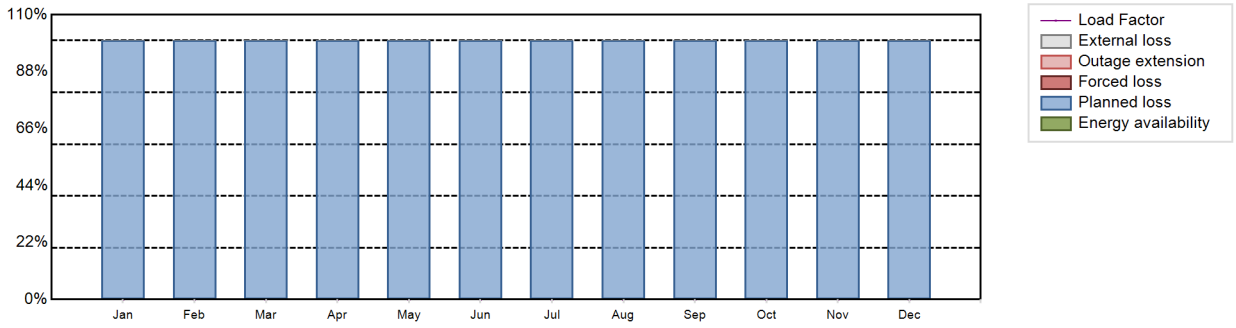
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.07
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]	:	0.310
Average fuel enrichment [% of U235]	:	3.8	**Secondary systems**		
Refuelling frequency [month]	:	15	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	25	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	45000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	5.16	HP cylinder inlet steam pressure [MPa]	:	6.69
Active core height/length [m]	:	3.71	Output voltage [kV]	:	24
Number of fissile fuel assemblies/bundles	:	872	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	17	Number of main condensate pumps	:	6
Number of control rod assemblies	:	205	Number of FW pumps for full power operation	:	2
Number of external reactor coolant loops	:	NA	Number of on-site safety related diesel generators	:	3
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

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	:	8784 hours

Annual Summary



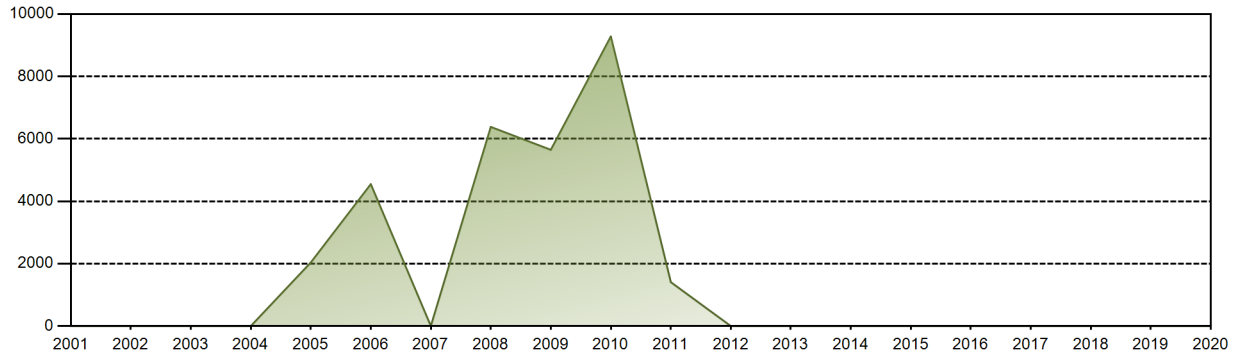
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

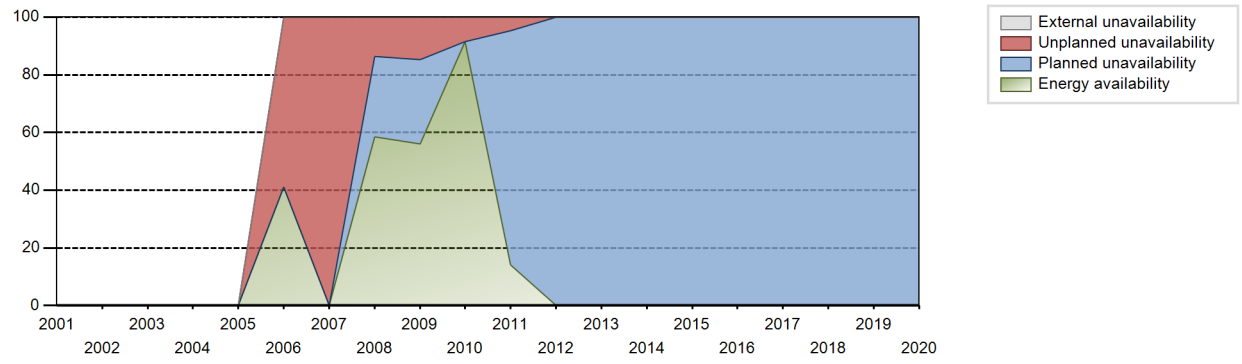
Lifetime energy generation	:	29296 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	43.46 %
Cumulative Energy Availability Factor (EAF)	:	17.38 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	14.32 %
Cumulative Unit Capability Factor (UCF)	:	17.39 %	Cumulative Planned Unavailability Factor (PUF)	:	68.3 %
Cumulative Load Factor (LF)	:	18.02 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	17.67 %			

Electricity Production (net) [GWh]



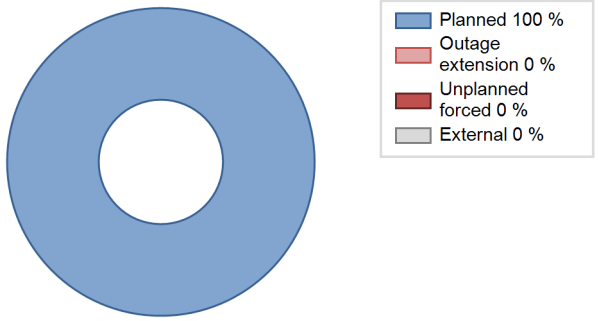
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2006	4547.85	3539	1304	41.15	41.15	41.29	41.26	58.85	58.85	0.00	0.00
2007	0.00	0	1304	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00
2008	6381.93	5610	1108	58.53	58.53	61.08	63.87	0.00	13.53	27.93	0.00
2009	5647.06	5044	1108	55.95	55.95	58.18	57.58	20.80	14.69	29.36	0.00
2010	9279.20	8038	1108	91.50	91.50	95.60	91.76	8.49	8.49	0.00	0.00
2011	1408.12	1263	1108	14.03	14.03	14.51	14.42	25.48	4.80	81.17	0.00
2012	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

Key Factors in Last 20 Years [%]

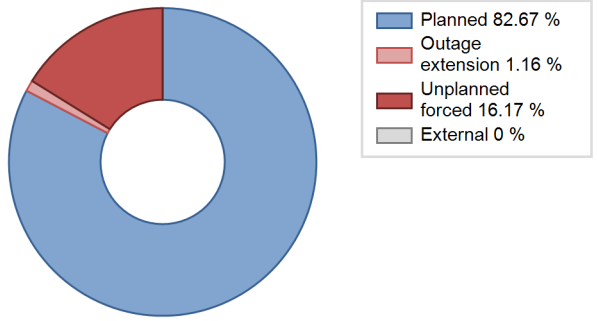


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2006 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					217	
C. Inspection, maintenance or repair combined with refuelling				478		
E. Testing of plant systems or components				61		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			5640		
H. Nuclear regulatory requirements					881	
L. Human factor related					2	
Subtotal	8784			6179	1100	
Total	**8784**			**7279**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2006 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		26
31. Turbine and auxiliaries		934
42. Electrical Power Supply Systems		126
Total		**1086**

Highlights (2020)

Implementation of safety measures for considering the Accident of Fukushima Dai-ichi and Dai-ni Nuclear Power Stations.

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2020 Operating Experience

JP-41 SHIMANE-2 JAPAN



Status at end of year	:	**Operational**
Operator	:	CHUGOKU (THE CHUGOKU ELECTRIC POWER CO., INC.)
Owner	:	CHUGOKU (THE CHUGOKU ELECTRIC POWER CO., INC.)
Reactor Supplier	:	HITACHI (HITACHI, LTD.)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	2436 MWth
Gross electrical power	:	820 MWe
Reference unit power (net)	:	789 MWe

Key Dates

Construction Date	:	1985-02-02
Grid Date	:	1988-07-11
Commercial Date	:	1989-02-10
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]	:	3.7
Refuelling frequency [month]	:	14
Part of the core refuelled [%]	:	25
Average discharge burnup [MWd/t]	:	45000
Active core diameter [m]	:	4.07
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	560
Fuel linear heat generation rate [kW/m]	:	44.0
Number of control rod assemblies	:	137
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

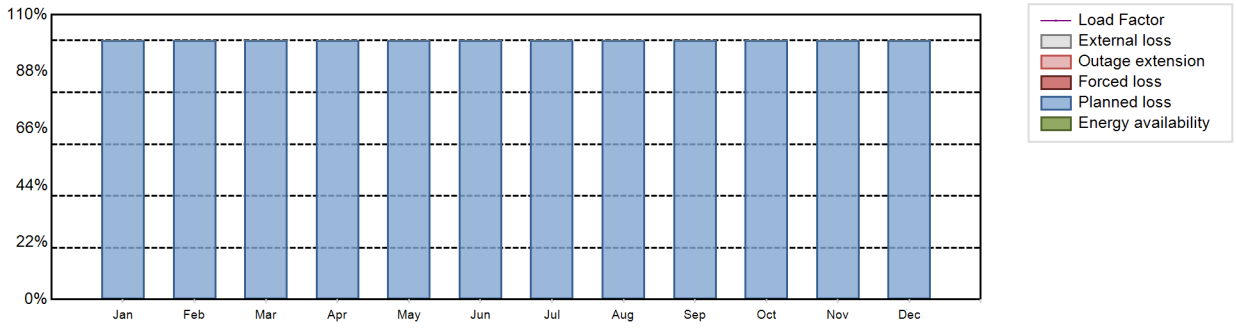
Operating coolant pressure [MPa]	:	6.93
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.427
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	6.55
Output voltage [kV]	:	15.5
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	:	3
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



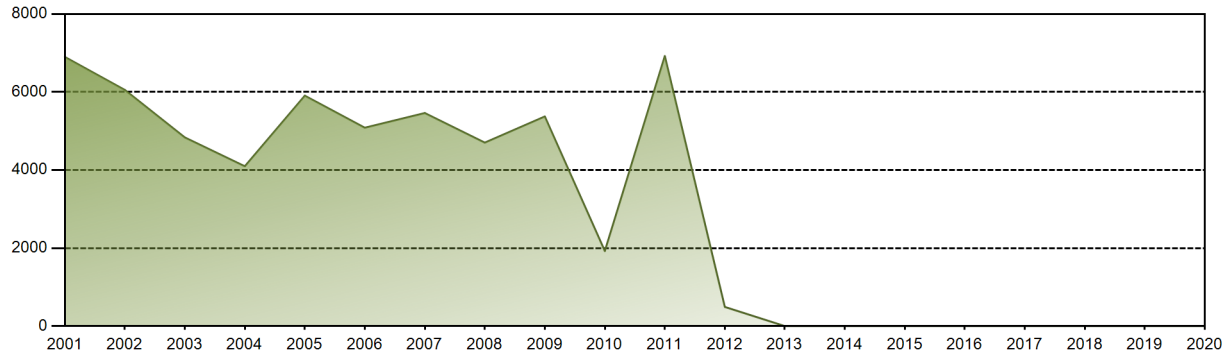
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	129177 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.73 %
Cumulative Energy Availability Factor (EAF)	:	57.84 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.61 %
Cumulative Unit Capability Factor (UCF)	:	57.86 %	Cumulative Planned Unavailability Factor (PUF)	:	39.53 %
Cumulative Load Factor (LF)	:	57.76 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	58.08 %			

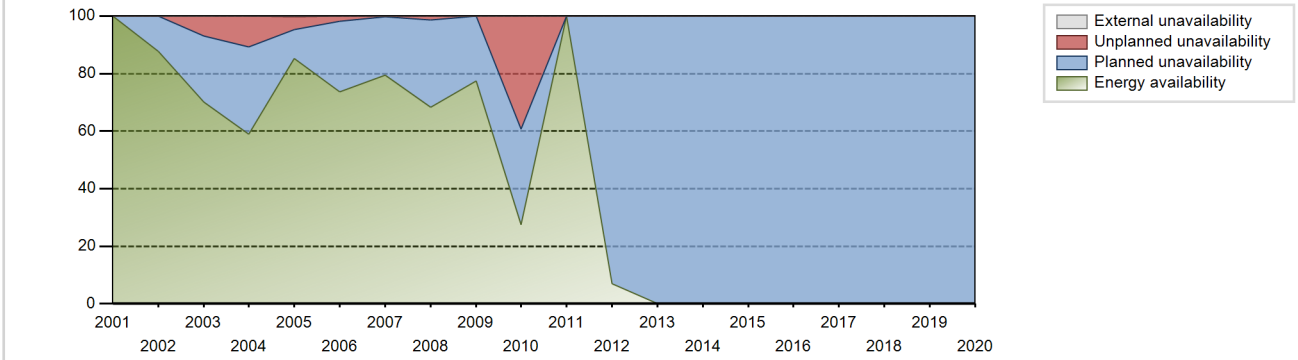
Electricity Production (net) [GWh]



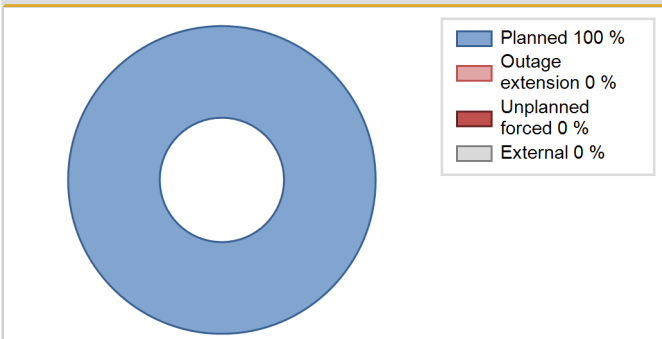
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	5852.06	7485	790	89.20	89.20	88.79	89.56	10.80	10.80	0.00	0.00
1990	5123.51	6592	790	74.03	74.03	74.03	75.25	7.01	5.58	20.38	0.00
1991	5544.50	7121	790	80.12	80.12	80.12	81.29	0.00	0.00	19.88	0.00
1992	5516.14	7072	790	79.69	79.69	79.49	80.51	0.00	0.00	20.31	0.00
1993	6756.90	8592	790	97.78	97.78	97.64	98.08	1.86	1.85	0.37	0.00
1994	5547.27	7071	790	80.55	80.62	80.16	80.72	0.00	0.00	19.38	0.07
1995	5363.61	6888	790	77.85	77.86	77.50	78.63	1.86	1.48	20.66	0.01
1996	5583.69	7166	790	80.83	80.83	80.46	81.58	0.00	0.00	19.17	0.00
1997	6903.19	8760	789	99.97	99.98	99.88	100.00	0.01	0.01	0.01	0.00
1998	5962.47	7600	789	86.46	86.50	86.27	86.76	0.00	0.00	13.50	0.03
1999	5758.72	7319	789	83.50	83.50	83.32	83.55	0.00	0.00	16.50	0.00
2000	6083.96	7747	789	88.12	88.17	87.78	88.19	0.00	0.00	11.83	0.05
2001	6901.04	8760	789	99.95	99.98	99.85	100.00	0.00	0.00	0.02	0.03
2002	6055.09	7678	789	87.61	87.64	87.61	87.65	0.00	0.00	12.36	0.03
2003	4836.24	6133	789	70.00	70.06	69.97	70.01	0.00	6.82	23.13	0.05
2004	4097.56	5202	789	58.97	58.97	59.12	59.22	13.59	10.64	30.40	0.00
2005	5907.46	7544	789	85.36	85.56	85.47	86.12	4.96	4.46	9.97	0.21
2006	5085.40	6469	789	73.61	73.61	73.58	73.85	0.00	1.77	24.62	0.00
2007	5462.01	6970	789	79.52	79.52	79.03	79.57	0.00	0.29	20.20	0.00
2008	4703.60	6001	789	68.25	68.25	67.87	68.32	0.00	1.37	30.38	0.00
2009	5373.85	6799	789	77.46	77.46	77.75	77.61	0.00	0.00	22.54	0.00
2010	1924.42	2438	789	27.61	27.61	27.84	27.83	0.00	39.32	33.07	0.00
2011	6921.96	8760	789	99.98	99.98	100.15	100.00	0.00	0.01	0.01	0.00
2012	491.69	625	789	7.06	7.06	7.09	7.12	0.00	0.00	92.94	0.00
2013	0.00	0	789	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	789	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	789	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	789	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	789	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	789	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	789	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	789	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

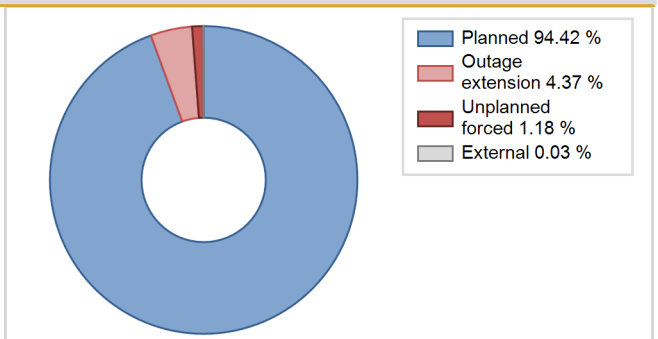
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1989 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					95	
C. Inspection, maintenance or repair combined with refuelling				995	5	
D. Inspection, maintenance or repair without refuelling				4		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			2453		
H. Nuclear regulatory requirements					109	
L. Human factor related					4	
Z. Other					19	
Subtotal	8784			3452	232	
Total	**8784**			**3684**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		30
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems		11
15. Reactor Cooling Systems		50
Total		**94**

Highlights (2020)

Highlights for the year:Implementaion of emergency safety measures for considering the Accident of Fukushima Dai-ichi and Dai-ni Nuclear Power Station

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2020 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	:	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]	:	4.0
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

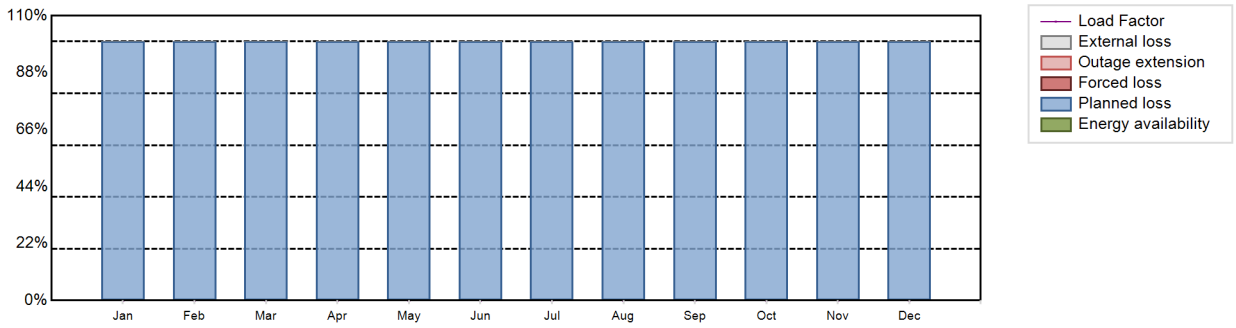
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	323
Number of SG	:	3
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.24
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	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	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



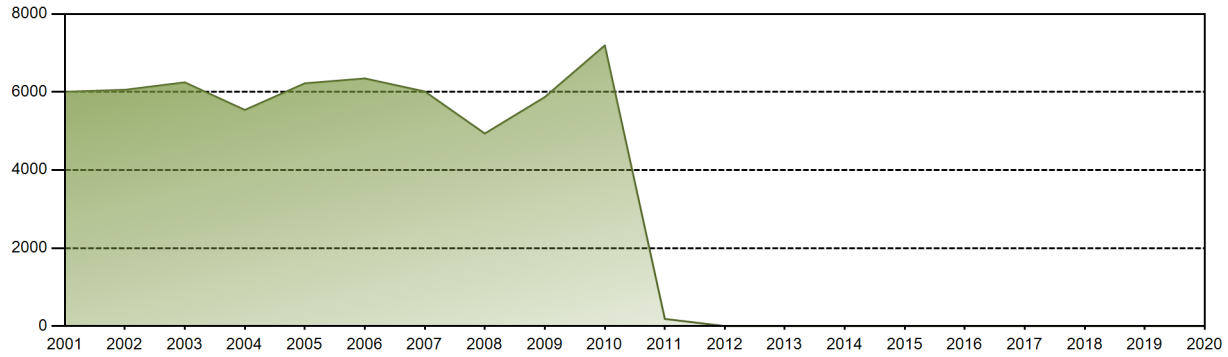
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	174314 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.4 %
Cumulative Energy Availability Factor (EAF)	:	54.48 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.78 %
Cumulative Unit Capability Factor (UCF)	:	54.5 %	Cumulative Planned Unavailability Factor (PUF)	:	41.71 %
Cumulative Load Factor (LF)	:	55.26 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	55.41 %			

Electricity Production (net) [GWh]

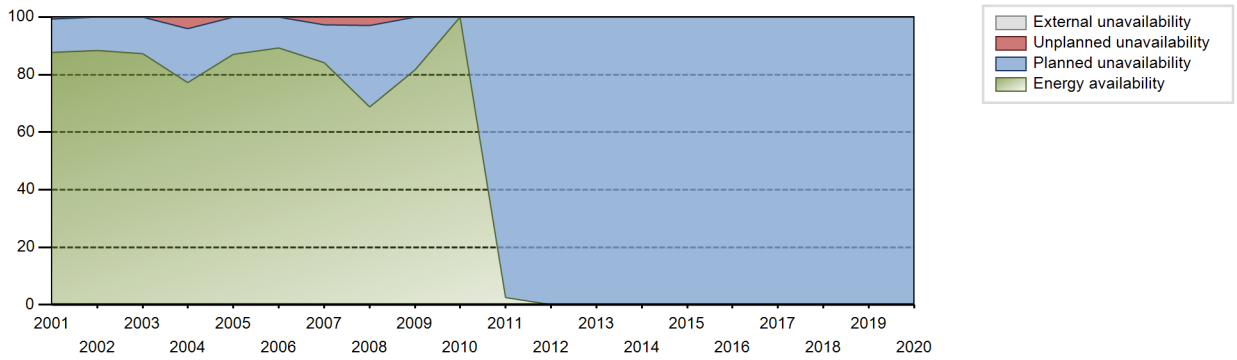


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	2660.40	4392	780	94.03	94.03	92.81	93.99	5.08	5.03	0.93	0.00
1975	4980.40	6938	780	72.81	72.81	72.89	79.20	12.81	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

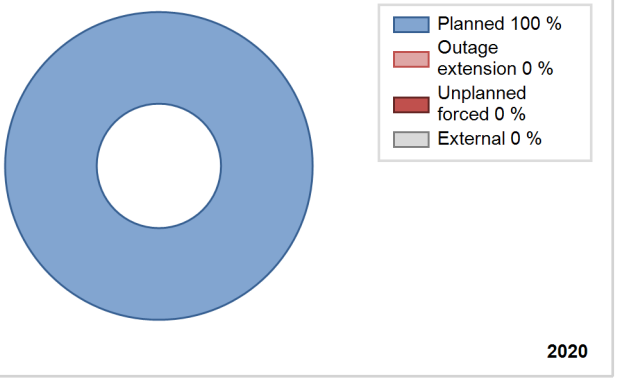
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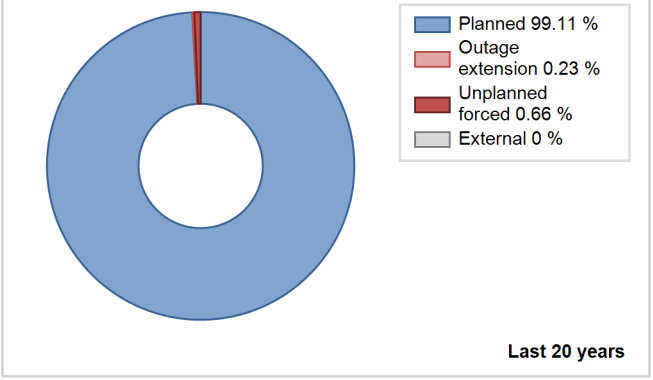
2011	183.43	226	780	2.53	2.53	2.68	2.58	0.00	0.00	97.47	0.00
2012	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					297	
C. Inspection, maintenance or repair combined with refuelling				1561		
D. Inspection, maintenance or repair without refuelling				154		
E. Testing of plant systems or components				0		
F. Major backfitting, refurbishment or upgrading activities with refuelling				39		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			1855		
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					1	
Z. Other					8	
Subtotal	8784			3609	306	2
Total	**8784**			**3917**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		6
12. Reactor I&C Systems		5
15. Reactor Cooling Systems		75
16. Steam generation systems		175
31. Turbine and auxiliaries		20
32. Feedwater and Main Steam System		19
42. Electrical Power Supply Systems		1
Total		**301**

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2020 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

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	:	1971-03-09
Grid Date	:	1975-01-17
Commercial Date	:	1975-11-14
Age at end of year	:	45 years

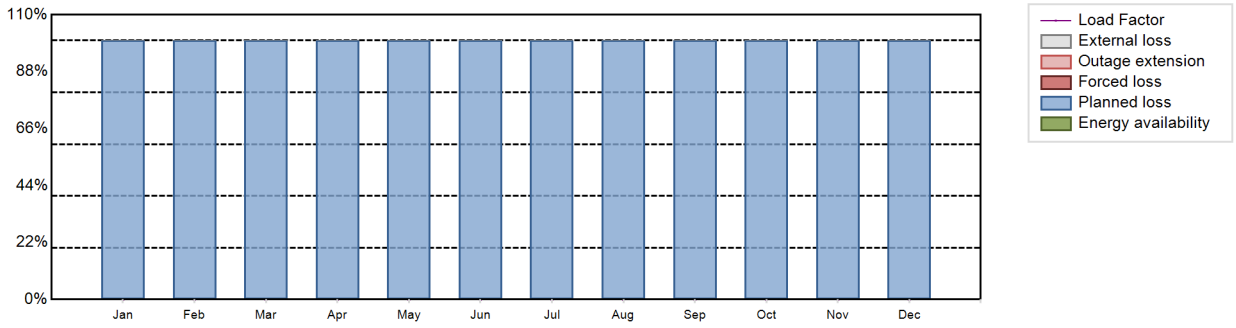
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	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	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



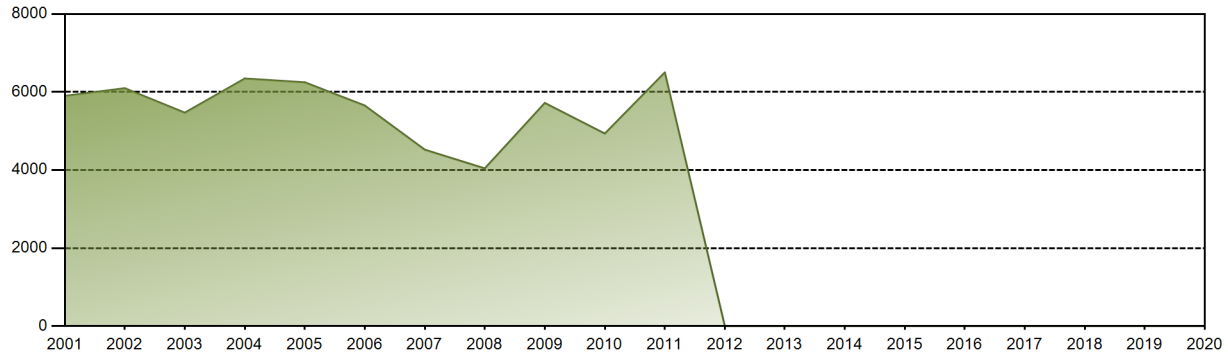
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	172658 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.67 %
Cumulative Energy Availability Factor (EAF)	:	54.89 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3 %
Cumulative Unit Capability Factor (UCF)	:	54.97 %	Cumulative Planned Unavailability Factor (PUF)	:	42.03 %
Cumulative Load Factor (LF)	:	55.95 %	Cumulative Externally cause unavailability (XUF)	:	0.08 %
Cumulative Operating Factor (OF)	:	56.06 %			

Electricity Production (net) [GWh]

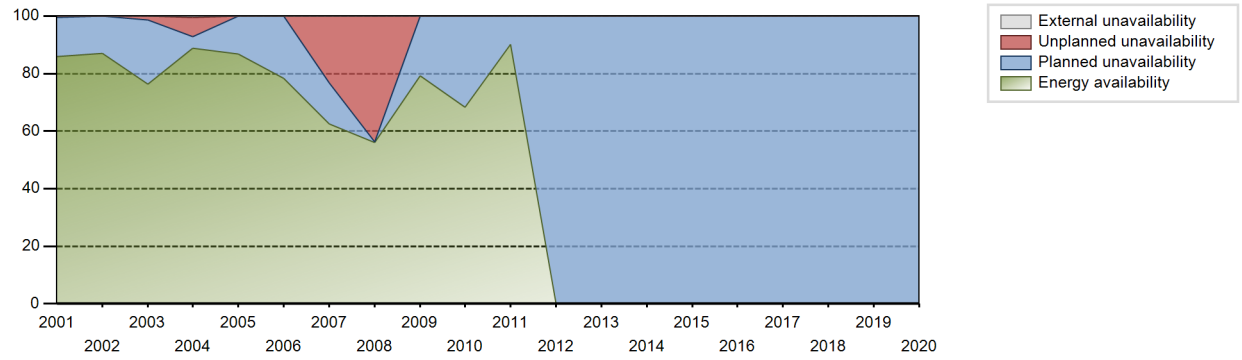


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	3168.50	5532	780	99.55	99.55	100.44	100.00	0.00	0.00	0.45	0.00
1976	3728.80	6214	780	54.17	54.17	54.42	70.74	23.83	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	90.06	90.06	95.17	90.13	0.00	0.00	9.94	0.00

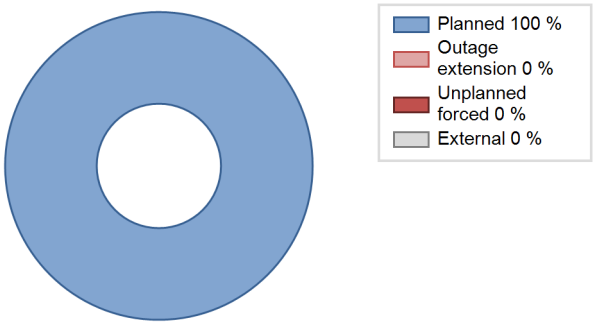
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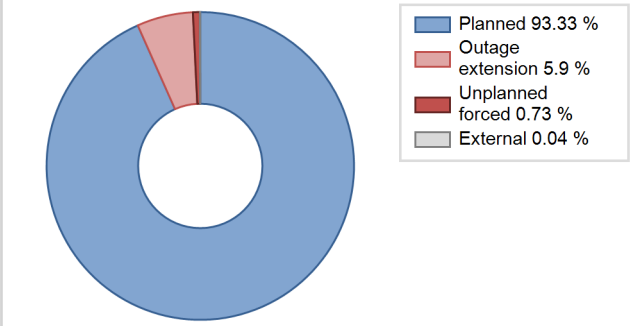
2012	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	780	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					227	
C. Inspection, maintenance or repair combined with refuelling				1835		
D. Inspection, maintenance or repair without refuelling				7		
F. Major backfitting, refurbishment or upgrading activities with refuelling				44		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			1729		
L. Human factor related					4	
Z. Other					13	
Subtotal	8784			3615	244	
Total	**8784**			**3859**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		159
16. Steam generation systems		59
31. Turbine and auxiliaries		15
32. Feedwater and Main Steam System		6
42. Electrical Power Supply Systems		5
Total		**244**

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2020 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	:	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]	:	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

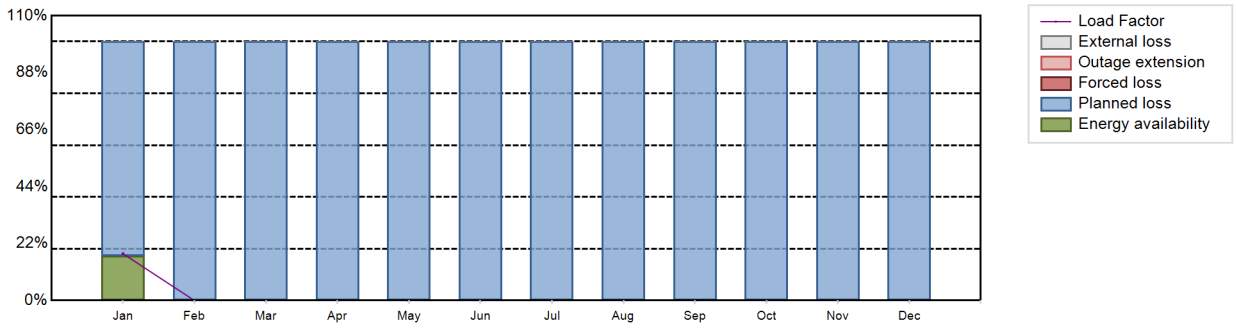
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	321
Number of SG	:	3
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.28
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	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	:	DS

Annual Production Results (2020)

Net Energy Production	:	111.74 GW(e).h
Energy Availability Factor (EAF)	:	1.45 %
Unit Capability Factor (UCF)	:	1.45 %
Load Factor (LF)	:	1.53 %
Operating Factor (OF)	:	1.49 %
Equivalent non-electrical energy generated (NEG)	:	7.56 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	98.55 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8653 hours

Annual Summary



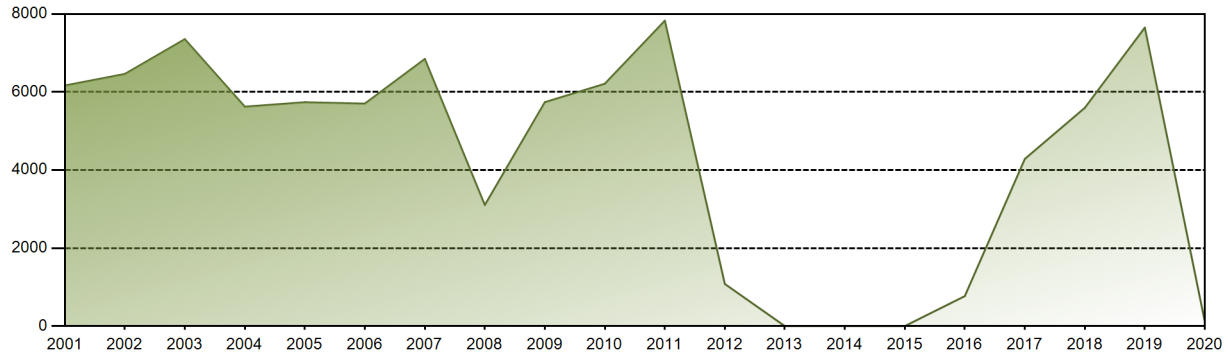
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	111.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	111.74
EAF [%]	17.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.45
UCF [%]	17.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.45
LF [%]	18.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53
OF [%]	17.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.49
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 [%]	82.88	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.55
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

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Historical Summary

Lifetime energy generation	:	185129.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.3 %
Cumulative Energy Availability Factor (EAF)	:	70.77 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.49 %
Cumulative Unit Capability Factor (UCF)	:	70.8 %	Cumulative Planned Unavailability Factor (PUF)	:	28.71 %
Cumulative Load Factor (LF)	:	70.7 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	69.01 %			

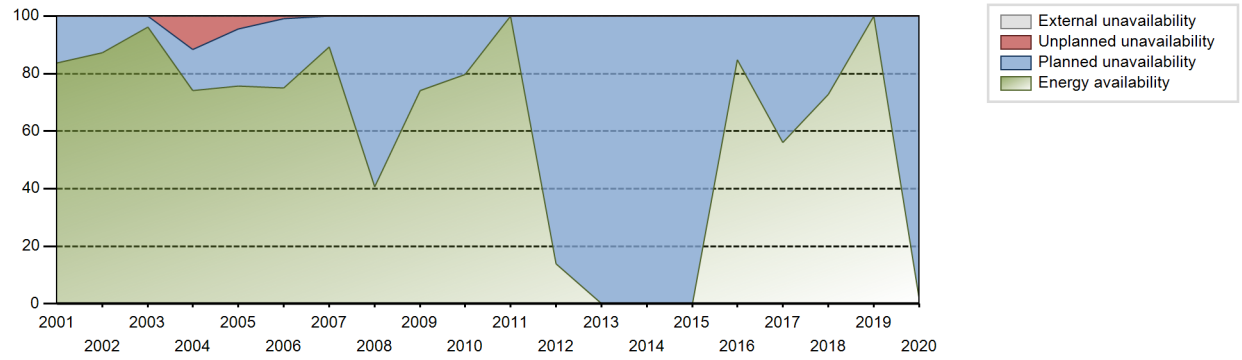
Electricity Production (net) [GWh]



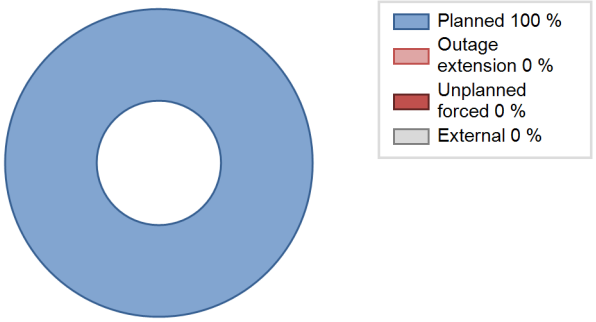
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	6199.46	7426	830	83.31	83.31	84.14	83.36	0.00	0.00	16.69	0.00
1986	6833.58	8215	830	93.08	93.08	93.99	93.78	0.00	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

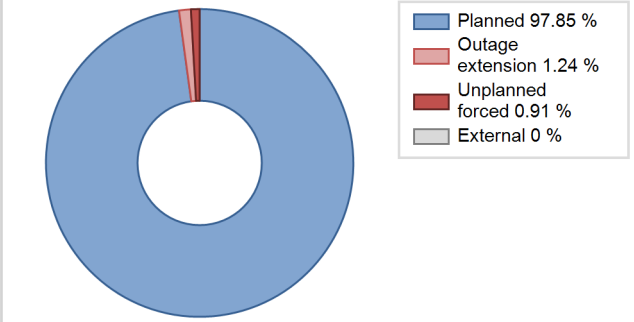
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 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	8653			1538		
F. Major backfitting, refurbishment or upgrading activities with refuelling				18		
G. Major backfitting, refurbishment or upgrading activities without refuelling				945		
H. Nuclear regulatory requirements					11	
J. Grid limitation, failure or grid unavailability						3
M. Governmental requirements or court decisions						183
Z. Other					29	
Subtotal	8653			2501	43	186
Total	**8653**			**2730**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		2
16. Steam generation systems		11
31. Turbine and auxiliaries		18
32. Feedwater and Main Steam System		0
Total		**43**

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2020 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	:	36 years

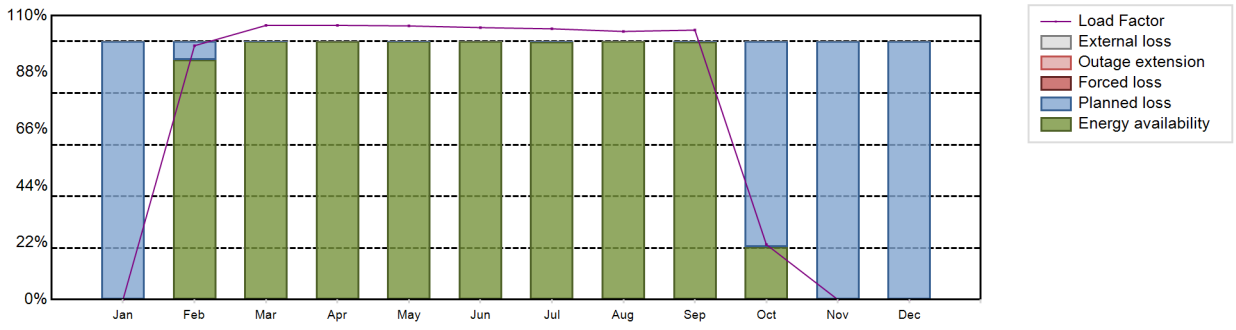
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.1
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	:	DS

Annual Production Results (2020)

Net Energy Production	:	5187.9 GW(e).h
Energy Availability Factor (EAF)	:	67.55 %
Unit Capability Factor (UCF)	:	67.55 %
Load Factor (LF)	:	71.16 %
Operating Factor (OF)	:	67.95 %
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)	:	32.45 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	2815 hours

Annual Summary



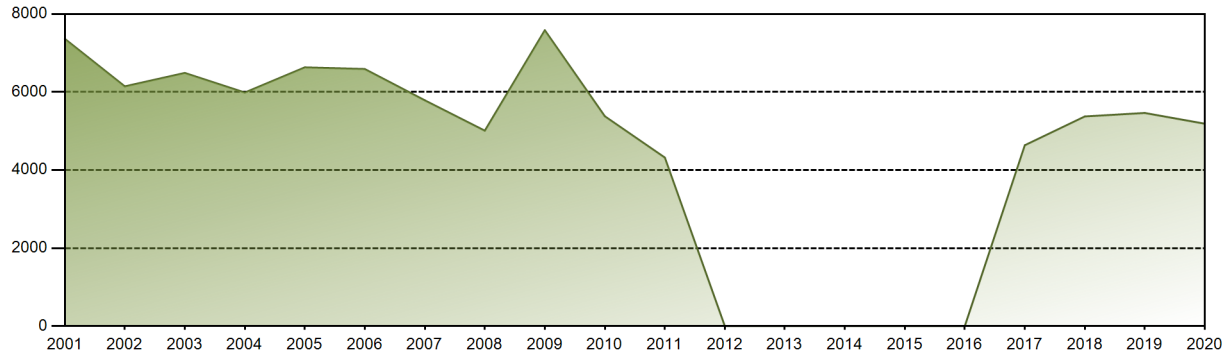
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	568.14	655.82	634.84	654.65	629.62	647.74	641.42	623.93	131.74	0.00	0.00	5187.90
EAF [%]	0.00	92.91	99.99	100.00	99.99	100.00	99.98	100.00	99.98	20.35	0.00	0.00	67.55
UCF [%]	0.00	92.91	99.99	100.00	99.99	100.00	99.98	100.00	99.98	20.35	0.00	0.00	67.55
LF [%]	0.00	98.35	106.20	106.23	106.01	105.36	104.89	103.87	104.41	21.33	0.00	0.00	71.16
OF [%]	0.00	97.41	100.00	100.00	100.00	100.00	100.00	100.00	100.00	20.83	0.00	0.00	67.95
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 [%]	100.00	7.09	0.01	0.00	0.01	0.00	0.02	0.00	0.02	79.65	100.00	100.00	32.45
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

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Historical Summary

Lifetime energy generation	:	184097.9 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.37 %
Cumulative Energy Availability Factor (EAF)	:	72.12 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.37 %
Cumulative Unit Capability Factor (UCF)	:	72.16 %	Cumulative Planned Unavailability Factor (PUF)	:	27.47 %
Cumulative Load Factor (LF)	:	71.1 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	69.47 %			

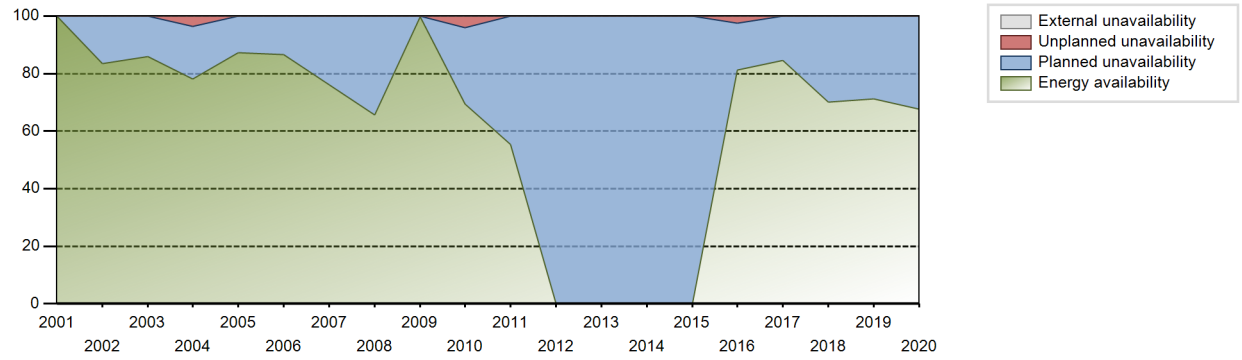
Electricity Production (net) [GWh]



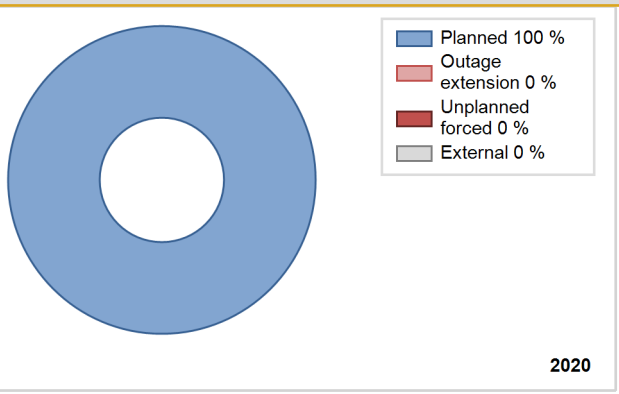
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	5479.31	6887	830	100.00	100.00	101.21	100.00	0.00	0.00	0.00	0.00
1986	5864.02	7073	830	79.59	79.59	80.65	80.74	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

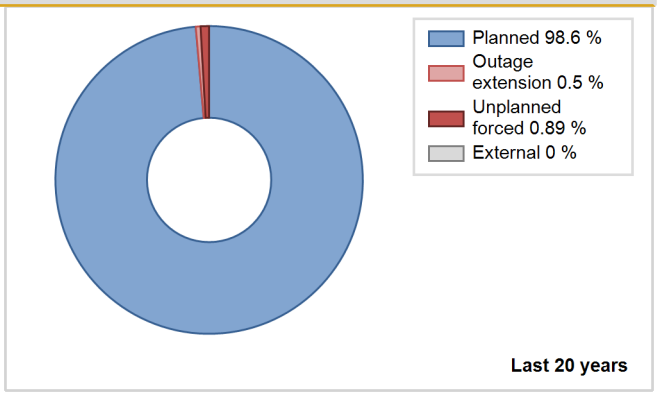
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					24	
C. Inspection, maintenance or repair combined with refuelling	2816			1352		
G. Major backfitting, refurbishment or upgrading activities without refuelling				1086		
J. Grid limitation, failure or grid unavailability						3
M. Governmental requirements or court decisions						263
Z. Other					9	
Subtotal	2816			2438	33	266
Total	**2816**			**2737**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		8
16. Steam generation systems		9
41. Main Generator Systems		16
Total		**33**

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2020 Operating Experience

JP-21 TOKAI-2 JAPAN

Status at end of year	:	**Operational**
Operator	:	JAPCO (JAPAN ATOMIC POWER CO.)
Owner	:	JAPCO (JAPAN ATOMIC POWER CO.)
Reactor Supplier	:	GE (GENERAL ELECTRIC CO.)
Turbine Supplier	:	GE/H (GENERAL ELECTRIC CO./ HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5
Thermal power	:	3293 MWth
Gross electrical power	:	1100 MWe
Reference unit power (net)	:	1060 MWe

Key Dates

Construction Date	:	1973-10-03
Grid Date	:	1978-03-13
Commercial Date	:	1978-11-28
Age at end of year	:	42 years

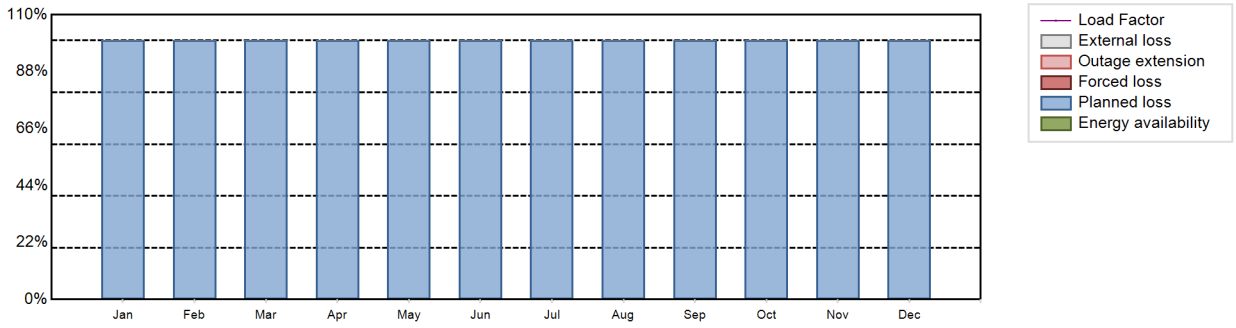
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	3.7
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	22
Average discharge burnup [MWd/t]	:	45000
Active core diameter [m]	:	4.75
Active core height/length [m]	:	3.71
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	15.9
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	6.93
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.385
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]	:	6.68
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	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



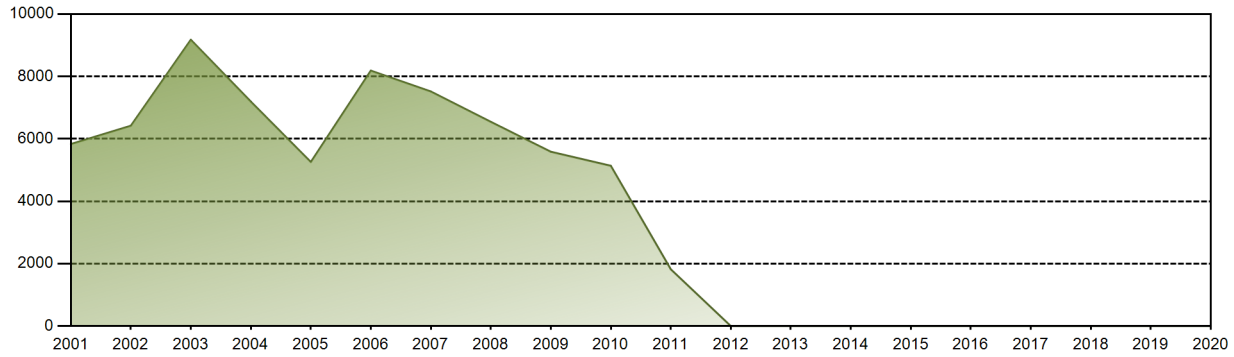
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	221610 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.1 %
Cumulative Energy Availability Factor (EAF)	:	55.71 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.35 %
Cumulative Unit Capability Factor (UCF)	:	56.25 %	Cumulative Planned Unavailability Factor (PUF)	:	39.39 %
Cumulative Load Factor (LF)	:	55.96 %	Cumulative Externally cause unavailability (XUF)	:	0.54 %
Cumulative Operating Factor (OF)	:	56.4 %			

Electricity Production (net) [GWh]

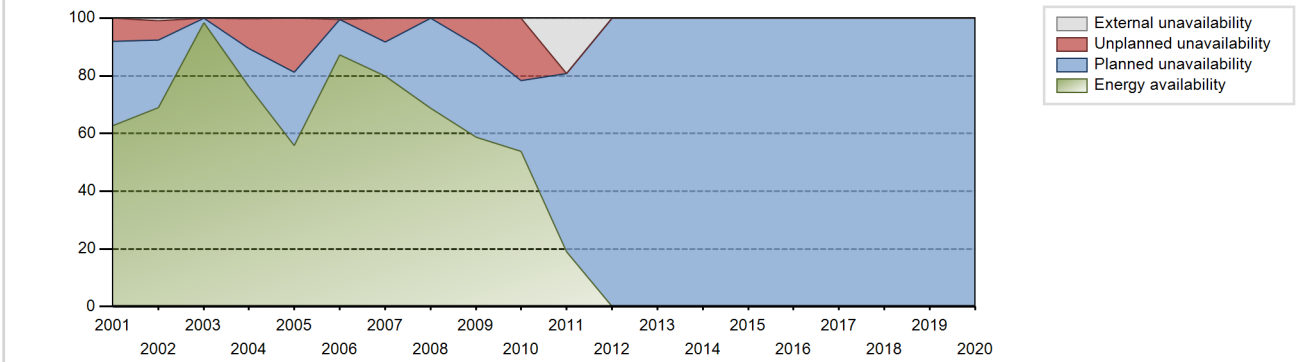


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1978	Data not provided										
1979	5209.50	5481	1056	56.32	56.32	56.32	62.57	9.83	6.14	37.55	0.00
1980	6743.20	6597	1056	72.59	72.59	72.70	75.10	1.40	1.03	26.38	0.00
1981	6059.10	6037	1056	65.32	65.32	65.50	68.92	7.15	5.03	29.65	0.00
1982	5571.60	5338	1056	59.60	59.60	60.23	60.94	0.00	0.00	40.40	0.00
1983	6556.64	6327	1056	70.45	70.45	70.88	72.23	4.32	3.18	26.37	0.00
1984	8695.17	8240	1056	93.46	93.46	93.74	93.81	1.09	1.03	5.51	0.00
1985	6957.48	6625	1056	75.03	75.03	75.21	75.63	2.53	1.94	23.02	0.00
1986	5797.62	5508	1056	62.46	62.46	62.67	62.88	0.00	0.00	37.54	0.00
1987	7040.45	6776	1056	76.46	76.46	76.11	77.35	1.72	1.34	22.20	0.00
1988	6088.38	5872	1056	65.97	65.97	65.64	66.85	0.00	0.00	34.03	0.00
1989	8434.97	8006	1056	91.22	91.22	91.18	91.39	0.00	0.00	8.78	0.00
1990	7291.60	6948	1056	78.90	78.90	78.82	79.32	3.85	3.16	17.94	0.00
1991	7025.25	6716	1056	76.07	76.07	75.94	76.67	0.00	0.00	23.93	0.00
1992	6307.75	5990	1080	68.46	68.64	66.49	68.19	0.00	0.00	31.36	0.18
1993	8707.18	8252	1080	93.84	93.84	92.03	94.20	2.88	2.78	3.37	0.00
1994	7325.77	6938	1056	78.85	78.87	79.19	79.20	0.00	0.00	21.13	0.01
1995	6845.05	6488	1056	73.66	73.69	74.00	74.06	0.00	0.00	26.31	0.03
1996	7562.05	7169	1056	80.75	80.79	81.52	81.61	1.39	1.14	18.07	0.04
1997	8884.54	8404	1056	95.60	95.70	96.04	95.94	4.28	4.28	0.02	0.10
1998	6999.42	6642	1056	74.97	75.07	75.66	75.82	0.00	0.00	24.93	0.10
1999	2316.08	2228	1056	24.95	25.37	25.04	25.43	63.91	44.93	29.70	0.42
2000	7031.57	6626	1056	75.40	76.28	75.80	75.43	23.71	23.71	0.02	0.87
2001	5833.18	5641	1056	62.68	62.69	63.06	64.39	11.40	8.07	29.25	0.00
2002	6420.06	6061	1056	68.93	69.96	69.40	69.19	8.63	6.61	23.43	1.03
2003	9176.55	8635	1056	98.51	98.56	99.20	98.57	0.00	0.00	1.44	0.05
2004	7195.36	6723	1060	76.33	76.50	77.28	76.54	0.00	10.33	13.17	0.17
2005	5259.48	4914	1060	55.84	55.84	56.64	56.10	0.00	18.78	25.38	0.00
2006	8186.87	7704	1060	87.33	87.90	88.17	87.95	0.00	0.00	12.10	0.57
2007	7518.75	7048	1060	79.98	79.98	80.97	80.46	9.32	8.22	11.79	0.00
2008	6545.88	6132	1060	68.76	68.76	70.30	69.81	0.00	0.00	31.24	0.00
2009	5587.41	5169	1060	58.70	58.70	60.17	59.01	13.89	9.47	31.83	0.00
2010	5137.03	4763	1060	53.90	53.90	55.32	54.37	28.74	21.74	24.36	0.00
2011	1819.07	1670	1060	19.07	38.36	19.59	19.06	0.00	0.00	61.64	19.28
2012	0.00	0	1060	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1060	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1060	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

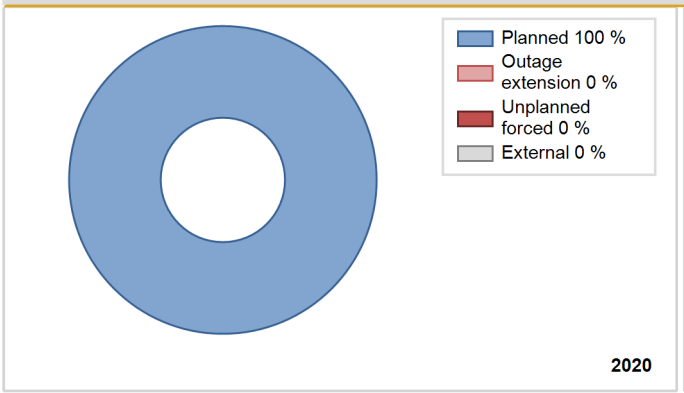
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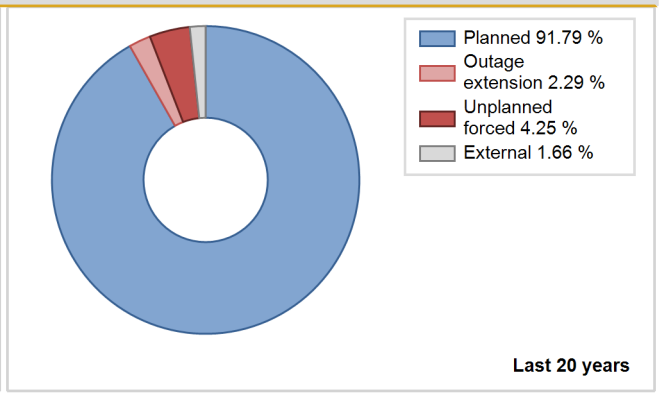
2015	0.00	0	1060	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1060	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1060	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1060	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1060	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1060	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		2020 Hours Lost			1978 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					310	
C.	Inspection, maintenance or repair combined with refuelling				1491		
D.	Inspection, maintenance or repair without refuelling				23	7	
G.	Major backfitting, refurbishment or upgrading activities without refuelling	8784			1906		
J.	Grid limitation, failure or grid unavailability						2
L.	Human factor related					0	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						42
Z.	Other					8	
Subtotal		8784			3420	325	44
Total		**8784**			**3789**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1978 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		7
12. Reactor I&C Systems		142
13. Reactor Auxiliary Systems		48
14. Safety Systems		22
15. Reactor Cooling Systems		29
31. Turbine and auxiliaries		29
32. Feedwater and Main Steam System		38
42. Electrical Power Supply Systems		10
Total		**325**

Highlights (2020)

Appropriate Implementation in new regulatory law

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2020 Operating Experience

JP-43 TOMARI-1 JAPAN



Status at end of year	:	**Operational**
Operator	:	HEPCO (HOKKAIDO ELECTRIC POWER CO., INC.)
Owner	:	HEPCO (HOKKAIDO 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 (2-loop)
Thermal power	:	1650 MWth
Gross electrical power	:	579 MWe
Reference unit power (net)	:	550 MWe

Key Dates

Construction Date	:	1985-04-18
Grid Date	:	1988-12-06
Commercial Date	:	1989-06-22
Age at end of year	:	32 years

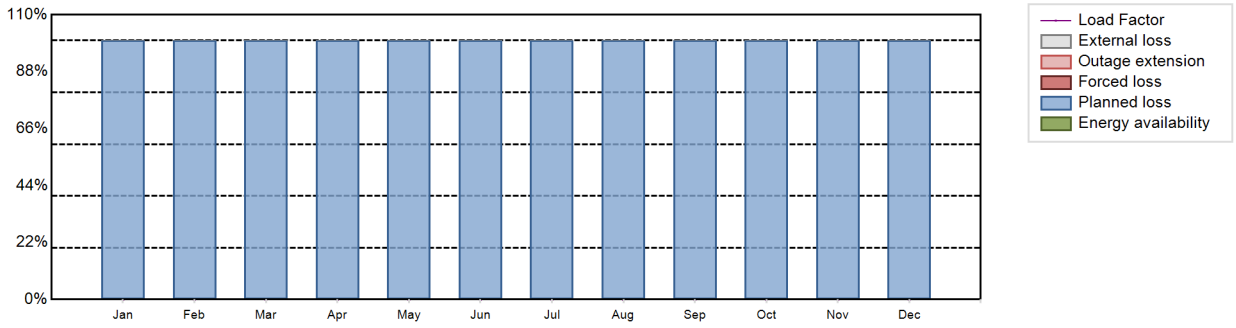
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.8
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	41000
Active core diameter [m]	:	2.46
Active core height/length [m]	:	3.64
Number of fissile fuel assemblies/bundles	:	121
Fuel linear heat generation rate [kW/m]	:	20.4
Number of control rod assemblies	:	29
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	323
Number of SG	:	2
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.254
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]	:	5.41
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	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



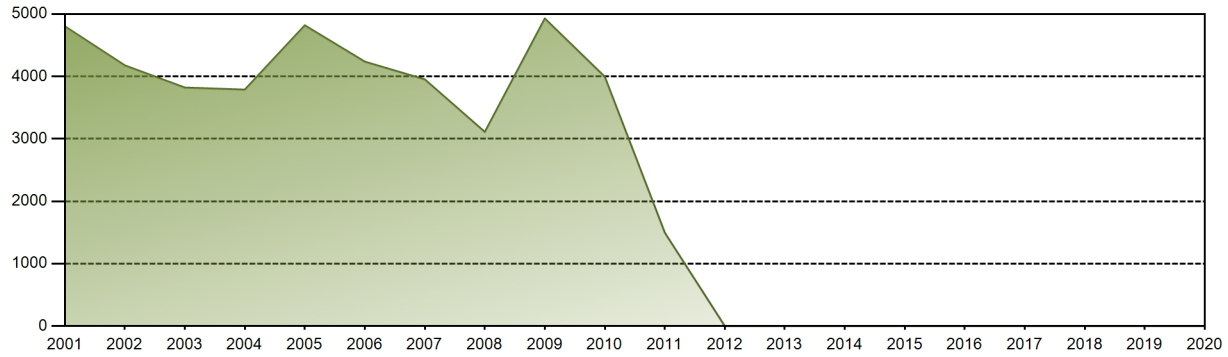
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	90971 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.89 %
Cumulative Energy Availability Factor (EAF)	:	58.8 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.53 %
Cumulative Unit Capability Factor (UCF)	:	58.8 %	Cumulative Planned Unavailability Factor (PUF)	:	40.67 %
Cumulative Load Factor (LF)	:	59.41 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	59.1 %			

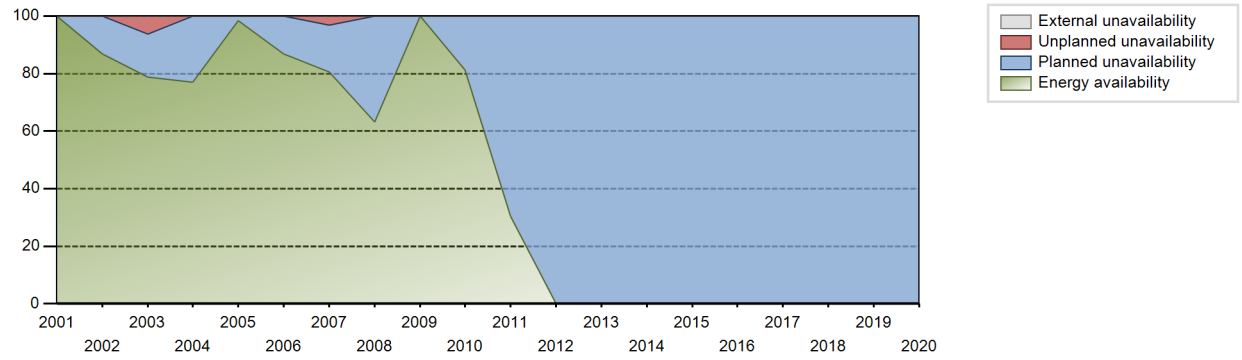
Electricity Production (net) [GWh]



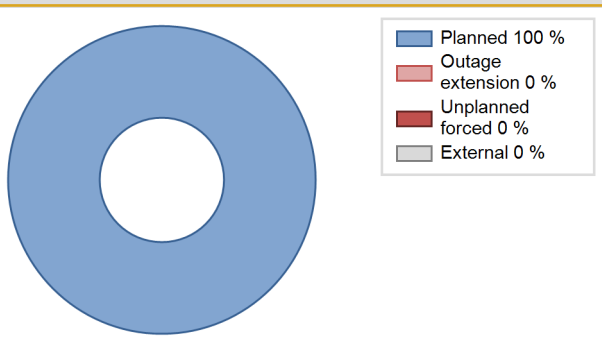
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	3607.01	7095	550	99.57	99.57	99.57	100.00	0.00	0.00	0.43	0.00
1990	3830.69	7092	550	79.51	79.51	79.51	80.96	0.00	0.00	20.49	0.00
1991	3540.38	6588	550	73.48	73.48	73.48	75.21	8.90	7.18	19.34	0.00
1992	3646.36	6780	550	75.86	75.86	75.48	77.19	0.00	0.00	24.14	0.00
1993	4795.23	8760	550	99.99	99.99	99.53	100.00	0.00	0.00	0.01	0.00
1994	3903.95	7208	550	81.38	81.38	81.03	82.28	0.00	0.00	18.62	0.00
1995	3946.25	7175	550	81.85	81.85	81.91	81.91	0.00	0.00	18.15	0.00
1996	3750.44	6920	550	78.06	78.06	77.63	78.78	0.00	0.00	21.94	0.00
1997	4795.59	8760	550	99.99	99.99	99.53	100.00	0.00	0.00	0.01	0.00
1998	4239.09	7373	550	83.12	83.12	87.98	84.17	0.00	0.00	16.88	0.00
1999	4074.58	6986	550	79.73	79.73	84.57	79.75	0.00	0.00	20.27	0.00
2000	4168.52	7598	550	86.49	86.49	86.28	86.50	0.00	0.00	13.51	0.00
2001	4803.96	8760	550	99.99	99.99	99.71	100.00	0.00	0.00	0.01	0.00
2002	4177.26	7614	550	86.91	86.91	86.70	86.92	0.00	0.00	13.09	0.00
2003	3821.66	6893	550	78.69	78.69	79.32	78.69	7.30	6.20	15.11	0.00
2004	3788.84	6762	550	76.97	76.97	78.42	76.98	0.00	0.00	23.03	0.00
2005	4818.78	8616	550	98.30	98.30	100.02	98.36	0.00	0.00	1.70	0.00
2006	4236.75	7643	550	86.89	86.89	87.94	87.25	0.00	0.00	13.11	0.00
2007	3952.55	7121	550	80.61	80.61	82.04	81.29	3.88	3.25	16.13	0.00
2008	3111.15	5578	550	63.10	63.10	64.40	63.50	0.00	0.00	36.90	0.00
2009	4928.21	8760	550	100.00	100.00	102.29	100.00	0.00	0.00	0.00	0.00
2010	3994.56	7156	550	81.28	81.28	82.91	81.69	0.00	0.00	18.72	0.00
2011	1496.72	2664	550	30.36	30.36	31.07	30.41	0.00	0.00	69.64	0.00
2012	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

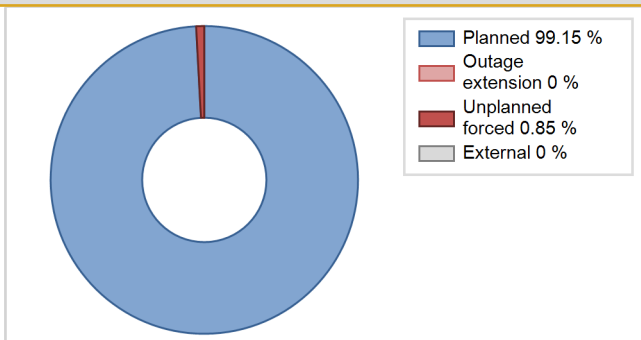
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					24	
C. Inspection, maintenance or repair combined with refuelling				925		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			2676		
Z. Other					18	
Subtotal	8784			3601	42	
Total	**8784**			**3643**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
32. Feedwater and Main Steam System		16
42. Electrical Power Supply Systems		8
Total		**24**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ich and Dai-ni Nuclear Power Stations Enforcement of Comprehensive Assessment for the Safety of Nuclear Power Reactor Facility(so-called Stress Test)

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2020 Operating Experience

JP-44 TOMARI-2 JAPAN



Status at end of year	:	**Operational**
Operator	:	HEPCO (HOKKAIDO ELECTRIC POWER CO., INC.)
Owner	:	HEPCO (HOKKAIDO 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 (2-loop)
Thermal power	:	1650 MWth
Gross electrical power	:	579 MWe
Reference unit power (net)	:	550 MWe

Key Dates

Construction Date	:	1985-06-13
Grid Date	:	1990-08-27
Commercial Date	:	1991-04-12
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]	:	4.8
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	41000
Active core diameter [m]	:	2.46
Active core height/length [m]	:	3.64
Number of fissile fuel assemblies/bundles	:	121
Fuel linear heat generation rate [kW/m]	:	20.4
Number of control rod assemblies	:	29
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

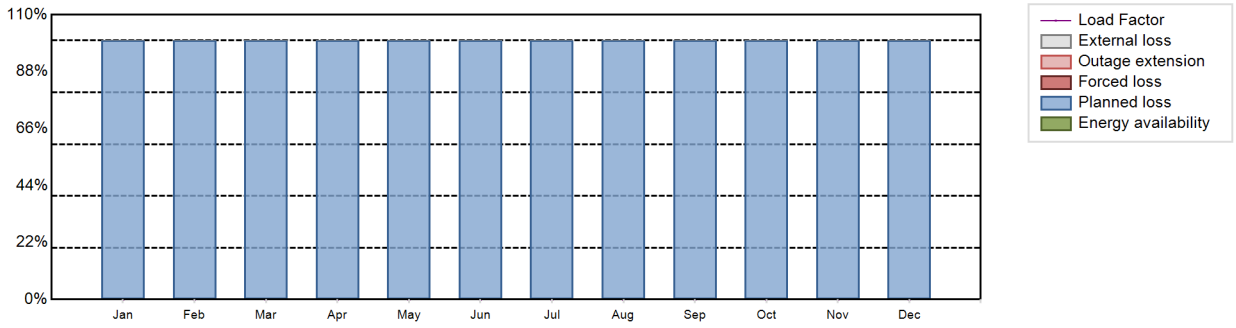
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	323
Number of SG	:	2
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.254
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	5.41
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	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



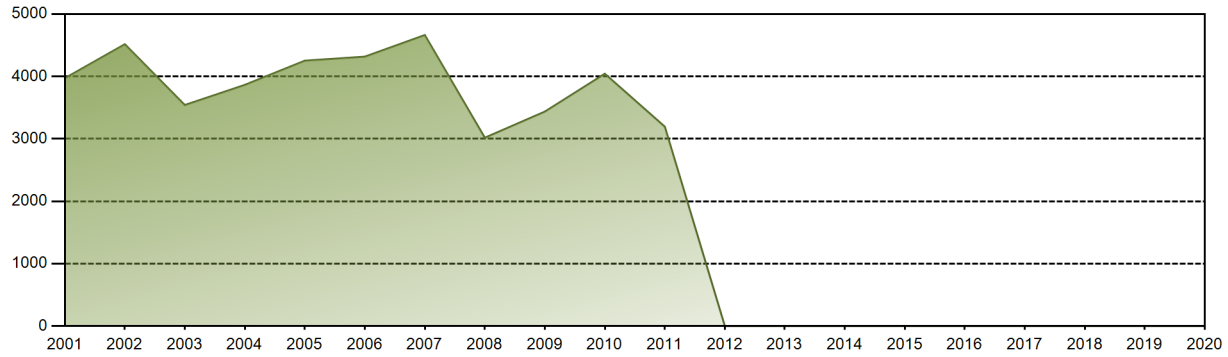
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	83574 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.14 %
Cumulative Energy Availability Factor (EAF)	:	56.94 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.66 %
Cumulative Unit Capability Factor (UCF)	:	56.94 %	Cumulative Planned Unavailability Factor (PUF)	:	42.4 %
Cumulative Load Factor (LF)	:	57.79 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	57.19 %			

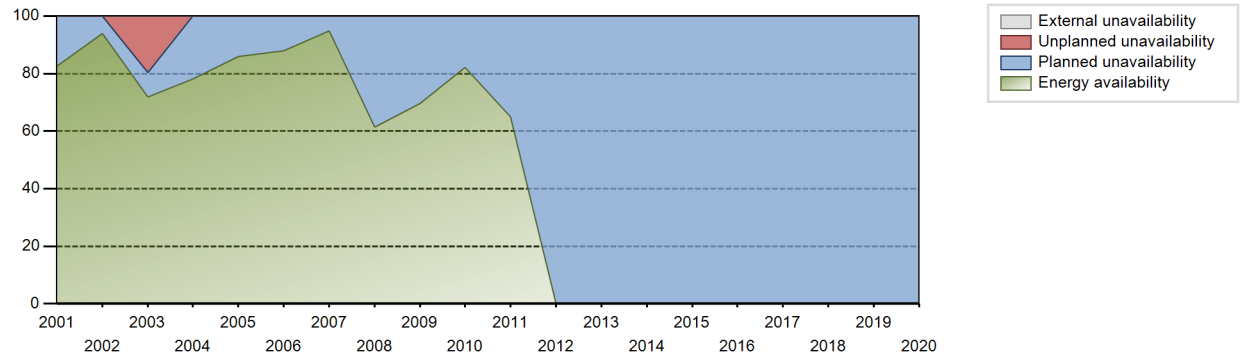
Electricity Production (net) [GWh]



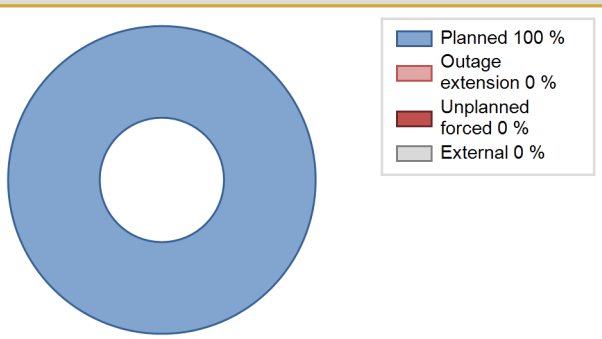
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1991	3277.78	6061	550	76.03	76.03	76.02	76.91	0.00	0.00	23.97	0.00
1992	3639.56	6756	550	75.48	75.48	75.33	76.91	0.00	0.00	24.52	0.00
1993	3847.52	7092	550	80.03	80.03	79.86	80.96	0.00	0.00	19.97	0.00
1994	4511.59	8232	550	93.91	93.91	93.64	93.97	0.00	0.00	6.09	0.00
1995	4161.85	7567	550	85.55	85.55	86.38	86.38	0.00	0.00	14.45	0.00
1996	3933.63	7232	550	81.54	81.54	81.42	82.33	0.00	0.00	18.46	0.00
1997	3775.23	6943	550	78.47	78.47	78.36	79.26	0.00	0.00	21.53	0.00
1998	5071.63	8760	550	99.99	99.99	105.26	100.00	0.00	0.00	0.01	0.00
1999	4273.16	7344	550	83.82	83.82	88.69	83.84	0.00	0.00	16.18	0.00
2000	4107.46	7477	550	85.11	85.11	85.02	85.12	0.00	0.00	14.89	0.00
2001	3971.26	7235	550	82.58	82.58	82.43	82.59	0.00	0.00	17.42	0.00
2002	4516.13	8228	550	93.92	93.92	93.73	93.93	0.00	0.00	6.08	0.00
2003	3542.02	6300	550	71.91	71.91	73.52	71.92	21.43	19.62	8.47	0.00
2004	3864.74	6862	550	78.10	78.10	80.00	78.12	0.00	0.00	21.90	0.00
2005	4252.61	7571	550	85.99	85.99	88.27	86.43	0.00	0.00	14.01	0.00
2006	4316.86	7704	550	87.90	87.90	89.60	87.95	0.00	0.00	12.10	0.00
2007	4663.24	8339	550	94.82	94.82	96.79	95.19	0.00	0.00	5.18	0.00
2008	3018.25	5411	550	61.45	61.45	62.47	61.60	0.00	0.00	38.55	0.00
2009	3436.45	6131	550	69.58	69.58	71.33	69.99	0.00	0.00	30.42	0.00
2010	4043.32	7232	550	82.14	82.14	83.92	82.56	0.00	0.00	17.86	0.00
2011	3194.68	5688	550	64.88	64.88	66.31	64.93	0.00	0.00	35.12	0.00
2012	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	550	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

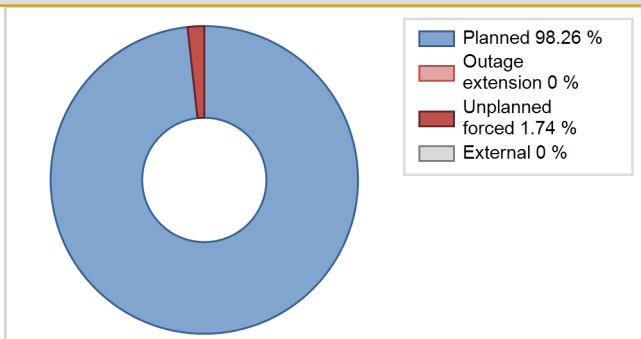
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1991 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					58	
C. Inspection, maintenance or repair combined with refuelling				960		
D. Inspection, maintenance or repair without refuelling				51		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			2687		
Subtotal	8784			3698	58	
Total	**8784**			**3756**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1991 to 2020 Average hours lost per reactor-year
13. Reactor Auxiliary Systems		57
Total		**57**

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ich and Dai-ni Nuclear Power Stations Enforcement of Comprehensive Assessment for the Safety of Nuclear Power Reactor Facility(so-called Stress Test)

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2020 Operating Experience

JP-64 TOMARI-3 JAPAN



Status at end of year	:	**Operational**
Operator	:	HEPCO (HOKKAIDO ELECTRIC POWER CO., INC.)
Owner	:	HEPCO (HOKKAIDO 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 (3-loop)
Thermal power	:	2660 MWth
Gross electrical power	:	912 MWe
Reference unit power (net)	:	866 MWe

Key Dates

Construction Date	:	2004-11-18
Grid Date	:	2009-03-20
Commercial Date	:	2009-12-22
Age at end of year	:	11 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

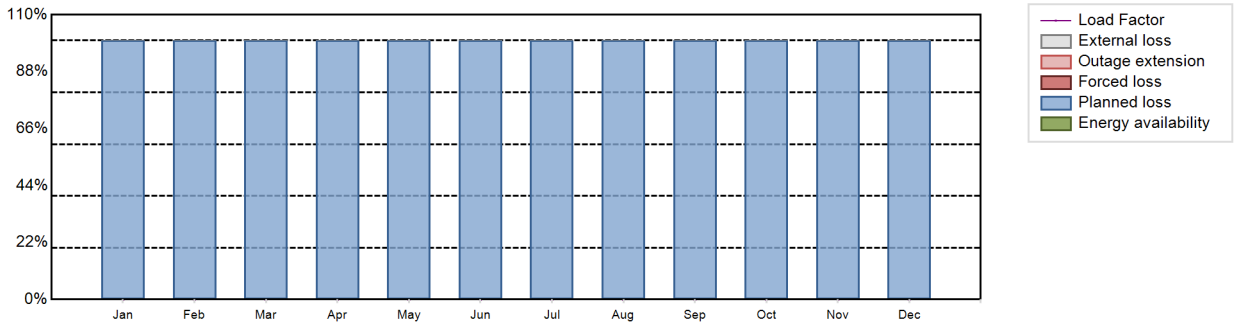
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	325
Number of SG	:	3
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.283
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	5.48
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	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



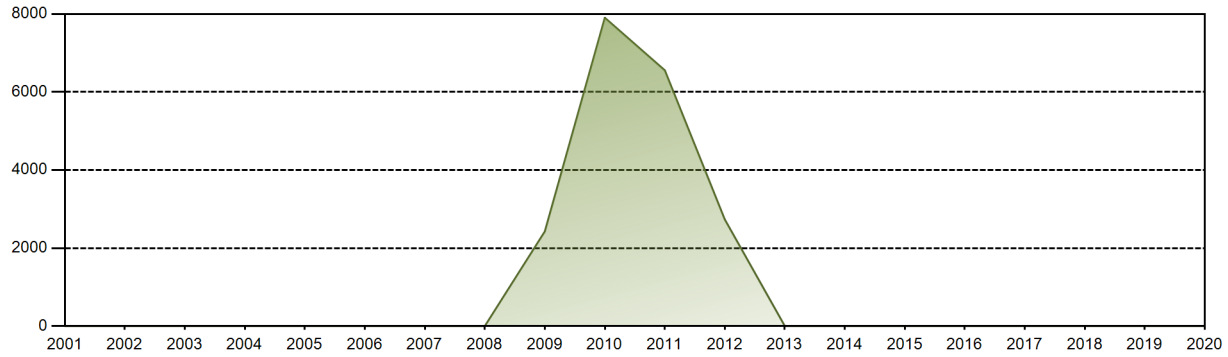
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

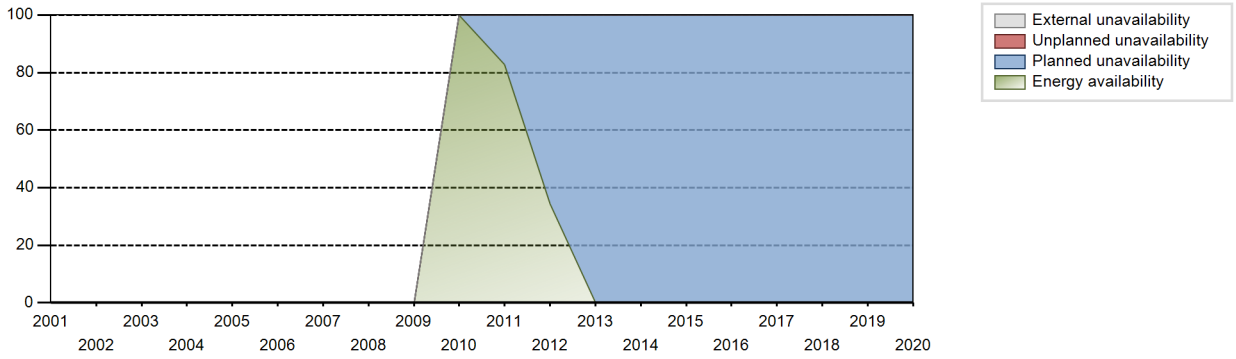
Lifetime energy generation	:	19620 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	19.74 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	19.74 %	Cumulative Planned Unavailability Factor (PUF)	:	80.26 %
Cumulative Load Factor (LF)	:	20.59 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	19.77 %			

Electricity Production (net) [GWh]



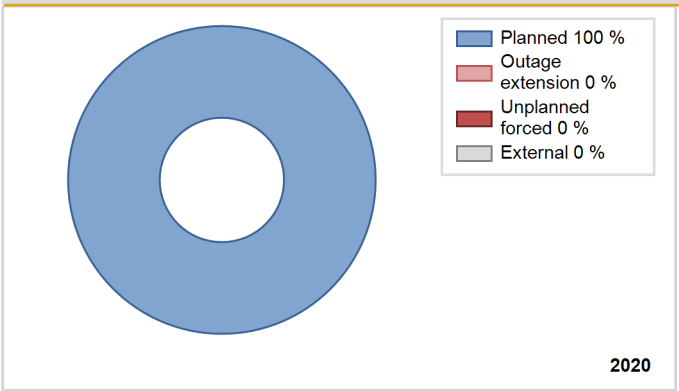
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2009	2426.85	3603	866	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	7904.94	8760	866	100.00	100.00	104.20	100.00	0.00	0.00	0.00	0.00
2011	6556.84	7283	866	82.88	82.88	86.43	83.14	0.00	0.00	17.12	0.00
2012	2731.82	3023	866	34.36	34.37	35.91	34.41	0.00	0.00	65.63	0.01
2013	0.00	0	866	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	866	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	866	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	866	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	866	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	866	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	866	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	866	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

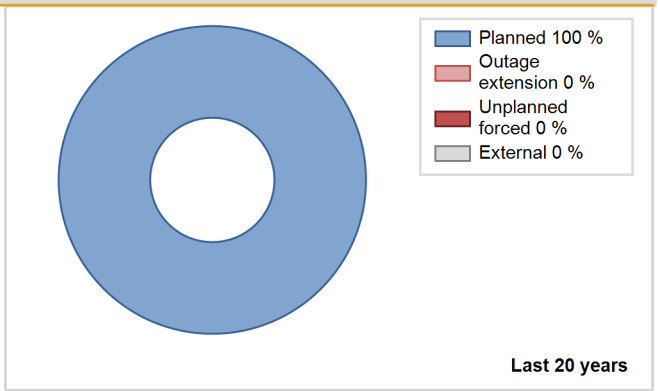
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2009 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling				316		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			7421		
Subtotal	8784			7737		
Total	**8784**			**7737**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2009 to 2020 Average hours lost per reactor-year
Total		

Highlights (2020)

Implementation of emergency safety measures for considering the Accident of Fukushima Dai-ich and Dai-ni Nuclear Power Stations Enforcement of Comprehensive Assessment for the Safety of Nuclear Power Reactor Facility(so-called Stress Test)

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2020 Operating Experience

JP-34 TSURUGA-2 JAPAN

Status at end of year	:	**Operational**
Operator	:	JAPCO (JAPAN ATOMIC POWER CO.)
Owner	:	JAPCO (JAPAN ATOMIC 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 (4-loop)
Thermal power	:	3411 MWth
Gross electrical power	:	1160 MWe
Reference unit power (net)	:	1108 MWe

Key Dates

Construction Date	:	1982-11-06
Grid Date	:	1986-06-19
Commercial Date	:	1987-02-17
Age at end of year	:	34 years

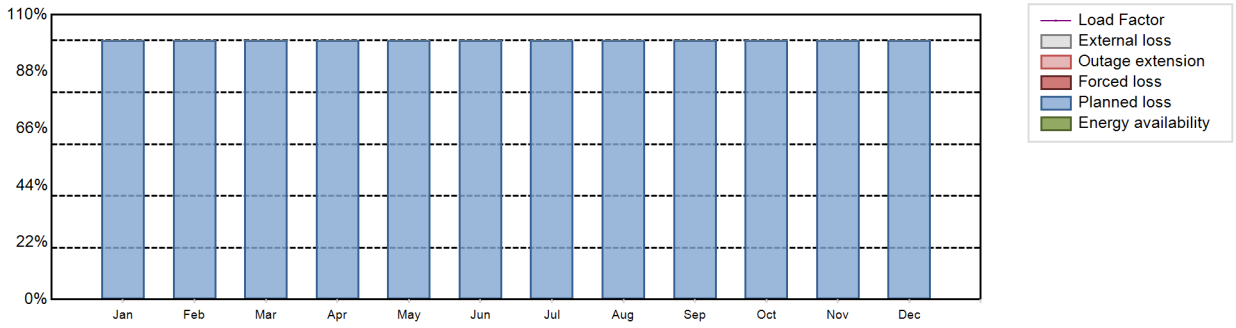
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.1
Refuelling frequency [month]	:	13
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	43000
Active core diameter [m]	:	3.07
Active core height/length [m]	:	3.65
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	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



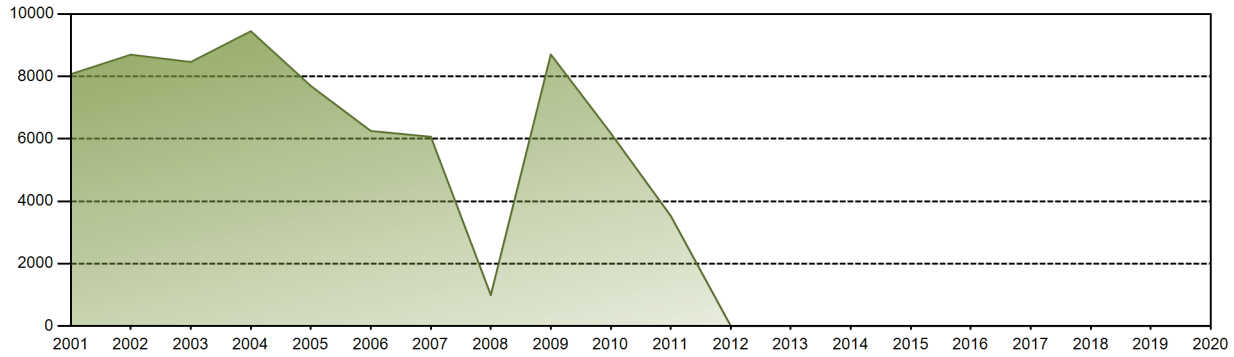
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	185893 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.38 %
Cumulative Energy Availability Factor (EAF)	:	55.56 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.8 %
Cumulative Unit Capability Factor (UCF)	:	55.67 %	Cumulative Planned Unavailability Factor (PUF)	:	39.53 %
Cumulative Load Factor (LF)	:	55.78 %	Cumulative Externally cause unavailability (XUF)	:	0.11 %
Cumulative Operating Factor (OF)	:	55.76 %			

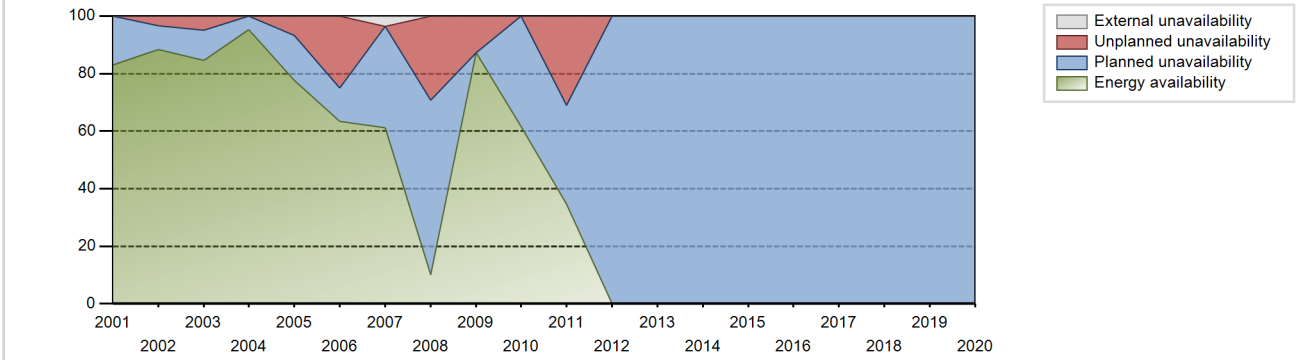
Electricity Production (net) [GWh]



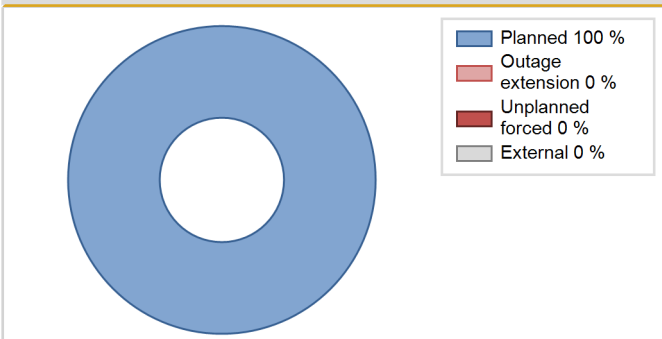
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	8751.33	8028	1115	94.99	94.99	94.65	95.10	0.00	0.00	5.01	0.00
1988	7939.68	7243	1115	81.26	81.26	81.07	82.46	2.39	1.99	16.75	0.00
1989	7507.68	6814	1115	77.03	77.03	76.86	77.79	0.00	0.00	22.97	0.00
1990	7200.99	6462	1115	72.87	72.87	73.72	73.77	0.00	0.00	27.13	0.00
1991	9259.18	8338	1115	95.07	95.07	94.80	95.18	0.00	0.00	4.93	0.00
1992	8118.69	7310	1115	82.52	82.52	82.89	83.22	0.00	0.00	17.48	0.00
1993	7844.10	7086	1115	80.15	80.15	80.31	80.89	0.00	0.00	19.85	0.00
1994	7814.60	7080	1115	80.23	80.23	80.01	80.82	0.00	0.00	19.77	0.00
1995	9220.46	8290	1115	94.55	94.55	94.40	94.63	0.00	0.00	5.45	0.00
1996	8092.28	7325	1115	82.96	82.96	82.62	83.39	2.36	2.00	15.03	0.00
1997	6522.19	5946	1115	66.98	66.98	66.78	67.88	10.59	7.93	25.08	0.00
1998	8534.55	7724	1115	91.96	91.96	87.38	88.17	0.00	0.00	8.04	0.00
1999	5131.68	4615	1115	52.68	52.68	52.54	52.68	41.73	37.73	9.60	0.00
2000	8993.76	8087	1115	92.06	92.06	91.83	92.07	0.00	0.00	7.94	0.00
2001	8072.72	7267	1115	82.95	82.95	82.65	82.96	0.00	0.00	17.05	0.00
2002	8695.54	7742	1115	88.36	88.36	89.03	88.38	3.67	3.37	8.28	0.00
2003	8460.92	7418	1115	84.67	84.67	86.62	84.68	0.00	4.85	10.48	0.00
2004	9447.05	8367	1115	95.24	95.24	96.46	95.25	0.00	0.00	4.76	0.00
2005	7693.61	6854	1115	77.59	77.59	78.77	78.24	7.98	6.73	15.68	0.00
2006	6250.76	5634	1110	63.34	63.34	64.28	64.32	21.62	25.03	11.62	0.00
2007	6065.32	5688	1110	61.18	64.86	62.38	64.93	0.00	0.00	35.14	3.68
2008	992.70	957	1110	10.04	10.04	10.18	10.89	74.44	29.24	60.72	0.00
2009	8701.08	7680	1108	87.34	87.34	89.65	87.67	12.66	12.65	0.01	0.00
2010	6178.19	5446	1108	61.65	61.65	63.65	62.17	0.00	0.00	38.35	0.00
2011	3526.88	3041	1108	34.65	34.65	36.34	34.71	47.29	31.10	34.25	0.00
2012	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2013	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2014	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2015	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2016	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2017	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2018	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2019	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2020	0.00	0	1108	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00

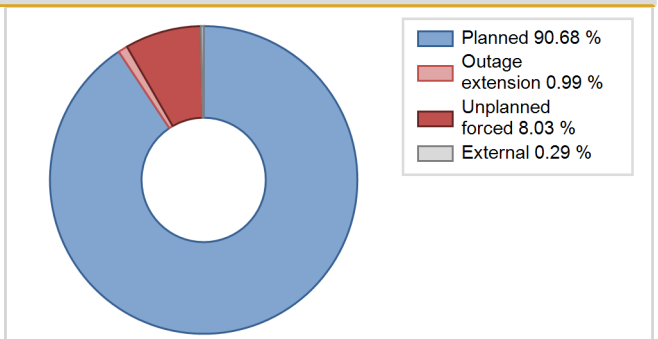
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					405	
C. Inspection, maintenance or repair combined with refuelling				1127		
G. Major backfitting, refurbishment or upgrading activities without refuelling	8784			2341		
L. Human factor related					4	
P. Fire					9	
Subtotal	8784			3468	418	
Total	**8784**			**3886**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		80
13. Reactor Auxiliary Systems		157
14. Safety Systems		18
15. Reactor Cooling Systems		12
31. Turbine and auxiliaries		116
32. Feedwater and Main Steam System		28
Total		**411**

Highlights (2020)

Appropriate for implementation in new regulatory standards

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2020 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

Reactor type and model	:	PWR / WH F
Thermal power	:	2787 MWth
Gross electrical power	:	1026 MWe
Reference unit power (net)	:	995 MWe

Key Dates

Construction Date	:	1981-06-04
Grid Date	:	1986-03-05
Commercial Date	:	1986-08-25
Age at end of year	:	34 years

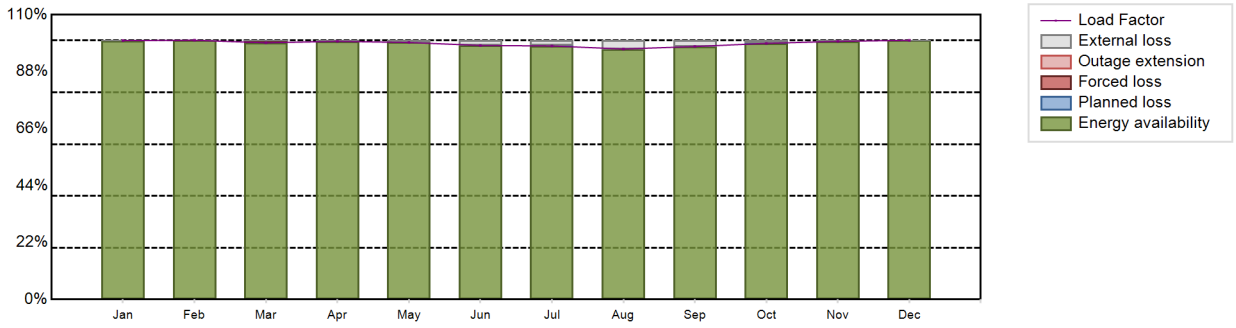
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.65
Refuelling frequency [month]	:	18
Part of the core refuelled [%]	:	41
Average discharge burnup [MWd/t]	:	18190
Active core diameter [m]	:	3.04
Active core height/length [m]	:	3.658
Number of fissile fuel assemblies/bundles	:	157
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]	:	0.41
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]	:	6.54
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	:	none

Annual Production Results (2020)

Net Energy Production	:	8648.72 GW(e).h
Energy Availability Factor (EAF)	:	98.92 %
Unit Capability Factor (UCF)	:	99.89 %
Load Factor (LF)	:	98.95 %
Operating Factor (OF)	:	100 %
Forced Loss Rate (FLR)	:	0.07 %
Unplanned Capability Loss Factor (UCL)	:	0.07 %
Planned Unavailability Factor (PUF)	:	0.04 %
Externally cause unavailability (XUF)	:	0.96 %
Total off-line time	:	0 hours

Annual Summary



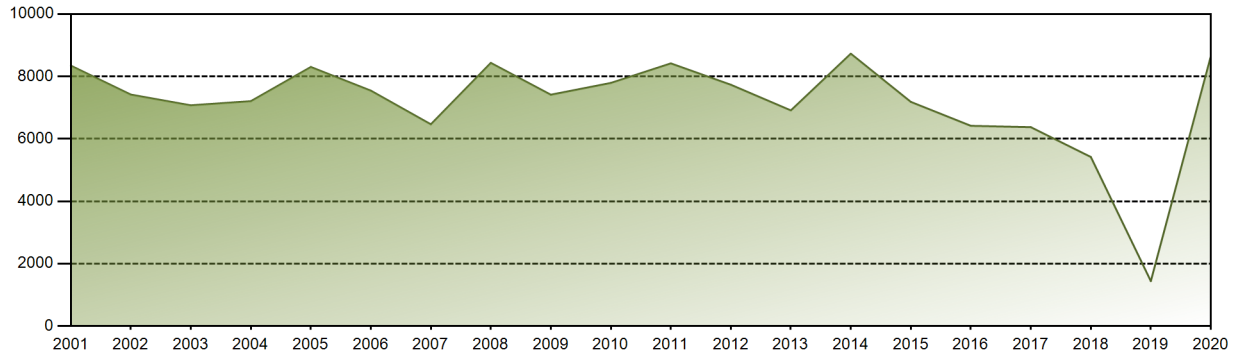
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	740.28	693.46	733.89	714.40	734.89	702.91	724.93	716.23	699.99	732.36	714.34	741.05	8648.72
EAF [%]	99.89	100.00	99.09	99.72	99.27	98.12	97.93	96.75	97.71	98.93	99.71	100.00	98.92
UCF [%]	99.89	100.00	99.14	99.88	100.00	100.00	99.86	100.00	100.00	99.87	100.00	100.00	99.89
LF [%]	100.00	100.14	99.14	99.72	99.27	98.12	97.93	96.75	97.71	98.93	99.71	100.10	98.95
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	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
UCL [%]	0.00	0.00	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
PUF [%]	0.11	0.00	0.00	0.12	0.00	0.00	0.14	0.00	0.00	0.13	0.00	0.00	0.04
XUF [%]	0.00	0.00	0.05	0.16	0.73	1.88	1.93	3.25	2.29	0.94	0.29	0.00	0.96

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Historical Summary

Lifetime energy generation	:	242164.16 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.04 %
Cumulative Energy Availability Factor (EAF)	:	84.59 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.85 %
Cumulative Unit Capability Factor (UCF)	:	84.8 %	Cumulative Planned Unavailability Factor (PUF)	:	12.35 %
Cumulative Load Factor (LF)	:	86.26 %	Cumulative Externally cause unavailability (XUF)	:	0.21 %
Cumulative Operating Factor (OF)	:	85.37 %			

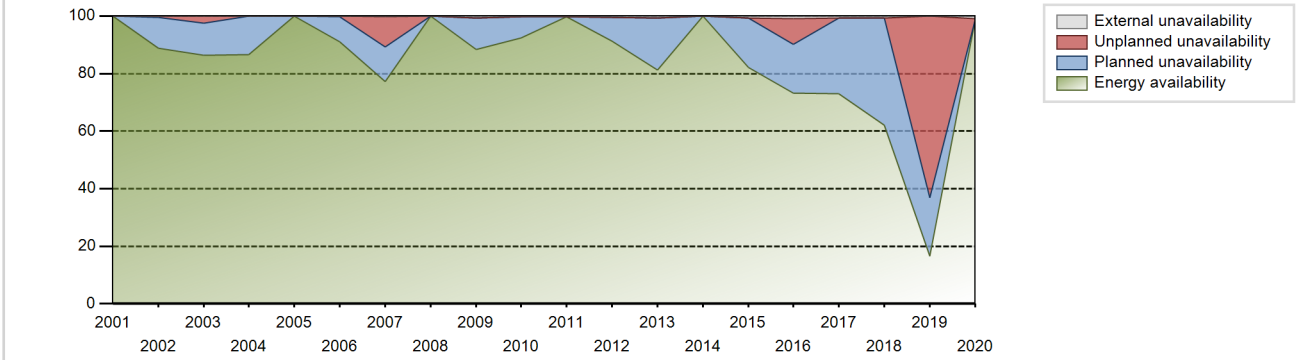
Electricity Production (net) [GWh]



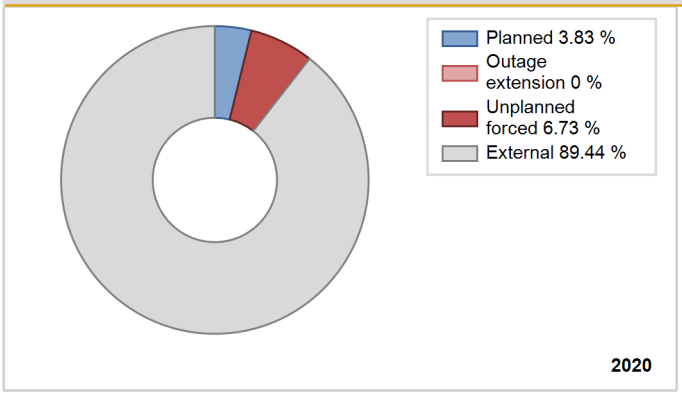
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	2467.92	2928	900	94.44	94.67	89.14	94.47	3.50	3.43	1.89	0.23
1987	5973.92	6870	900	78.77	78.77	75.77	78.42	2.26	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

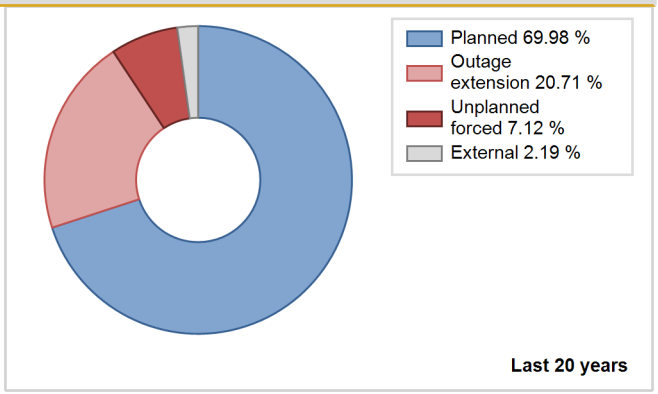
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 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				1043		
D. Inspection, maintenance or repair without refuelling				5		
J. Grid limitation, failure or grid unavailability						0
L. Human factor related					122	
P. Fire					39	
Z. Other						1
Subtotal				1048	231	1
Total		**0**			**1280**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		125
15. Reactor Cooling Systems		40
16. Steam generation systems		0
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		24
32. Feedwater and Main Steam System		2
34. Miscellaneous Systems		0
41. Main Generator Systems		31
42. Electrical Power Supply Systems		2
Total		**227**

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2020 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

Reactor type and model	:	PWR / WH F
Thermal power	:	2787 MWth
Gross electrical power	:	1026 MWe
Reference unit power (net)	:	988 MWe

Key Dates

Construction Date	:	1981-12-01
Grid Date	:	1986-11-11
Commercial Date	:	1987-06-10
Age at end of year	:	34 years

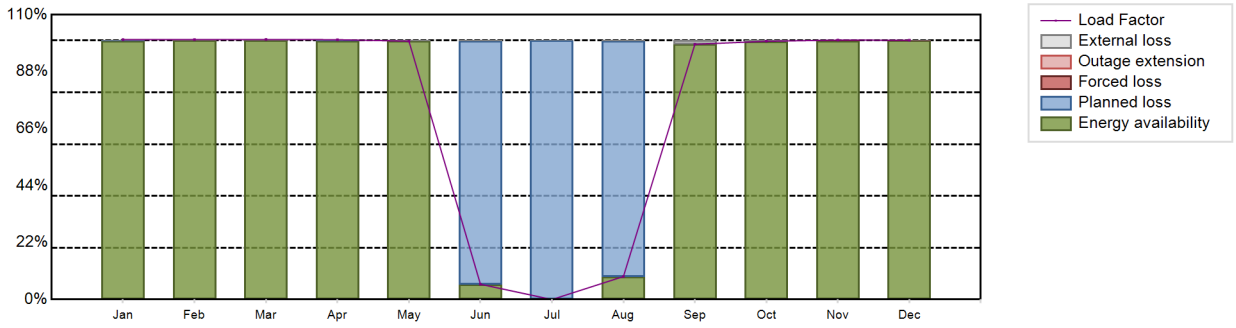
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.4
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	326
Fuel material	:	UO2	Number of SG	:	3
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.41
Average fuel enrichment [% of U235]	:	4.65	**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]	:	17960	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	6.54
Active core height/length [m]	:	3.658	Output voltage [kV]	:	22
Number of fissile fuel assemblies/bundles	:	157	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	17.83	Number of main condensate pumps	:	4
Number of control rod assemblies	:	28	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 (2020)

Net Energy Production	:	6603.94 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	75.93 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	76.11 %	Planned Unavailability Factor (PUF)	:	23.89 %
Load Factor (LF)	:	76.09 %	Externally cause unavailability (XUF)	:	0.19 %
Operating Factor (OF)	:	76.53 %	Total off-line time	:	2062 hours

Annual Summary



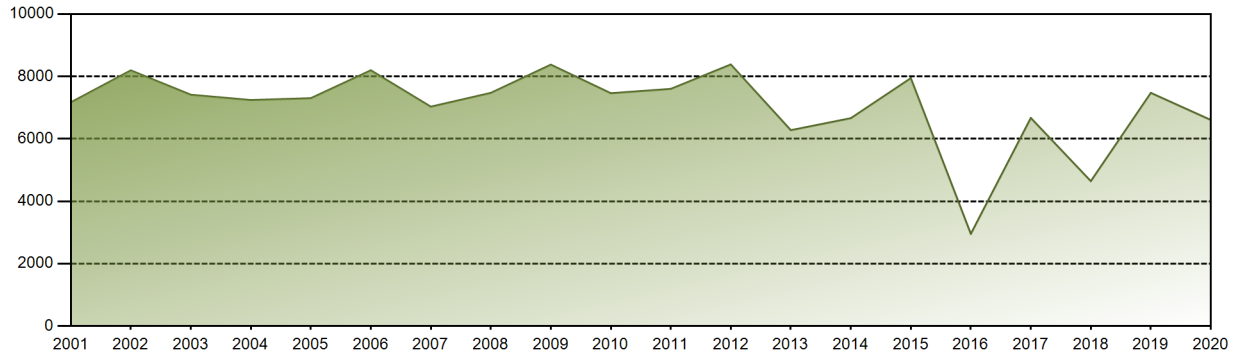
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	737.78	690.24	738.18	713.80	733.38	42.04	0.00	65.25	701.16	733.17	712.70	736.25	6603.94
EAF [%]	99.97	100.00	100.00	99.98	99.76	5.91	0.00	8.88	98.57	99.65	99.97	100.00	75.93
UCF [%]	99.97	100.00	100.00	99.98	100.00	5.94	0.00	9.06	100.00	100.00	99.97	100.00	76.11
LF [%]	100.37	100.38	100.42	100.34	99.77	5.91	0.00	8.88	98.57	99.74	100.19	100.16	76.09
OF [%]	100.00	100.00	100.00	100.00	100.00	8.06	0.00	11.83	100.00	100.00	100.00	100.00	76.53
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 [%]	0.03	0.00	0.00	0.02	0.00	94.06	100.00	90.94	0.00	0.00	0.03	0.00	23.89
XUF [%]	0.00	0.00	0.00	0.00	0.24	0.03	0.00	0.18	1.43	0.35	0.00	0.00	0.19

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Historical Summary

Lifetime energy generation	:	232401.28 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.83 %
Cumulative Energy Availability Factor (EAF)	:	82.99 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.89 %
Cumulative Unit Capability Factor (UCF)	:	83.13 %	Cumulative Planned Unavailability Factor (PUF)	:	15.97 %
Cumulative Load Factor (LF)	:	84.43 %	Cumulative Externally cause unavailability (XUF)	:	0.15 %
Cumulative Operating Factor (OF)	:	83.86 %			

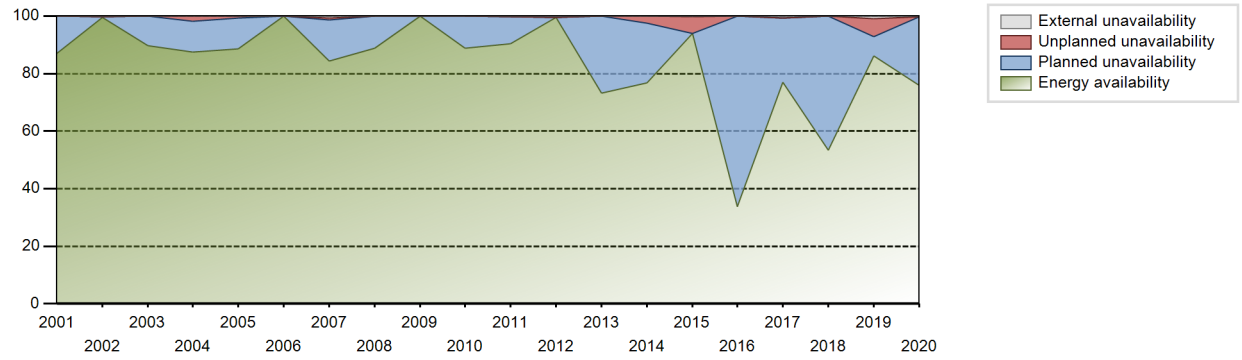
Electricity Production (net) [GWh]



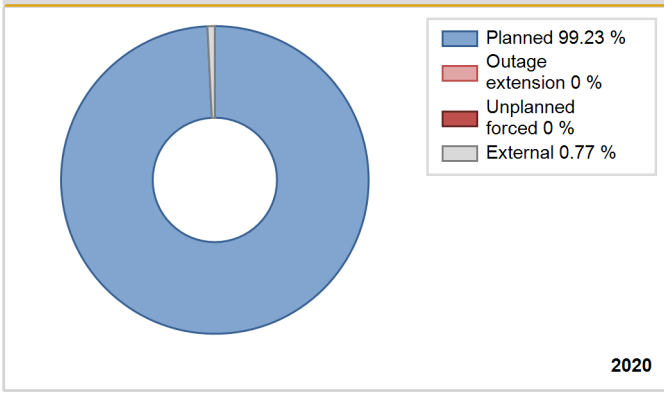
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	4297.03	4826	900	98.15	98.15	97.02	98.07	1.85	1.85	0.00	0.00
1988	6280.88	7085	900	80.65	80.65	79.45	80.66	0.31	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

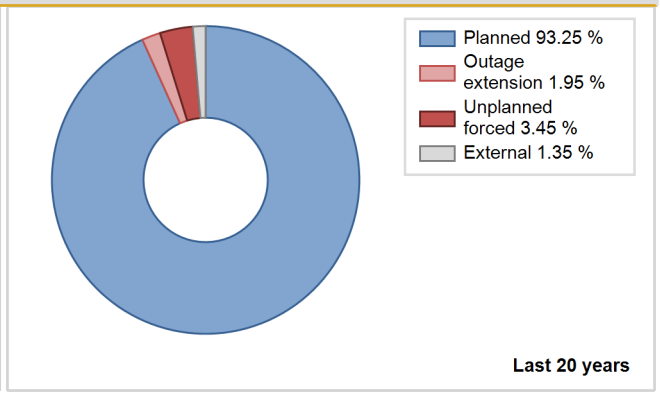
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					51	
C. Inspection, maintenance or repair combined with refuelling	2064			1262		
D. Inspection, maintenance or repair without refuelling				76		
J. Grid limitation, failure or grid unavailability						7
L. Human factor related					19	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						0
Subtotal	2064			1338	70	7
Total	**2064**			**1415**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		1
15. Reactor Cooling Systems		16
16. Steam generation systems		27
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		2
32. Feedwater and Main Steam System		5
35. All other I&C Systems		1
41. Main Generator Systems		12
42. Electrical Power Supply Systems		6
Total		**70**

Highlights (2020)

24th refueling and maintenance(20.06.03 ~ 20.08.28)

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2020 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

Reactor type and model	:	PWR / OPR-1000
Thermal power	:	2825 MWth
Gross electrical power	:	1039 MWe
Reference unit power (net)	:	986 MWe

Key Dates

Construction Date	:	1989-12-23
Grid Date	:	1994-10-30
Commercial Date	:	1995-03-31
Age at end of year	:	26 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

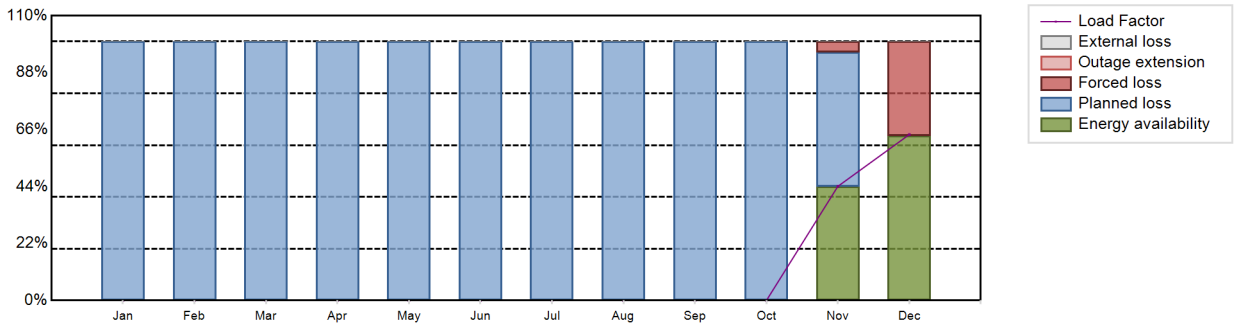
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.37
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	783.33 GW(e).h
Energy Availability Factor (EAF)	:	9 %
Unit Capability Factor (UCF)	:	9 %
Load Factor (LF)	:	9.04 %
Operating Factor (OF)	:	10.28 %

Forced Loss Rate (FLR)	:	27.5 %
Unplanned Capability Loss Factor (UCL)	:	3.41 %
Planned Unavailability Factor (PUF)	:	87.59 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	7881 hours

Annual Summary



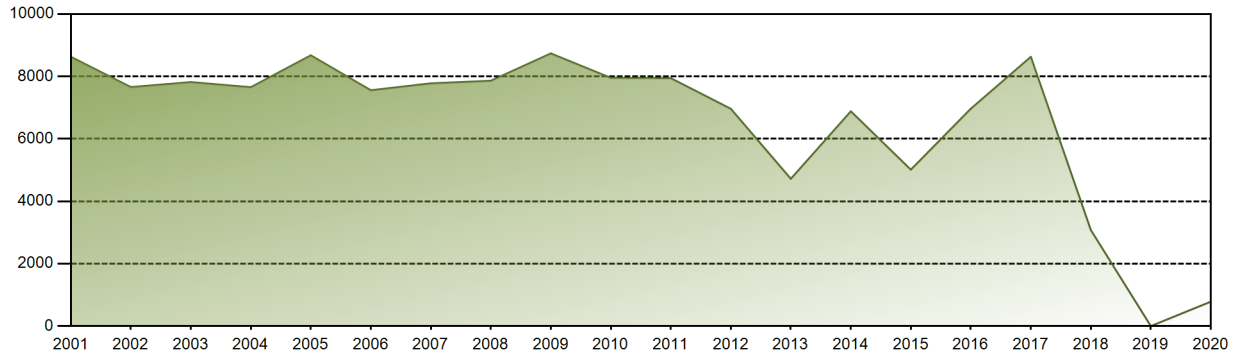
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	313.08	470.25	783.33
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.97	63.71	9.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.97	63.71	9.00
LF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.10	64.10	9.04
OF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	54.58	68.55	10.28
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.61	36.29	27.50
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.14	36.29	3.41
PUF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	51.89	0.00	87.59
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

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Historical Summary

Lifetime energy generation	:	175132.1 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.16 %
Cumulative Energy Availability Factor (EAF)	:	77.55 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.91 %
Cumulative Unit Capability Factor (UCF)	:	77.7 %	Cumulative Planned Unavailability Factor (PUF)	:	21.39 %
Cumulative Load Factor (LF)	:	78.78 %	Cumulative Externally cause unavailability (XUF)	:	0.15 %
Cumulative Operating Factor (OF)	:	78.28 %			

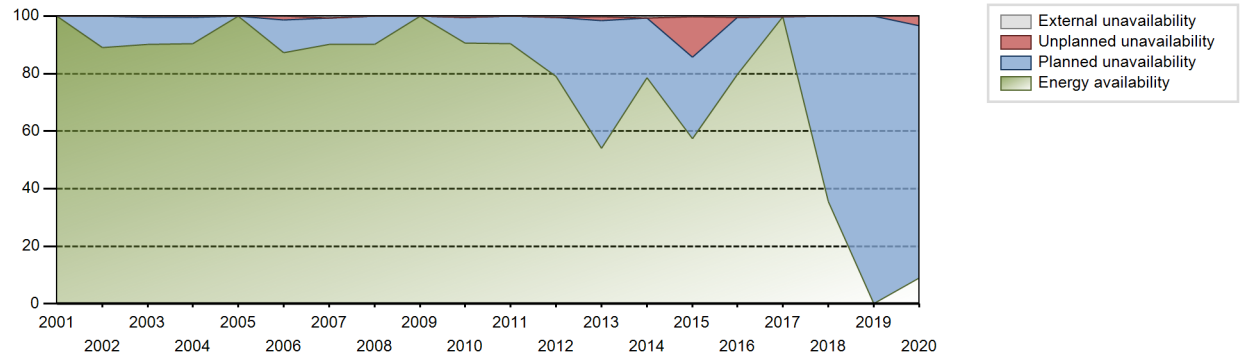
Electricity Production (net) [GWh]



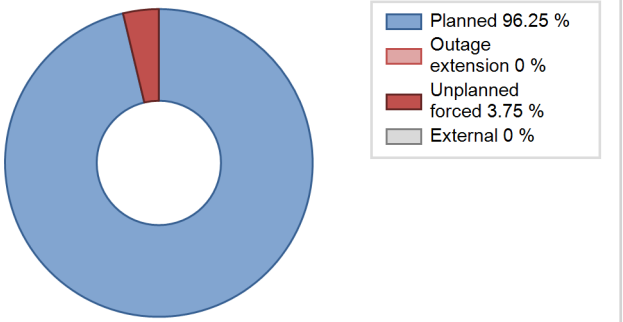
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1995	6430.28	6573	950	99.19	99.19	102.56	99.59	0.77	0.77	0.04	0.00
1996	6366.17	6589	950	73.97	73.98	76.29	75.01	0.22	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

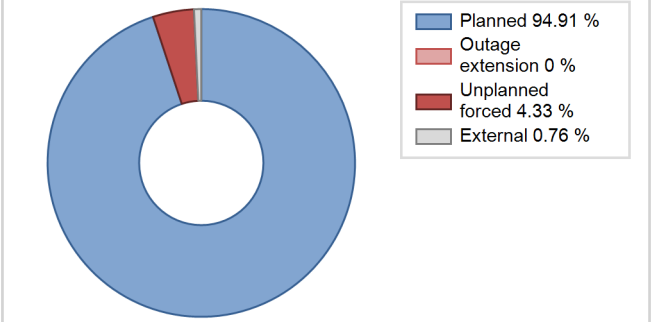
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1995 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		234			67	
C. Inspection, maintenance or repair combined with refuelling	7651			1833		
D. Inspection, maintenance or repair without refuelling				5		
E. Testing of plant systems or components					0	
L. Human factor related					0	
Subtotal	7651	234		1838	67	
Total		**7885**			**1905**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1995 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		1
15. Reactor Cooling Systems		47
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	234	14
Total	**234**	**67**

Highlights (2020)

Refueling and Maintenance(2018.05.11.~2020.11.14.)
Manual turbine trip for replacing Main-TR C phase(2020.12.3.~12.13.)

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2020 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	:	1022 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	:	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]	:	4.2
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

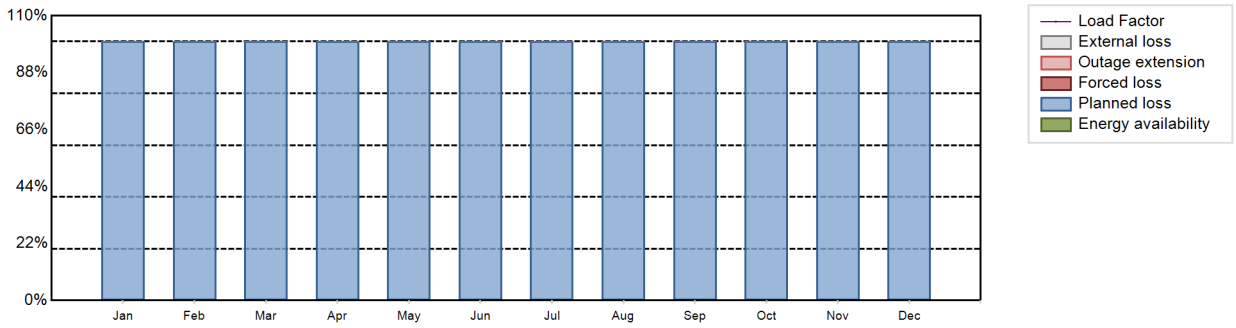
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.37
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

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)	:	100 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



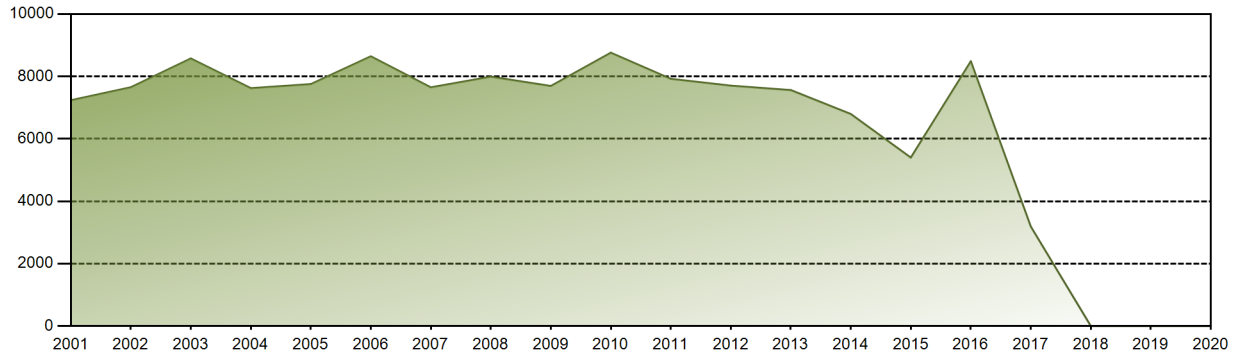
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	165873.44 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.38 %
Cumulative Energy Availability Factor (EAF)	:	75.71 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.34 %
Cumulative Unit Capability Factor (UCF)	:	75.88 %	Cumulative Planned Unavailability Factor (PUF)	:	23.77 %
Cumulative Load Factor (LF)	:	77.04 %	Cumulative Externally cause unavailability (XUF)	:	0.17 %
Cumulative Operating Factor (OF)	:	76.36 %			

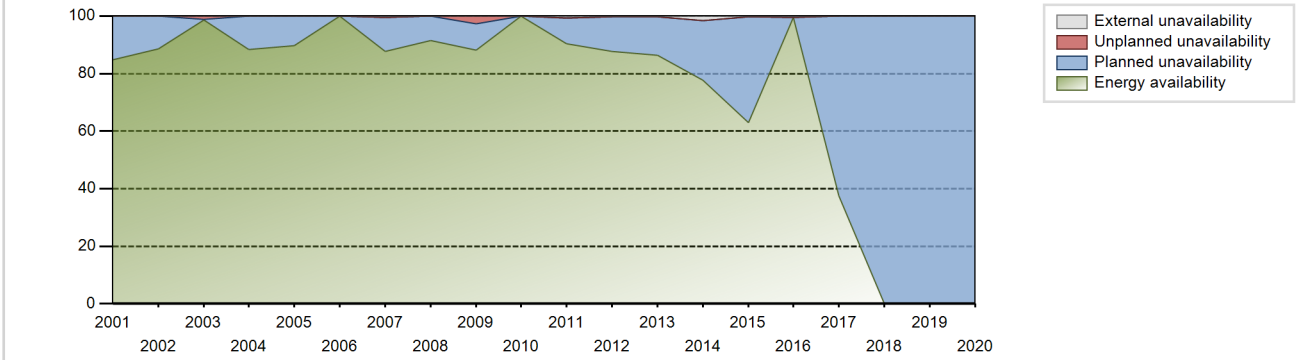
Electricity Production (net) [GWh]



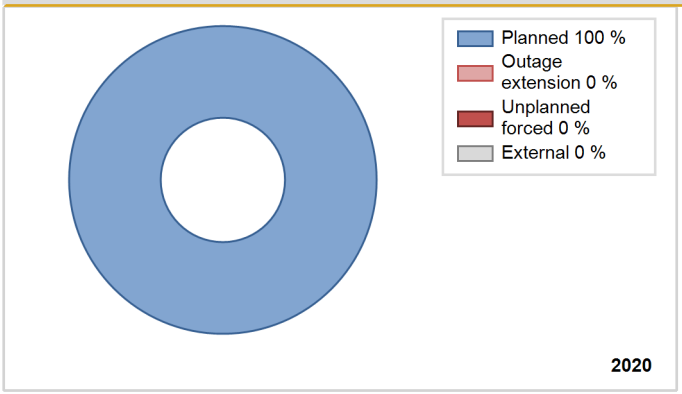
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1996	7197.47	7565	950	83.49	83.50	86.25	86.12	1.71	1.45	15.05	0.00
1997	6767.71	7125	950	78.80	78.80	81.32	81.34	3.24	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

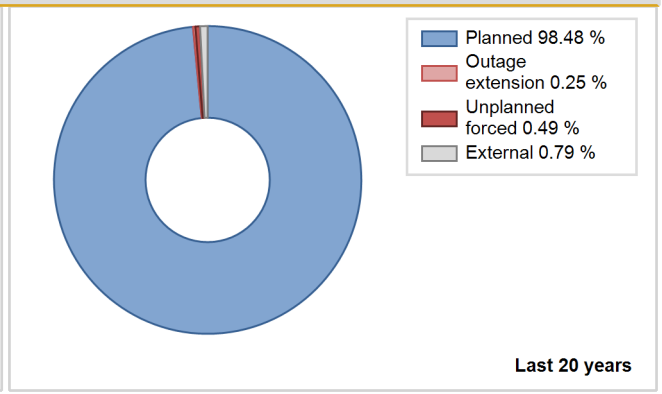
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1996 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					24	
C. Inspection, maintenance or repair combined with refuelling	8784			2047		
L. Human factor related					0	
Subtotal	8784			2047	24	
Total	**8784**			**2071**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1996 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		3
14. Safety Systems		5
31. Turbine and auxiliaries		2
32. Feedwater and Main Steam System		2
41. Main Generator Systems		5
42. Electrical Power Supply Systems		8
Total		**25**

Highlights (2020)

Refueling and Maintenance(2017.05.18.~)

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2020 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	:	1050 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	:	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]	:	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

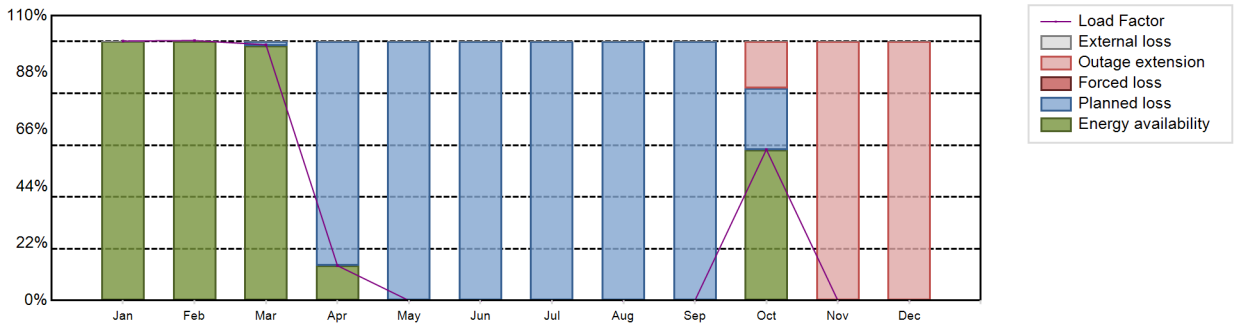
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	4
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	2688.51 GW(e).h
Energy Availability Factor (EAF)	:	30.76 %
Unit Capability Factor (UCF)	:	30.76 %
Load Factor (LF)	:	30.85 %
Operating Factor (OF)	:	32.81 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	18.19 %
Planned Unavailability Factor (PUF)	:	51.05 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	5902 hours

Annual Summary



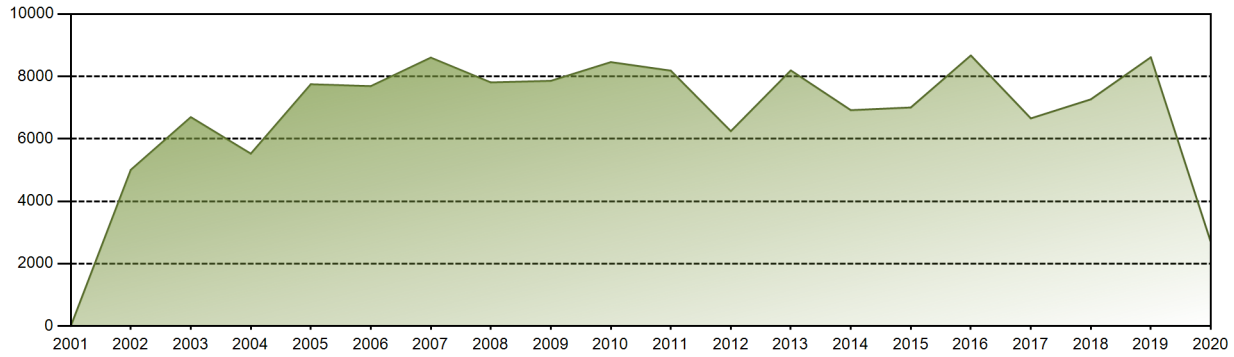
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	739.74	693.18	729.09	96.23	0.00	0.00	0.00	0.00	0.00	430.27	0.00	0.00	2688.51
EAF [%]	100.00	100.00	98.40	13.47	0.00	0.00	0.00	0.00	0.00	58.12	0.00	0.00	30.76
UCF [%]	100.00	100.00	98.40	13.47	0.00	0.00	0.00	0.00	0.00	58.12	0.00	0.00	30.76
LF [%]	100.23	100.40	98.79	13.47	0.00	0.00	0.00	0.00	0.00	58.30	0.00	0.00	30.85
OF [%]	100.00	100.00	100.00	31.39	0.00	0.00	0.00	0.00	0.00	63.44	0.00	0.00	32.81
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	18.00	100.00	100.00	18.19
PUF [%]	0.00	0.00	1.60	86.53	100.00	100.00	100.00	100.00	100.00	23.88	0.00	0.00	51.05
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

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Historical Summary

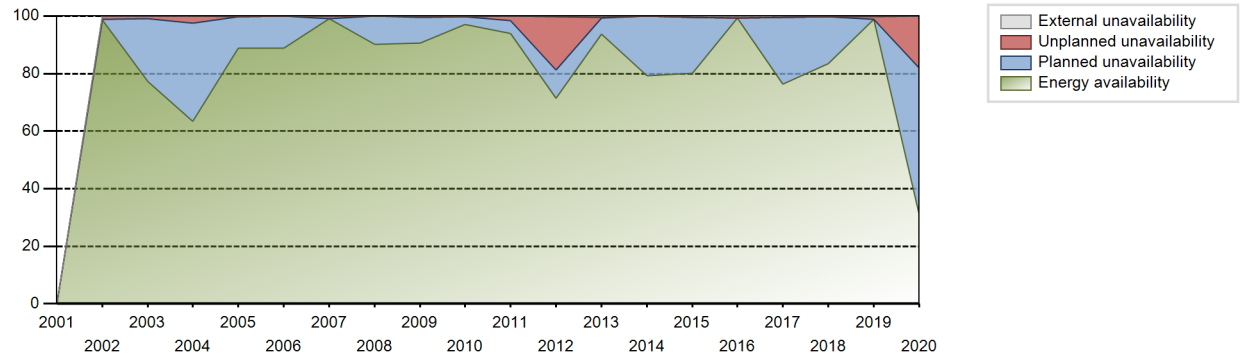
Lifetime energy generation	:	137696.34 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.66 %
Cumulative Energy Availability Factor (EAF)	:	83.96 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.41 %
Cumulative Unit Capability Factor (UCF)	:	84.16 %	Cumulative Planned Unavailability Factor (PUF)	:	13.44 %
Cumulative Load Factor (LF)	:	84.77 %	Cumulative Externally cause unavailability (XUF)	:	0.19 %
Cumulative Operating Factor (OF)	:	84.79 %			

Electricity Production (net) [GWh]



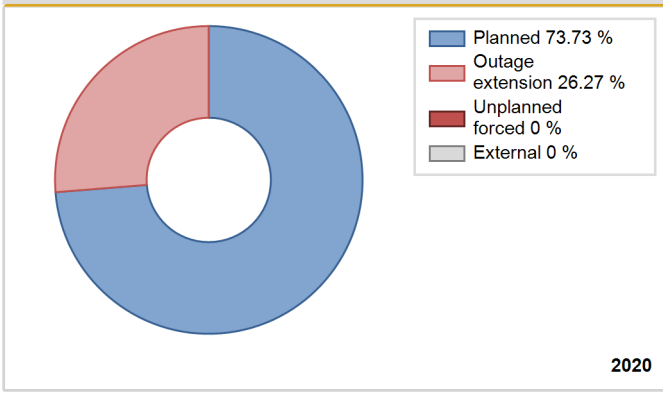
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	5006.77	5095	950	98.71	98.71	102.59	99.18	1.25	1.25	0.03	0.00
2003	6694.37	6856	950	77.12	77.12	80.44	78.26	1.14	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

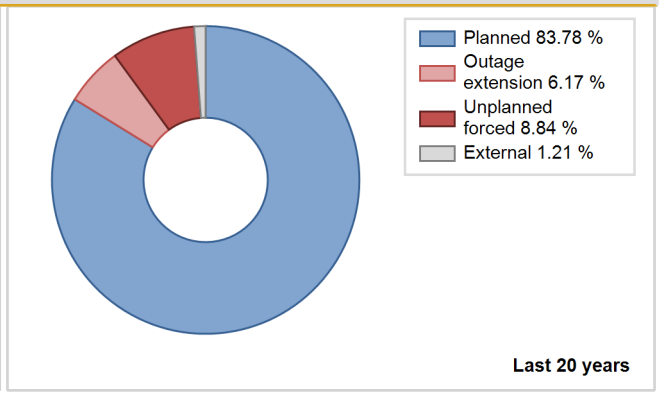
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			2002 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		1598			198	
C. Inspection, maintenance or repair combined with refuelling	4304			1112		
D. Inspection, maintenance or repair without refuelling				22		
E. Testing of plant systems or components					2	
Subtotal	4304	1598		1134	200	
Total	**5902**			**1334**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2002 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		5
12. Reactor I&C Systems	1598	89
13. Reactor Auxiliary Systems		2
14. Safety Systems		2
16. Steam generation systems		11
35. All other I&C Systems		14
42. Electrical Power Supply Systems		73
Total	**1598**	**196**

Highlights (2020)

The 13th Refueling & maintenance(2020-04-10 ~).
Reactor trip due to reactor protection signal caused by activation test for Reactor power cut-back system during maintenance(2020-10-26).

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2020 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	:	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]	:	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

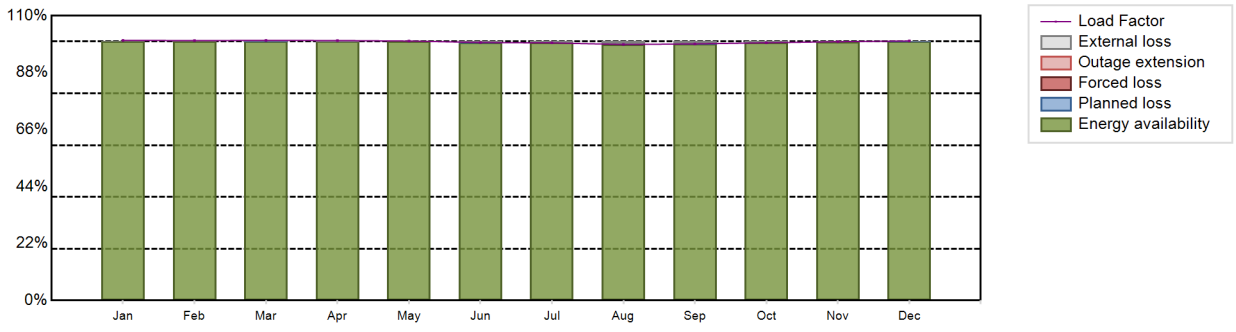
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	8714.05 GW(e).h
Energy Availability Factor (EAF)	:	99.71 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	99.9 %
Operating Factor (OF)	:	100 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0.29 %
Total off-line time	:	0 hours

Annual Summary



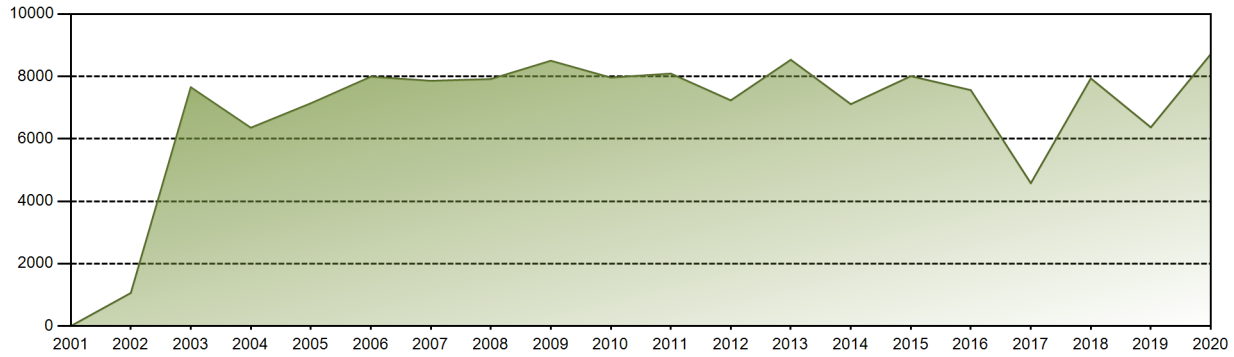
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	742.29	693.91	742.13	717.86	740.41	712.49	735.12	730.47	708.59	735.41	714.71	740.67	8714.05
EAF [%]	100.00	100.00	99.99	100.00	100.00	99.65	99.50	98.87	99.11	99.54	99.87	99.99	99.71
UCF [%]	100.00	100.00	99.99	100.00	100.00	99.99	100.00	100.00	99.98	100.00	100.00	99.99	100.00
LF [%]	100.47	100.40	100.45	100.41	100.22	99.65	99.50	98.87	99.11	99.54	99.96	100.25	99.90
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	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01	0.00
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.34	0.50	1.13	0.88	0.46	0.13	0.00	0.29

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Historical Summary

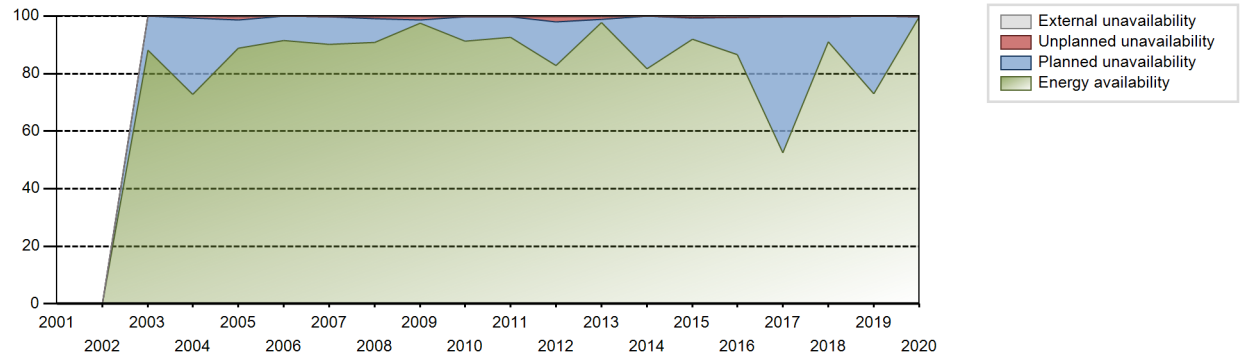
Lifetime energy generation	:	137212.78 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.38 %
Cumulative Energy Availability Factor (EAF)	:	86.72 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.33 %
Cumulative Unit Capability Factor (UCF)	:	86.96 %	Cumulative Planned Unavailability Factor (PUF)	:	12.71 %
Cumulative Load Factor (LF)	:	87.03 %	Cumulative Externally cause unavailability (XUF)	:	0.24 %
Cumulative Operating Factor (OF)	:	87.4 %			

Electricity Production (net) [GWh]



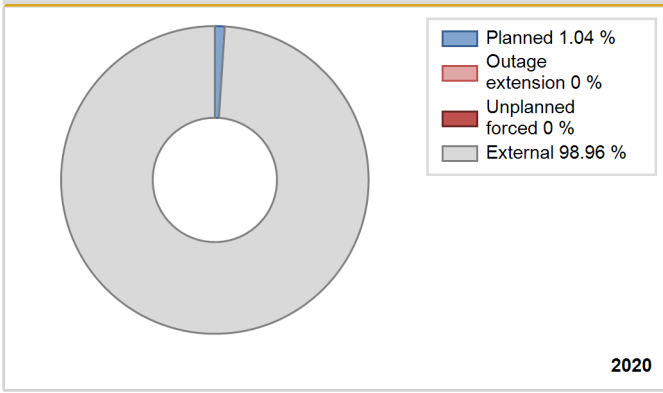
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2002	1058.41	1461	996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	7652.19	7728	950	88.21	88.21	91.95	88.22	0.00	0.00	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

Key Factors in Last 20 Years [%]

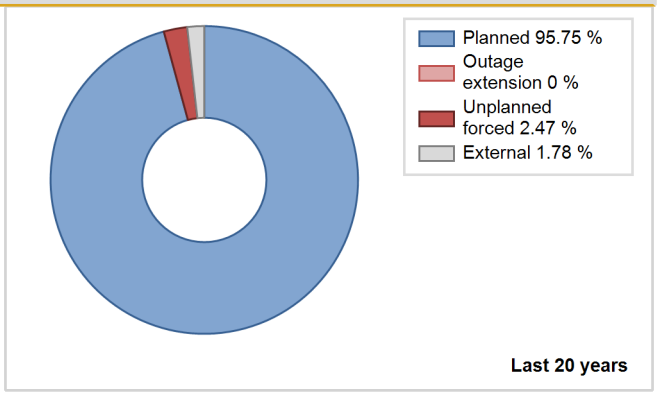


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2002 to 2020		
	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				1077		
D. Inspection, maintenance or repair without refuelling				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.)						0
Subtotal				1082	23	0
Total	**0**			**1105**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2002 to 2020
	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)		4
41. Main Generator Systems		2
42. Electrical Power Supply Systems		11
Total		**22**

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2020 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	:	1010 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	:	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
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

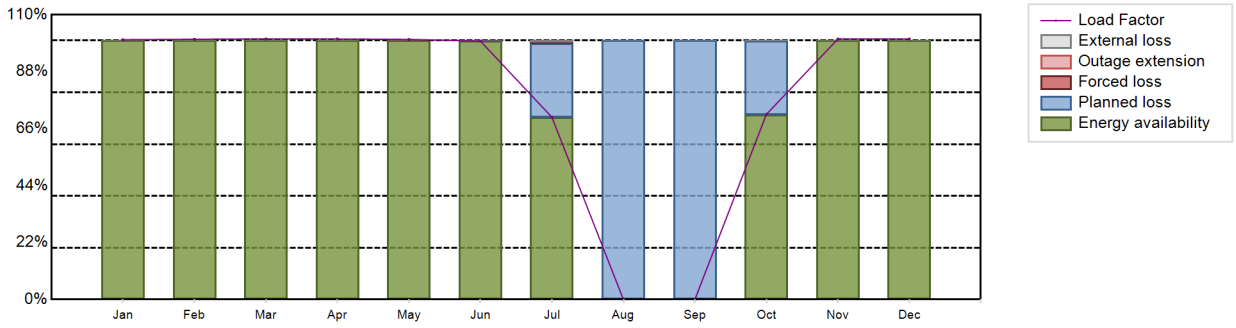
Operating coolant pressure [MPa]	:	15.4
Reactor outlet temperature [°C]	:	323.2
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	0.42
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6679.8 GW(e).h
Energy Availability Factor (EAF)	:	78.38 %
Unit Capability Factor (UCF)	:	78.44 %
Load Factor (LF)	:	78.72 %
Operating Factor (OF)	:	78.79 %

Forced Loss Rate (FLR)	:	0.05 %
Unplanned Capability Loss Factor (UCL)	:	0.04 %
Planned Unavailability Factor (PUF)	:	21.52 %
Externally cause unavailability (XUF)	:	0.06 %
Total off-line time	:	1863 hours

Annual Summary



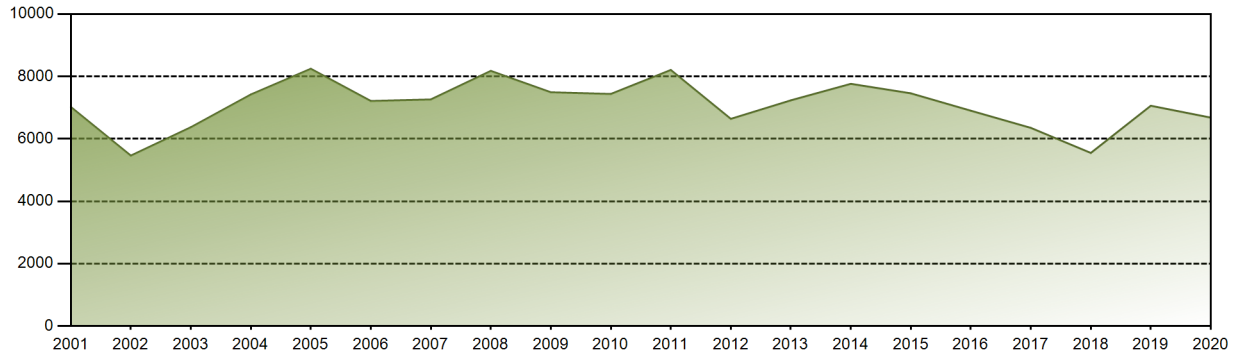
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	721.28	675.87	723.46	699.75	722.15	694.16	505.94	0.00	0.00	514.01	699.82	723.36	6679.80
EAF [%]	100.00	100.00	100.00	100.00	99.99	99.80	70.40	0.00	0.00	71.27	100.00	100.00	78.38
UCF [%]	100.00	100.00	100.00	100.00	99.99	99.80	71.11	0.00	0.00	71.29	100.00	100.00	78.44
LF [%]	100.36	100.53	100.66	100.61	100.48	99.81	70.40	0.00	0.00	71.52	100.62	100.65	78.72
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	72.31	0.00	0.00	74.06	100.00	100.00	78.79
FLR [%]	0.00	0.00	0.00	0.00	0.01	0.19	0.41	0.00	0.00	0.00	0.00	0.00	0.05
UCL [%]	0.00	0.00	0.00	0.00	0.01	0.19	0.30	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	28.60	100.00	100.00	28.71	0.00	0.00	21.52
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.02	0.00	0.00	0.06

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Historical Summary

Lifetime energy generation	:	227724.82 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.47 %
Cumulative Energy Availability Factor (EAF)	:	85.27 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.16 %
Cumulative Unit Capability Factor (UCF)	:	85.52 %	Cumulative Planned Unavailability Factor (PUF)	:	12.32 %
Cumulative Load Factor (LF)	:	85.53 %	Cumulative Externally cause unavailability (XUF)	:	0.25 %
Cumulative Operating Factor (OF)	:	85.8 %			

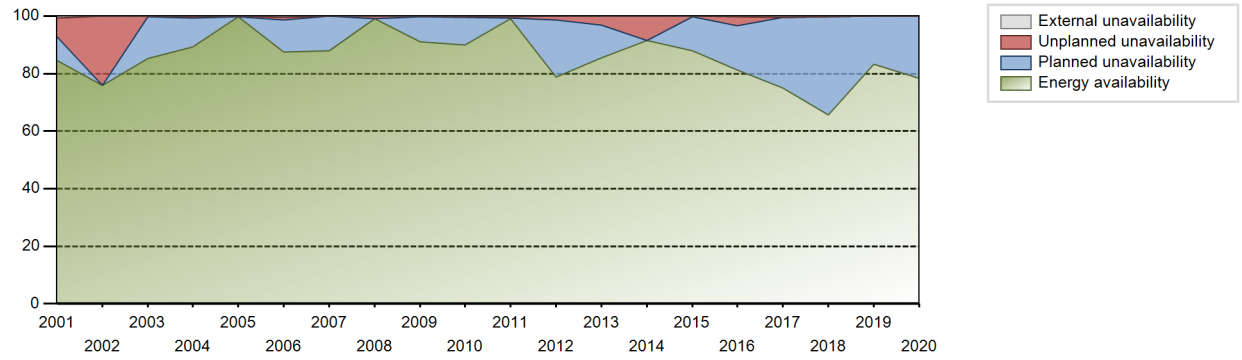
Electricity Production (net) [GWh]



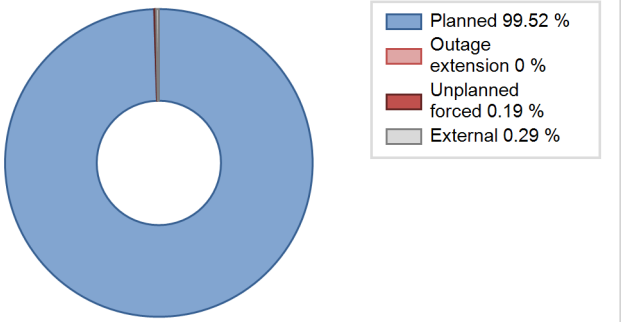
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	Data not provided										
1989	5205.36	5821	920	66.45	66.45	64.59	66.45	15.49	12.18	21.37	0.00
1990	6166.21	7156	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

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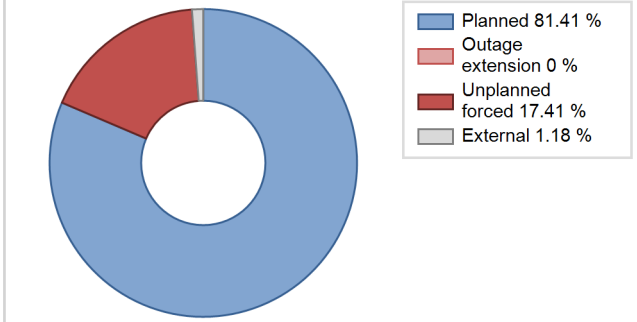
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					151	
C. Inspection, maintenance or repair combined with refuelling	1863			1031		
D. Inspection, maintenance or repair without refuelling				84		
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.)						2
Z. Other						2
Subtotal	1863			1115	158	5
Total	**1863**			**1278**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		30
15. Reactor Cooling Systems		3
17. Safety I&C Systems (excluding reactor I&C)		9
31. Turbine and auxiliaries		7
32. Feedwater and Main Steam System		4
33. Circulating Water System		4
41. Main Generator Systems		98
42. Electrical Power Supply Systems		5
Total		**160**

Highlights (2020)

23rd Refueling(2020.07.23 ~2020.10.09)

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2020 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	:	1010 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	:	31 years

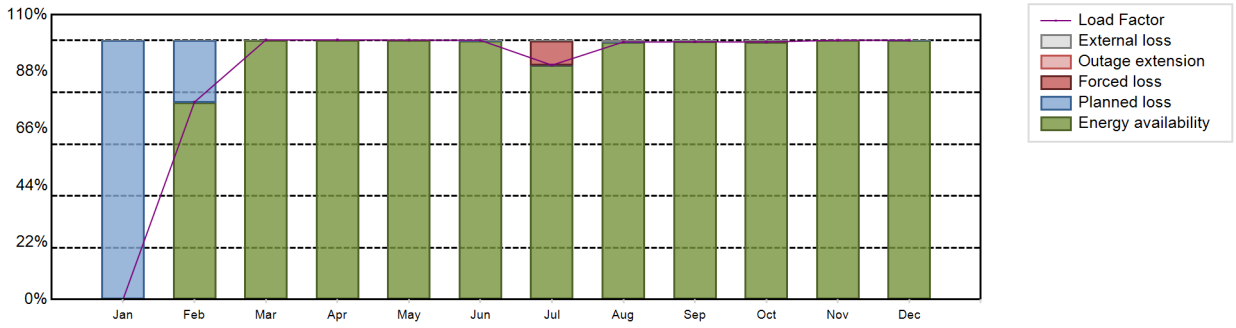
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.4
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	323.2
Fuel material	:	UO2	Number of SG	:	3
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.42
Average fuel enrichment [% of U235]	:	4	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	38	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	42500	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	5.53
Active core height/length [m]	:	3.66	Output voltage [kV]	:	22
Number of fissile fuel assemblies/bundles	:	157	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	17.83	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 (2020)

Net Energy Production	:	7544.08 GW(e).h	Forced Loss Rate (FLR)	:	0.9 %
Energy Availability Factor (EAF)	:	88.69 %	Unplanned Capability Loss Factor (UCL)	:	0.81 %
Unit Capability Factor (UCF)	:	88.82 %	Planned Unavailability Factor (PUF)	:	10.37 %
Load Factor (LF)	:	88.82 %	Externally cause unavailability (XUF)	:	0.13 %
Operating Factor (OF)	:	89.36 %	Total off-line time	:	935 hours

Annual Summary



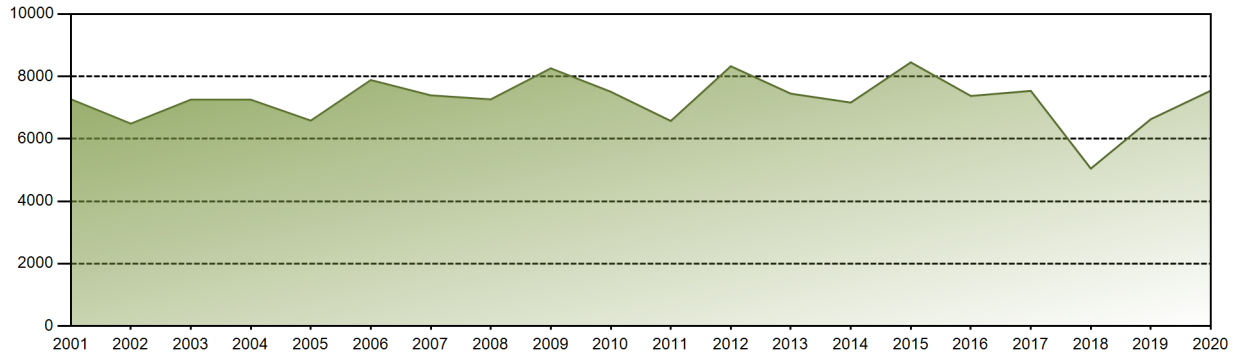
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	513.22	721.54	698.30	720.98	697.08	651.09	715.62	692.86	715.57	697.28	720.53	7544.08
EAF [%]	0.00	76.04	100.00	100.00	100.00	99.98	90.50	99.47	99.52	99.46	100.00	100.00	88.69
UCF [%]	0.00	76.04	100.00	100.00	100.00	100.00	90.74	100.00	100.00	99.70	100.00	100.00	88.82
LF [%]	0.00	76.26	100.29	100.30	100.21	100.12	90.50	99.47	99.52	99.46	100.15	100.15	88.82
OF [%]	0.00	79.45	100.00	100.00	100.00	100.00	93.55	100.00	100.00	100.00	100.00	100.00	89.36
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	9.26	0.00	0.00	0.30	0.00	0.00	0.90
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	9.26	0.00	0.00	0.30	0.00	0.00	0.81
PUF [%]	100.00	23.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.37
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.02	0.24	0.53	0.48	0.24	0.00	0.00	0.13

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Historical Summary

Lifetime energy generation	:	225459.61 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.12 %
Cumulative Energy Availability Factor (EAF)	:	86.81 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.05 %
Cumulative Unit Capability Factor (UCF)	:	86.98 %	Cumulative Planned Unavailability Factor (PUF)	:	11.97 %
Cumulative Load Factor (LF)	:	87.74 %	Cumulative Externally cause unavailability (XUF)	:	0.17 %
Cumulative Operating Factor (OF)	:	87.68 %			

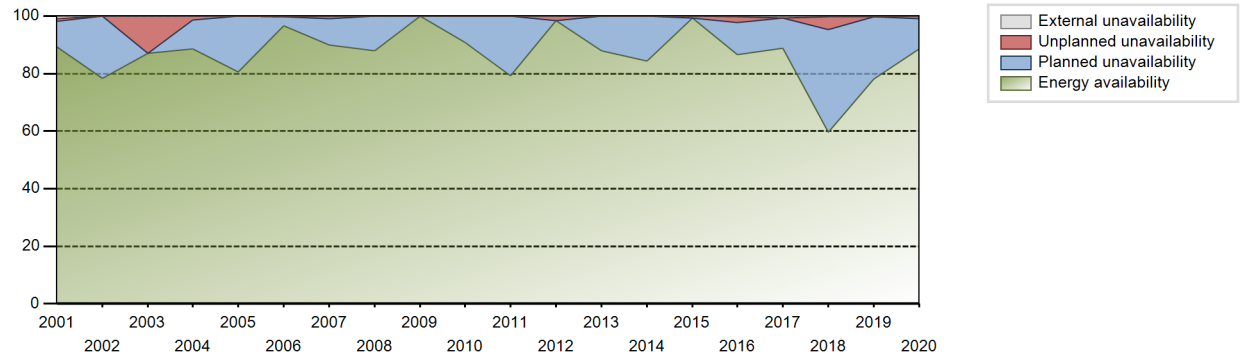
Electricity Production (net) [GWh]



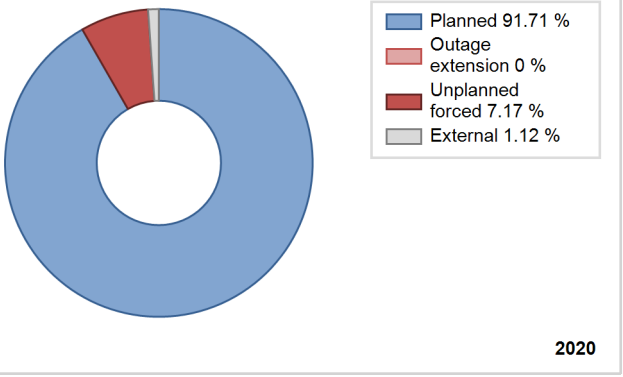
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	Data not provided										
1990	5547.29	6395	920	73.00	73.00	68.83	73.00	0.27	0.19	26.80	0.00
1991	6671.16	7603	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

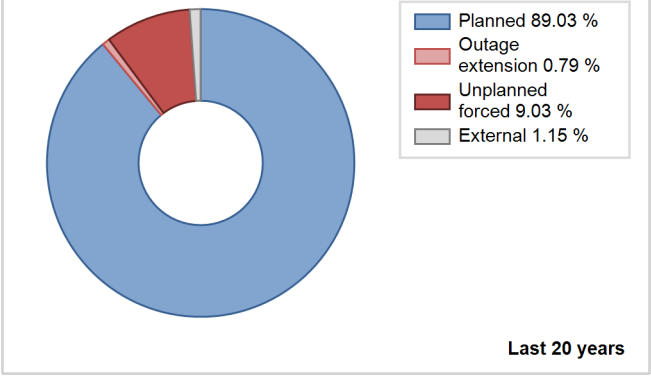
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		48			101	
C. Inspection, maintenance or repair combined with refuelling	887			1009		
D. Inspection, maintenance or repair without refuelling				42		
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.)						2
Z. Other						3
Subtotal	887	48		1051	102	5
Total	**935**			**1158**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		0
16. Steam generation systems	48	2
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		60
32. Feedwater and Main Steam System		2
33. Circulating Water System		5
41. Main Generator Systems		34
42. Electrical Power Supply Systems		3
Total	**48**	**106**

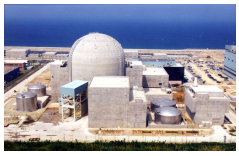
Highlights (2020)

22nd Refueling (2019.10.14 ~ 2020.02.06)
Manual Turbine Trip due to Increased Sodium Concentration and Cation Conductivity in Steam Generator Blowdown System (2020.07.04 ~ 2020.07.06)

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2020 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

Reactor type and model	:	PWR / OPR-1000
Thermal power	:	2825 MWth
Gross electrical power	:	1051 MWe
Reference unit power (net)	:	997 MWe

Key Dates

Construction Date	:	1993-07-21
Grid Date	:	1998-01-06
Commercial Date	:	1998-08-11
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 [%]	:	36.7
Average discharge burnup [MWd/t]	:	45800
Active core diameter [m]	:	3.122
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	177
Fuel linear heat generation rate [kW/m]	:	17.24
Number of control rod assemblies	:	73
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

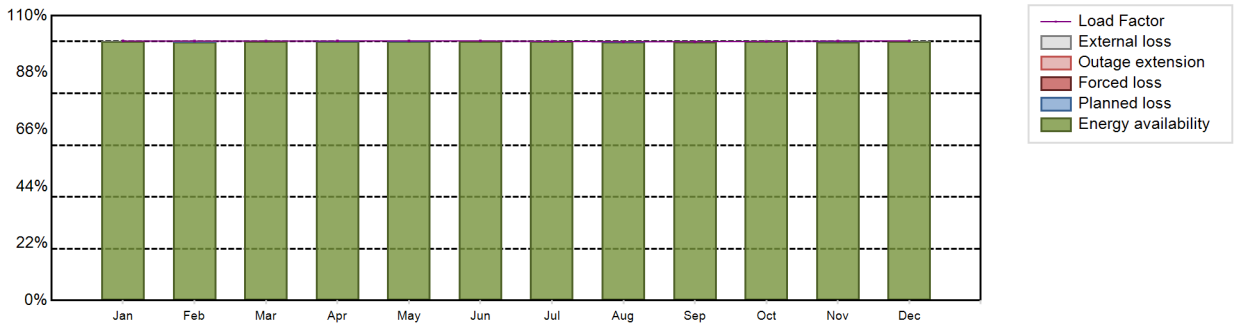
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	7.136
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	:	none

Annual Production Results (2020)

Net Energy Production	:	8772.41 GW(e).h
Energy Availability Factor (EAF)	:	99.98 %
Unit Capability Factor (UCF)	:	99.99 %
Load Factor (LF)	:	100.17 %
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)	:	0.02 %
Total off-line time	:	0 hours

Annual Summary



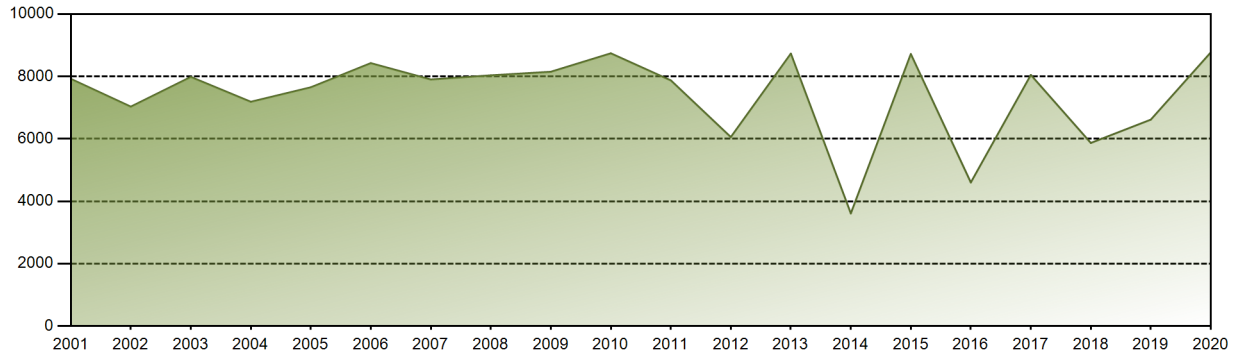
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	743.54	695.34	743.29	719.59	743.83	719.95	742.28	741.28	717.55	742.47	719.39	743.91	8772.41
EAF [%]	100.00	99.97	100.00	100.00	99.99	100.00	99.99	99.89	99.92	99.99	99.99	100.00	99.98
UCF [%]	100.00	99.98	100.00	100.00	99.99	100.00	100.00	99.98	100.00	100.00	99.99	100.00	99.99
LF [%]	100.24	100.21	100.20	100.24	100.28	100.29	100.07	99.93	99.96	100.09	100.22	100.29	100.17
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	0.02	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.01
XUF [%]	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.10	0.08	0.01	0.00	0.00	0.02

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Historical Summary

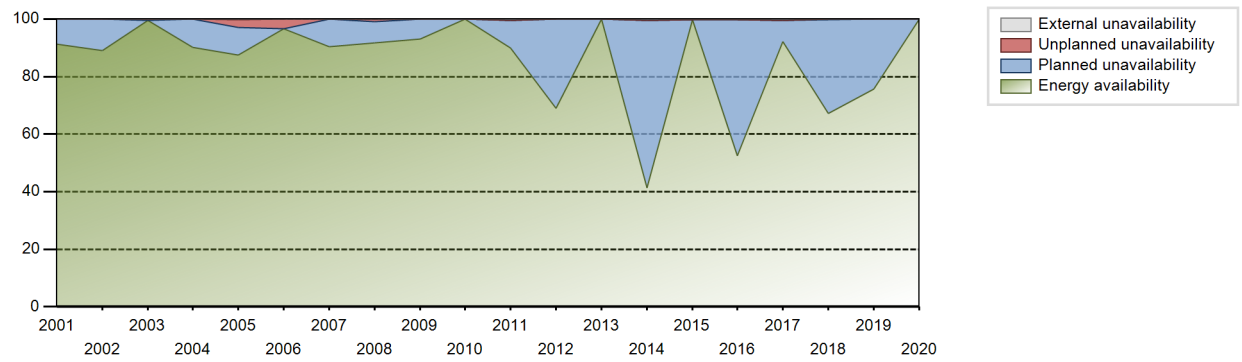
Lifetime energy generation	:	169202.6 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.44 %
Cumulative Energy Availability Factor (EAF)	:	85.82 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.4 %
Cumulative Unit Capability Factor (UCF)	:	86 %	Cumulative Planned Unavailability Factor (PUF)	:	13.6 %
Cumulative Load Factor (LF)	:	85.77 %	Cumulative Externally cause unavailability (XUF)	:	0.18 %
Cumulative Operating Factor (OF)	:	86.53 %			

Electricity Production (net) [GWh]



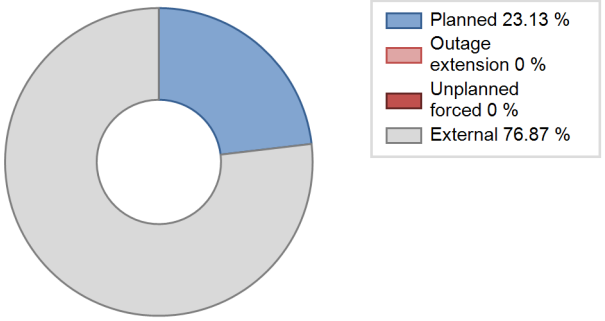
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1998	4822.23	5872	960	99.98	99.98	99.17	97.74	0.00	0.00	0.02	0.00
1999	6918.04	7149	960	79.67	81.45	82.26	81.61	0.68	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

Key Factors in Last 20 Years [%]

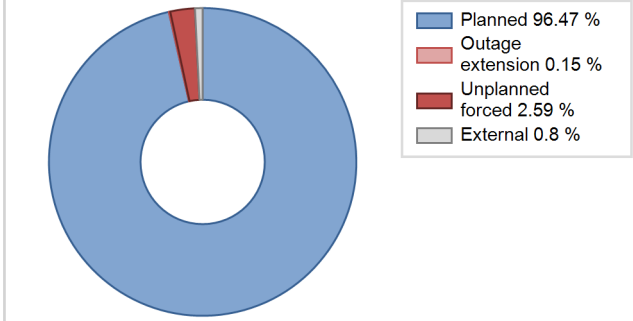


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1998 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					26	
C. Inspection, maintenance or repair combined with refuelling				1175		
Subtotal				1175	26	
Total		**0**			**1201**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1998 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		10
31. Turbine and auxiliaries		1
32. Feedwater and Main Steam System		2
41. Main Generator Systems		13
Total		**26**

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2020 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

Reactor type and model	:	PWR / OPR-1000
Thermal power	:	2825 MWth
Gross electrical power	:	1052 MWe
Reference unit power (net)	:	999 MWe

Key Dates

Construction Date	:	1993-11-01
Grid Date	:	1998-12-28
Commercial Date	:	1999-12-31
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]	:	46603
Active core diameter [m]	:	3.122
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	177
Fuel linear heat generation rate [kW/m]	:	17.24
Number of control rod assemblies	:	73
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

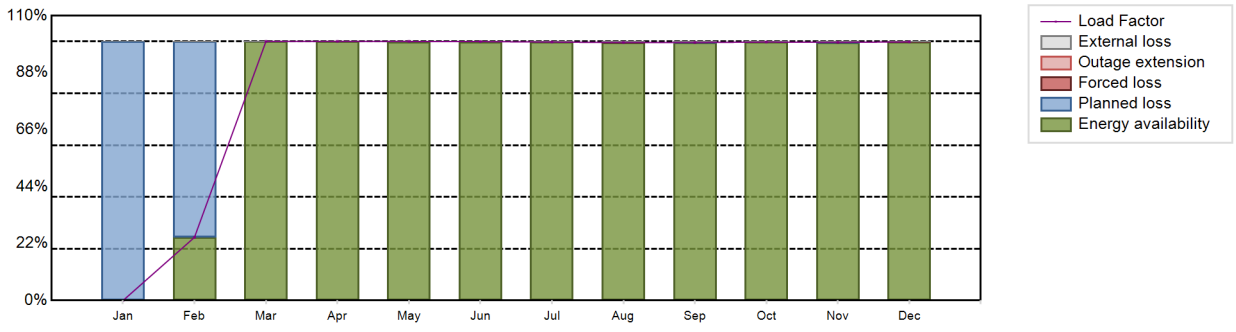
Operating coolant pressure [MPa]	:	15.52502
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	7.136
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	:	none

Annual Production Results (2020)

Net Energy Production	:	7497.57 GW(e).h
Energy Availability Factor (EAF)	:	85.41 %
Unit Capability Factor (UCF)	:	85.5 %
Load Factor (LF)	:	85.44 %
Operating Factor (OF)	:	85.93 %

Forced Loss Rate (FLR)	:	0.04 %
Unplanned Capability Loss Factor (UCL)	:	0.03 %
Planned Unavailability Factor (PUF)	:	14.47 %
Externally cause unavailability (XUF)	:	0.09 %
Total off-line time	:	1236 hours

Annual Summary



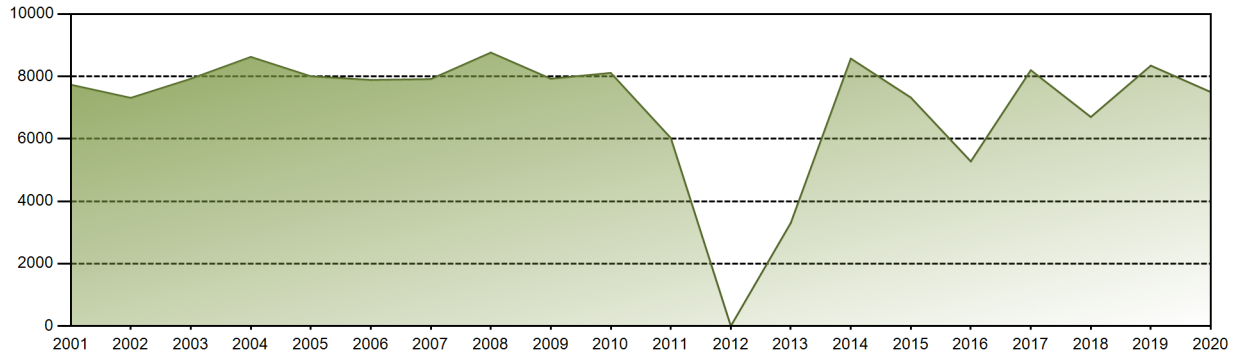
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	169.77	744.02	719.97	743.65	719.35	741.98	740.45	716.77	741.95	717.21	742.45	7497.57
EAF [%]	0.00	24.38	100.00	100.00	99.98	99.97	99.83	99.62	99.65	99.82	99.71	99.89	85.41
UCF [%]	0.00	24.38	100.00	100.00	99.98	100.00	100.00	99.92	100.00	100.00	99.73	99.94	85.50
LF [%]	0.00	24.42	100.10	100.10	100.05	100.01	99.83	99.62	99.65	99.82	99.71	99.89	85.44
OF [%]	0.00	29.31	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	85.93
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.25	0.06	0.04
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.25	0.06	0.03
PUF [%]	100.00	75.62	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.02	0.00	14.47
XUF [%]	0.00	0.00	0.00	0.00	0.01	0.03	0.17	0.30	0.35	0.18	0.02	0.05	0.09

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Historical Summary

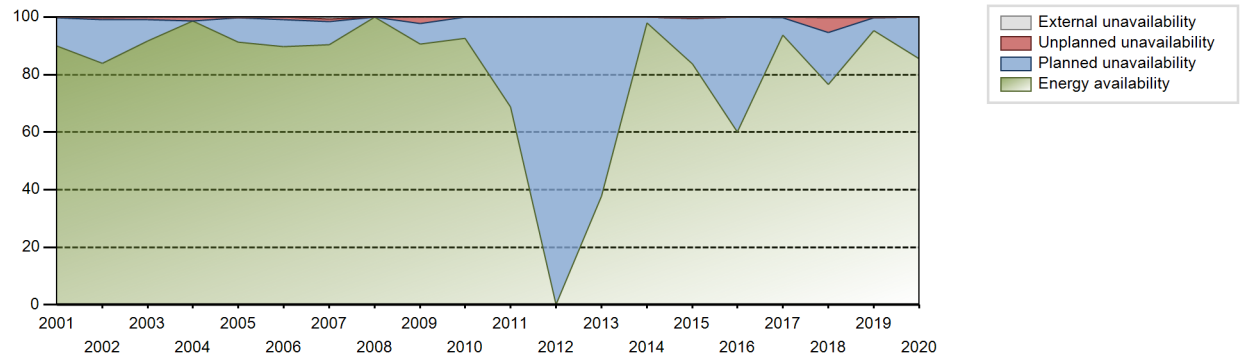
Lifetime energy generation	:	155551.79 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.76 %
Cumulative Energy Availability Factor (EAF)	:	80.8 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.62 %
Cumulative Unit Capability Factor (UCF)	:	80.92 %	Cumulative Planned Unavailability Factor (PUF)	:	18.47 %
Cumulative Load Factor (LF)	:	81.71 %	Cumulative Externally cause unavailability (XUF)	:	0.12 %
Cumulative Operating Factor (OF)	:	82.05 %			

Electricity Production (net) [GWh]



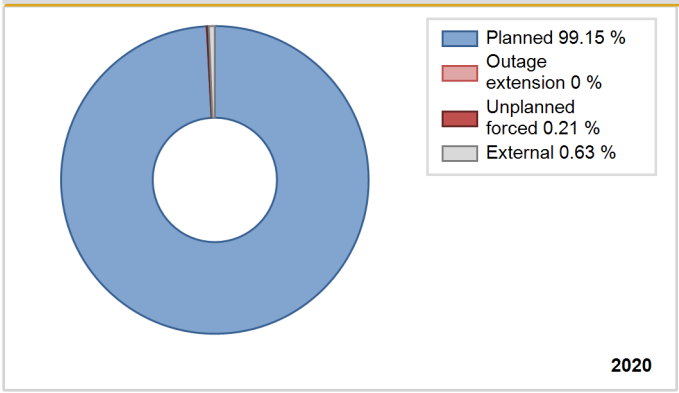
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1999	Data not provided										
2000	7042.47	7229	960	81.26	81.26	83.51	82.30	0.50	0.40	18.33	0.00
2001	7732.33	7880	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

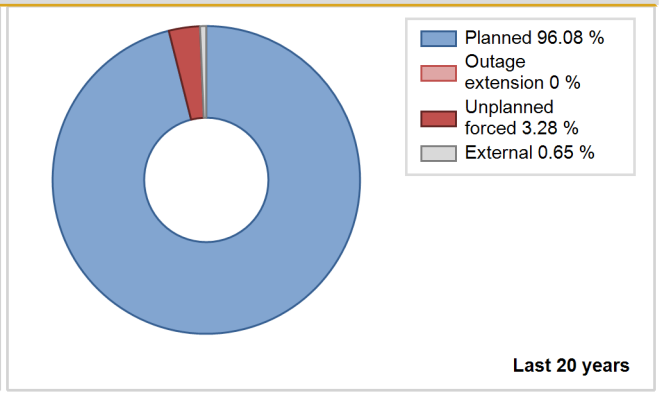
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1999 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					41	
C. Inspection, maintenance or repair combined with refuelling	1236			719		
D. Inspection, maintenance or repair without refuelling				7		
F. Major backfitting, refurbishment or upgrading activities with refuelling				805		
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	1236			1531	41	2
Total	**1236**			**1574**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1999 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		4
31. Turbine and auxiliaries		1
32. Feedwater and Main Steam System		23
41. Main Generator Systems		4
42. Electrical Power Supply Systems		11
Total		**43**

Highlights (2020)

the 14th refueling(2019-12-16 ~ 2020-02-21)

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2020 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	:	1048 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	:	17 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

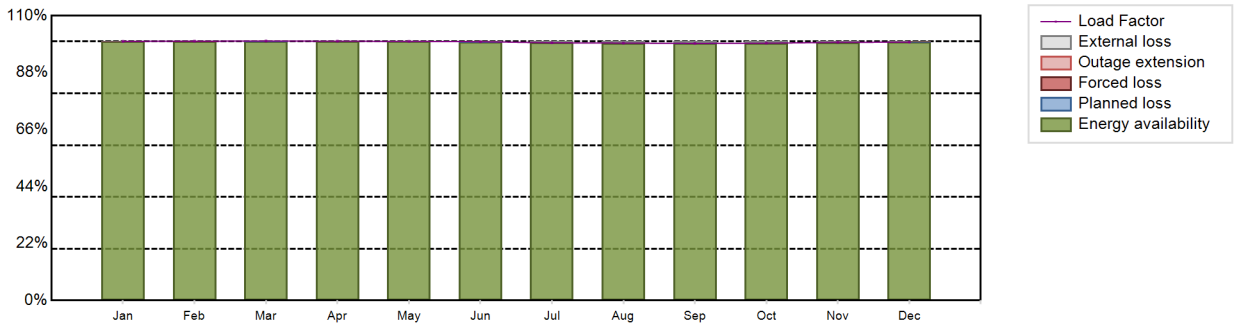
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	8750.36 GW(e).h
Energy Availability Factor (EAF)	:	99.75 %
Unit Capability Factor (UCF)	:	99.96 %
Load Factor (LF)	:	99.82 %
Operating Factor (OF)	:	100 %

Forced Loss Rate (FLR)	:	0.04 %
Unplanned Capability Loss Factor (UCL)	:	0.04 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0.21 %
Total off-line time	:	0 hours

Annual Summary



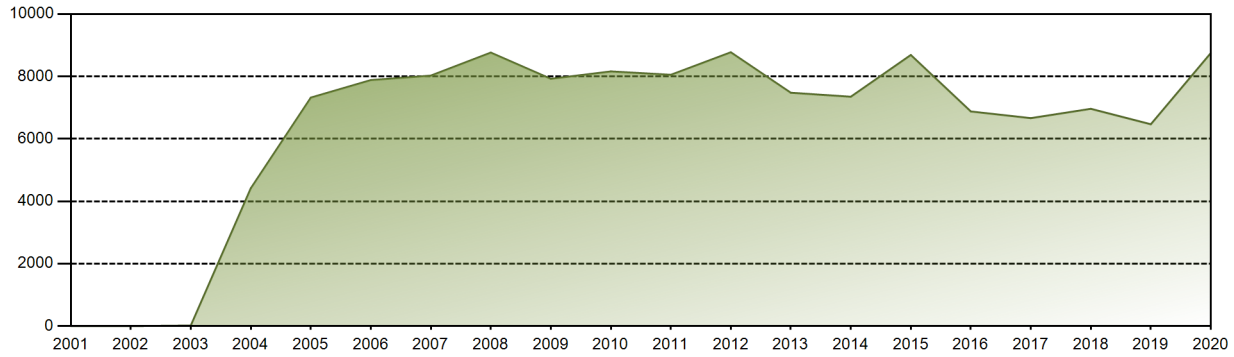
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	743.31	695.68	744.15	719.68	743.12	718.44	739.05	738.23	713.48	737.91	716.48	740.83	8750.36
EAF [%]	100.00	100.00	99.99	100.00	99.99	99.94	99.53	99.42	99.29	99.38	99.71	99.77	99.75
UCF [%]	100.00	100.00	99.99	100.00	99.99	99.99	100.00	100.00	99.98	100.00	99.76	99.77	99.96
LF [%]	100.11	100.15	100.22	100.16	100.08	99.98	99.53	99.42	99.29	99.38	99.71	99.77	99.82
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	0.01	0.00	0.00	0.00	0.00	0.00	0.24	0.22	0.04
UCL [%]	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.24	0.22	0.04
PUF [%]	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01	0.00
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.05	0.47	0.58	0.69	0.62	0.05	0.00	0.21

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Historical Summary

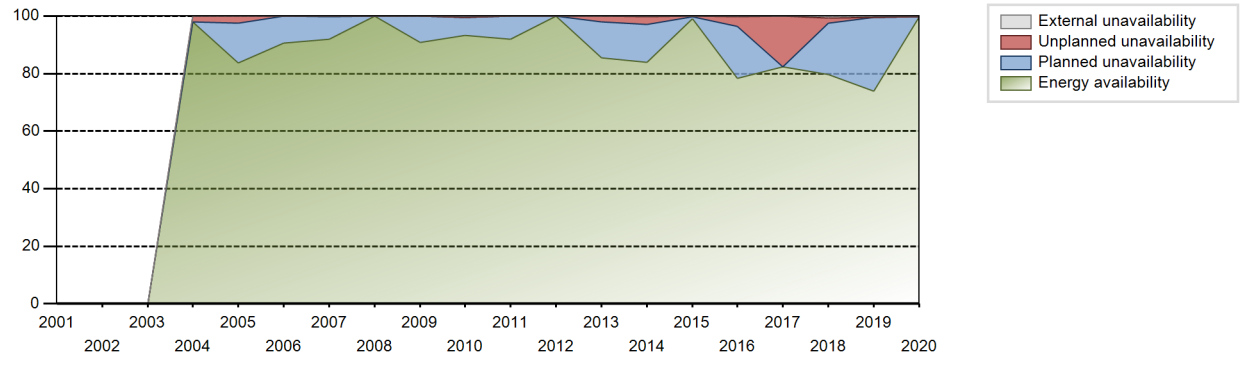
Lifetime energy generation	:	128846.2 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.95 %
Cumulative Energy Availability Factor (EAF)	:	89.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.87 %
Cumulative Unit Capability Factor (UCF)	:	89.45 %	Cumulative Planned Unavailability Factor (PUF)	:	8.68 %
Cumulative Load Factor (LF)	:	89.23 %	Cumulative Externally cause unavailability (XUF)	:	0.18 %
Cumulative Operating Factor (OF)	:	89.47 %			

Electricity Production (net) [GWh]



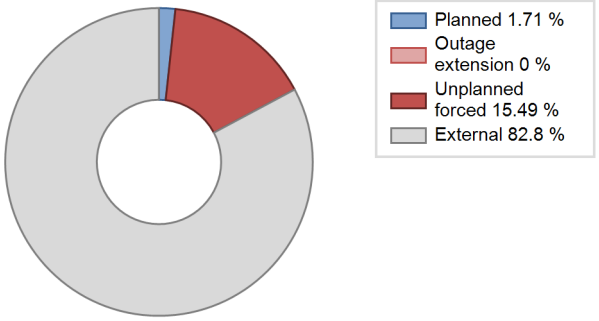
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2004	4415.65	4963	960	97.88	97.88	101.42	97.93	2.11	2.11	0.01	0.00
2005	7321.60	7409	960	83.79	83.79	87.06	84.58	2.77	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

Key Factors in Last 20 Years [%]

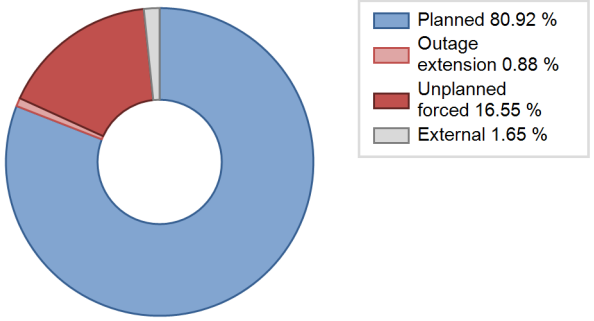


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2004 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					156	
C. Inspection, maintenance or repair combined with refuelling				736		
M. Governmental requirements or court decisions						33
Subtotal				736	156	33
Total		**0**			**925**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2004 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		4
12. Reactor I&C Systems		88
15. Reactor Cooling Systems		8
16. Steam generation systems		9
35. All other I&C Systems		41
Total		**150**

Highlights (2020)

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2020 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	:	15 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

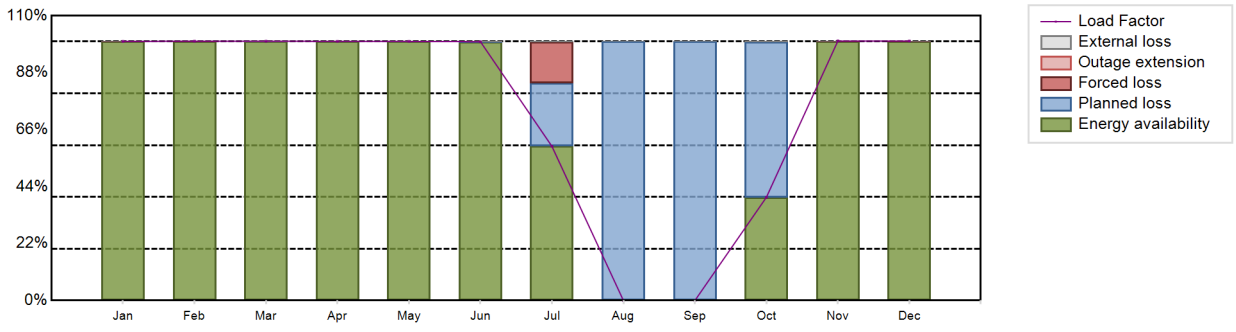
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6559.04 GW(e).h
Energy Availability Factor (EAF)	:	74.81 %
Unit Capability Factor (UCF)	:	74.83 %
Load Factor (LF)	:	74.89 %
Operating Factor (OF)	:	75.22 %

Forced Loss Rate (FLR)	:	1.76 %
Unplanned Capability Loss Factor (UCL)	:	1.34 %
Planned Unavailability Factor (PUF)	:	23.83 %
Externally cause unavailability (XUF)	:	0.02 %
Total off-line time	:	2177 hours

Annual Summary



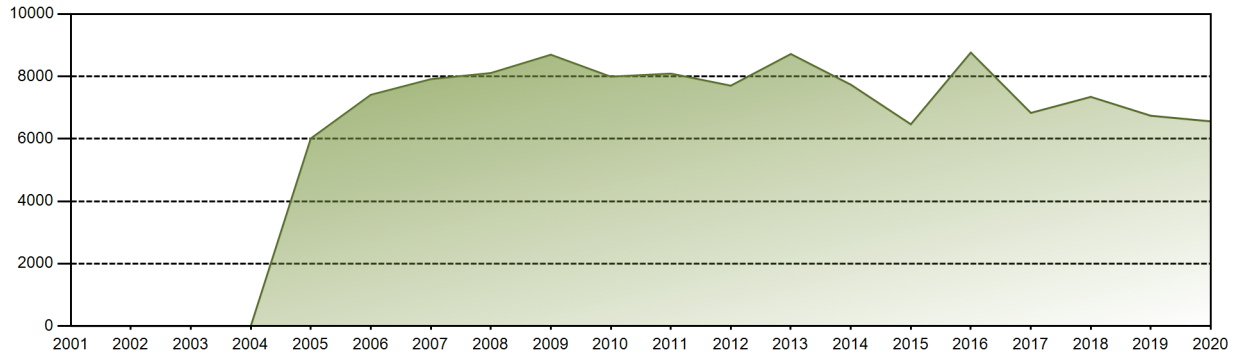
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	742.47	694.87	743.02	718.49	742.17	717.70	441.77	0.19	0.00	295.69	719.52	743.15	6559.04
EAF [%]	100.00	100.00	99.99	100.00	99.99	99.95	59.56	0.03	0.00	39.85	100.00	100.00	74.81
UCF [%]	100.00	100.00	99.99	100.00	100.00	99.99	59.69	0.03	0.00	39.88	100.00	100.00	74.83
LF [%]	100.09	100.14	100.17	100.09	100.05	99.98	59.56	0.03	0.00	39.86	100.23	100.19	74.89
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	59.68	0.00	0.00	44.49	100.00	100.00	75.22
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	20.98	0.00	0.00	0.00	0.00	0.00	1.76
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	15.85	0.00	0.00	0.00	0.00	0.00	1.34
PUF [%]	0.00	0.00	0.01	0.00	0.00	0.01	24.46	99.97	100.00	60.12	0.00	0.00	23.83
XUF [%]	0.00	0.00	0.00	0.00	0.01	0.04	0.14	0.00	0.00	0.02	0.00	0.00	0.02

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Historical Summary

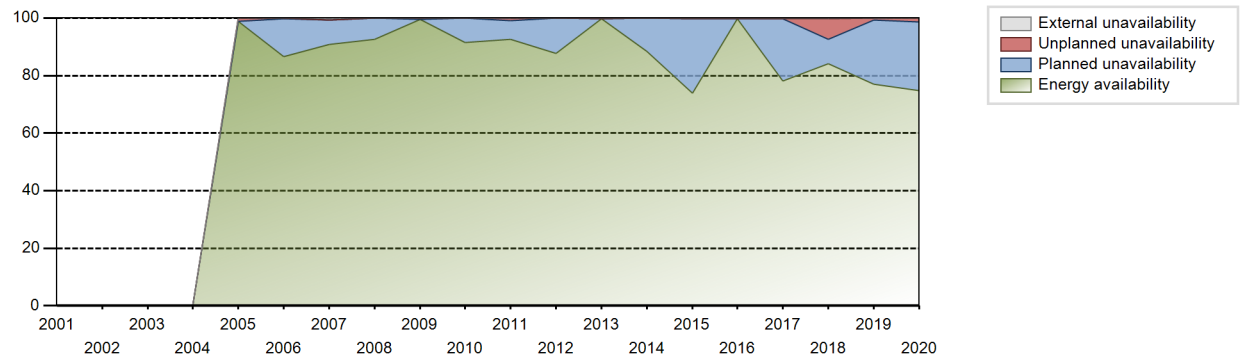
Lifetime energy generation	:	122153.33 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.82 %
Cumulative Energy Availability Factor (EAF)	:	88.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.73 %
Cumulative Unit Capability Factor (UCF)	:	88.45 %	Cumulative Planned Unavailability Factor (PUF)	:	10.82 %
Cumulative Load Factor (LF)	:	88.39 %	Cumulative Externally cause unavailability (XUF)	:	0.15 %
Cumulative Operating Factor (OF)	:	88.78 %			

Electricity Production (net) [GWh]



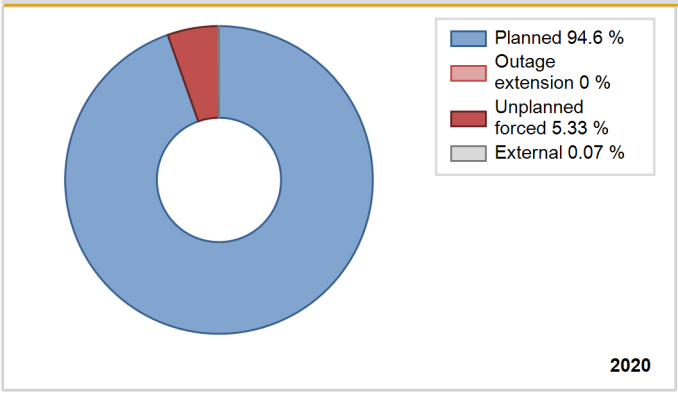
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2005	6010.96	6041	960	98.82	98.82	102.65	99.06	1.18	1.18	0.00	0.00
2006	7409.91	7543	991	86.65	86.65	85.36	86.11	0.38	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

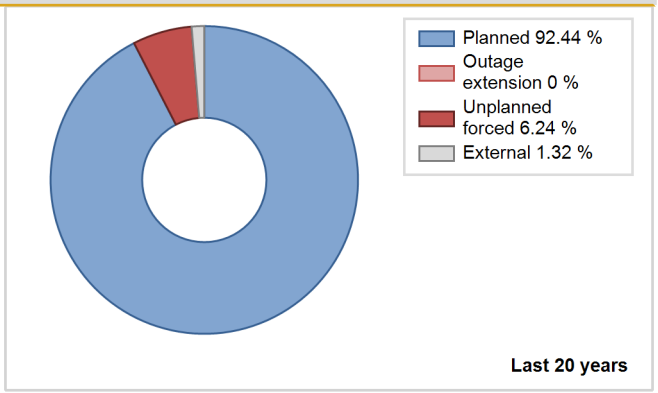
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2005 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					53	
C. Inspection, maintenance or repair combined with refuelling	2062			921		
L. Human factor related		118			8	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						3
Subtotal	2062	118		921	61	3
Total	**2180**			**985**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2005 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		3
15. Reactor Cooling Systems		4
35. All other I&C Systems	118	45
41. Main Generator Systems		5
42. Electrical Power Supply Systems		5
Total	**118**	**62**

Highlights (2020)

Automatic scram(Human error occurred during PCS card replacement operation, 2020.7.19~7.24)
Refueling and Maintenace(2020.7.24 ~ 2020.10.18)

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2020 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	:	37 years

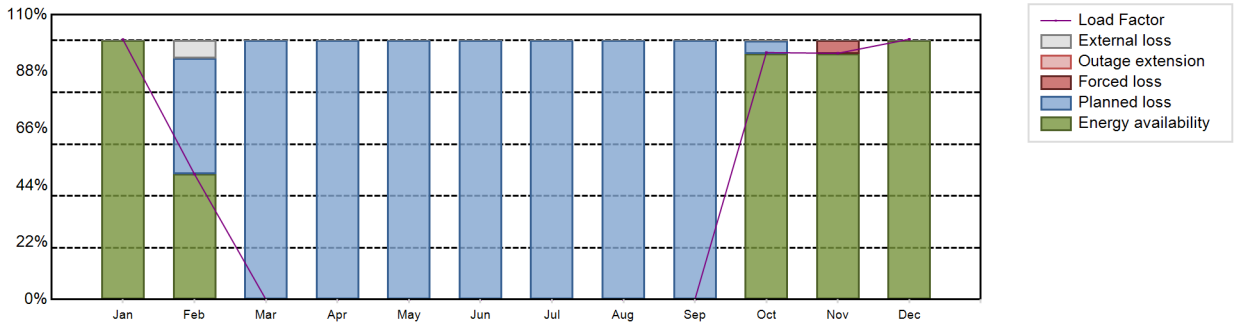
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	324.5
Fuel material	:	UO2	Number of SG	:	2
Refuelling type	:	OFF-line	Containment type	:	Double
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.31
Average fuel enrichment [% of U235]	:	3.8	**Secondary systems**		
Refuelling frequency [month]	:	13	Number of turbine-generators per unit/reactor	:	3
Part of the core refuelled [%]	:	40	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	36946	Number of LP cylinders per turbine	:	2
Active core diameter [m]	:	2.46	HP cylinder inlet steam pressure [MPa]	:	6.35
Active core height/length [m]	:	3.658	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]	:	18.04	Number of main condensate pumps	:	4
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 (2020)

Net Energy Production	:	2064.65 GW(e).h	Forced Loss Rate (FLR)	:	1.14 %
Energy Availability Factor (EAF)	:	36.59 %	Unplanned Capability Loss Factor (UCL)	:	0.43 %
Unit Capability Factor (UCF)	:	37.14 %	Planned Unavailability Factor (PUF)	:	62.44 %
Load Factor (LF)	:	36.73 %	Externally cause unavailability (XUF)	:	0.55 %
Operating Factor (OF)	:	37.88 %	Total off-line time	:	5457 hours

Annual Summary



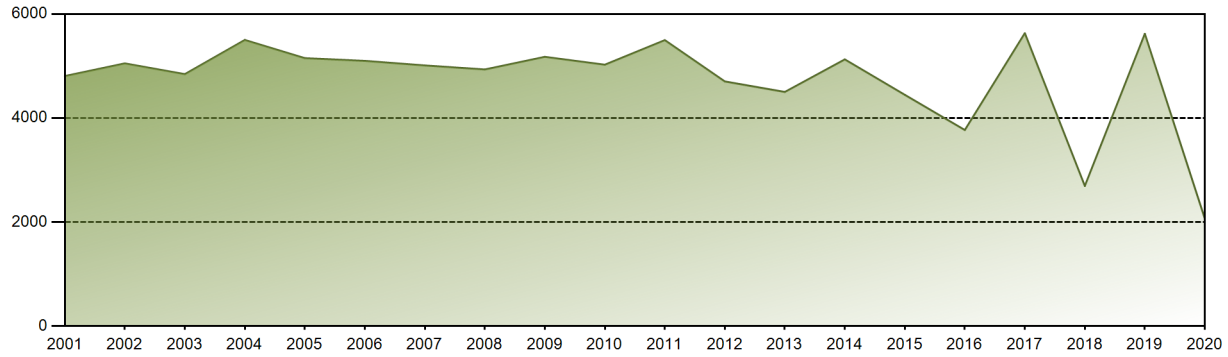
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	477.93	215.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	454.14	438.22	478.64	2064.65
EAF [%]	100.00	48.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	94.99	94.80	100.00	36.59
UCF [%]	100.00	55.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	95.01	94.80	100.00	37.14
LF [%]	100.37	48.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	95.38	95.10	100.52	36.73
OF [%]	100.00	56.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.45	100.00	100.00	37.88
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.20	0.00	1.14
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.20	0.00	0.43
PUF [%]	0.00	44.72	100.00	100.00	100.00	100.00	100.00	100.00	100.00	4.99	0.00	0.00	62.44
XUF [%]	0.00	6.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.55

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Historical Summary

Lifetime energy generation	:	174615.87 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.77 %
Cumulative Energy Availability Factor (EAF)	:	84.14 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.52 %
Cumulative Unit Capability Factor (UCF)	:	84.48 %	Cumulative Planned Unavailability Factor (PUF)	:	13.99 %
Cumulative Load Factor (LF)	:	85.35 %	Cumulative Externally cause unavailability (XUF)	:	0.34 %
Cumulative Operating Factor (OF)	:	84.99 %			

Electricity Production (net) [GWh]

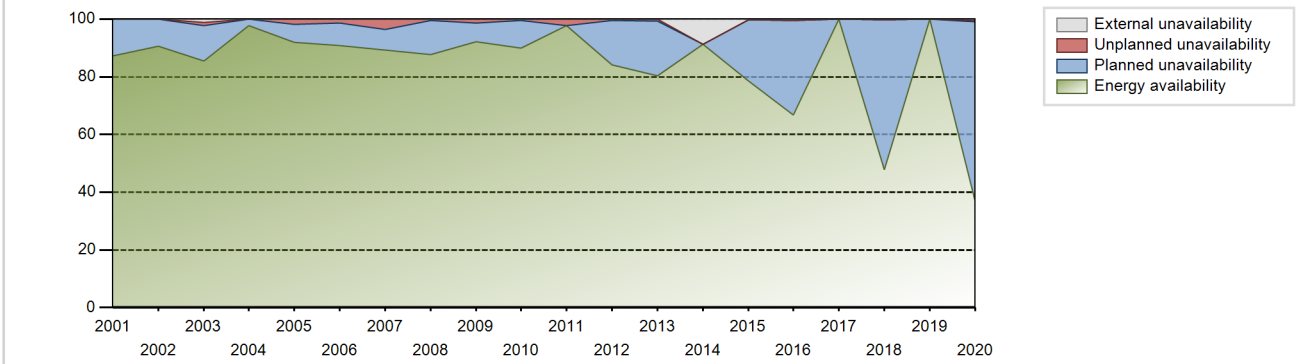


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	Data not provided										
1984	4086.38	6876	605	76.10	76.10	76.89	78.28	10.44	8.87	15.03	0.00
1985	3731.40	6641	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

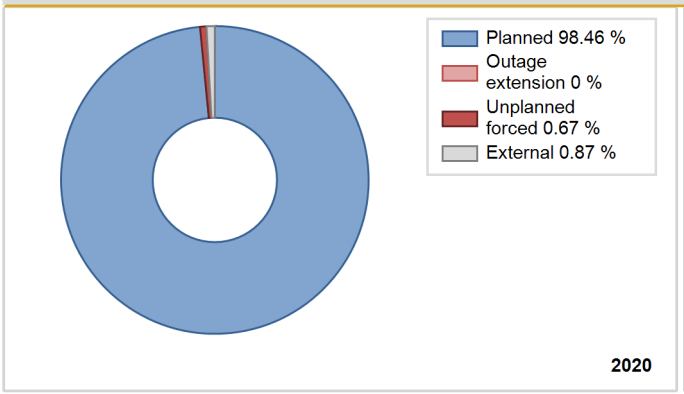
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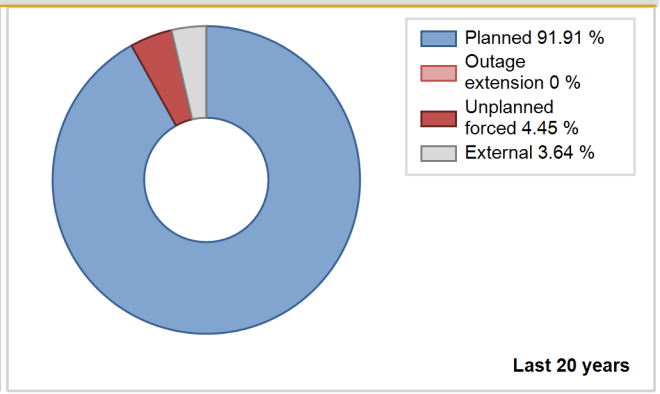
2020	2064.65	3327	640	36.59	37.14	36.73	37.88	1.14	0.43	62.44	0.55

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1983 to 2020 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	5457			1134		
D. Inspection, maintenance or repair without refuelling				26		
E. Testing of plant systems or components					0	
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.)						19
Subtotal	5457			1160	103	23
Total	**5457**			**1286**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1983 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		16
14. Safety Systems		0
15. Reactor Cooling Systems		9
16. Steam generation systems		2
31. Turbine and auxiliaries		30
32. Feedwater and Main Steam System		10
33. Circulating Water System		20
35. All other I&C Systems		0
41. Main Generator Systems		30
42. Electrical Power Supply Systems		5
Total		**122**

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Highlights (2020)

Refueling and Maintenance(2020.2.17~10.1)

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2020 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	:	1045 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	:	35 years

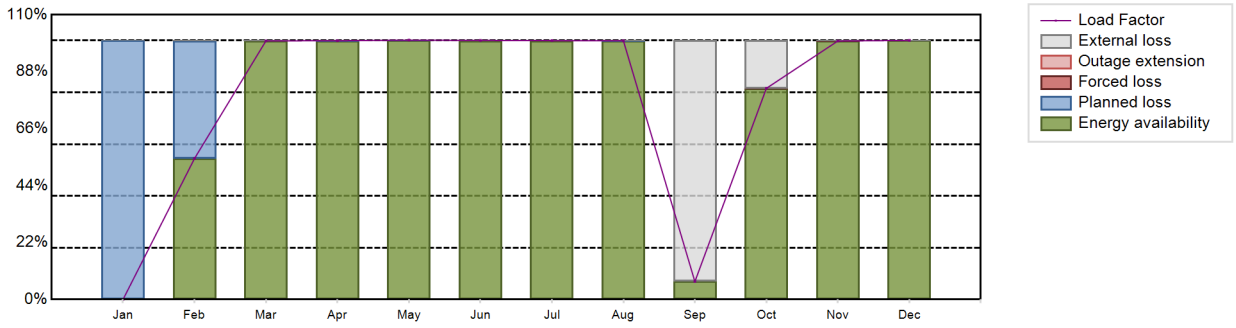
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.4
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	326
Fuel material	:	UO2	Number of SG	:	3
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.31
Average fuel enrichment [% of U235]	:	4.5	**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]	:	17910	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	6.53
Active core height/length [m]	:	3.658	Output voltage [kV]	:	22
Number of fissile fuel assemblies/bundles	:	151	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	17.83	Number of main condensate pumps	:	4
Number of control rod assemblies	:	28	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 (2020)

Net Energy Production	:	6991.45 GW(e).h	Forced Loss Rate (FLR)	:	0.01 %
Energy Availability Factor (EAF)	:	78.68 %	Unplanned Capability Loss Factor (UCL)	:	0.01 %
Unit Capability Factor (UCF)	:	87.91 %	Planned Unavailability Factor (PUF)	:	12.08 %
Load Factor (LF)	:	78.73 %	Externally cause unavailability (XUF)	:	9.23 %
Operating Factor (OF)	:	79.16 %	Total off-line time	:	1831 hours

Annual Summary



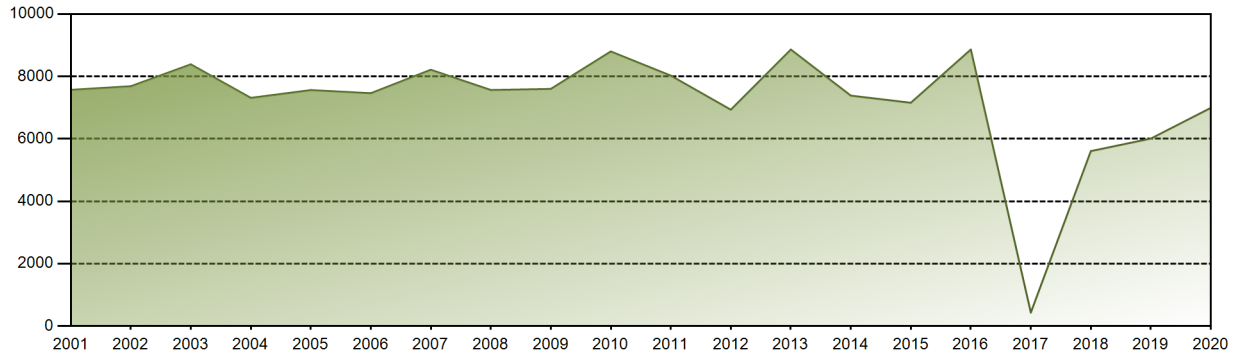
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	383.19	751.39	727.69	753.51	728.41	752.09	751.73	50.42	613.48	726.86	752.68	6991.45
EAF [%]	0.00	54.46	99.89	99.95	100.00	99.97	99.93	99.85	6.93	81.56	99.84	100.00	78.68
UCF [%]	0.00	54.52	100.00	99.97	100.00	100.00	100.00	99.99	100.00	100.00	99.87	100.00	87.91
LF [%]	0.00	54.46	99.89	99.97	100.18	100.07	99.99	99.94	6.93	81.56	99.85	100.07	78.73
OF [%]	0.00	57.47	100.00	100.00	100.00	100.00	100.00	100.00	7.08	83.60	100.00	100.00	79.16
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	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	0.13	0.00	0.01
PUF [%]	100.00	45.48	0.00	0.03	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	12.08
XUF [%]	0.00	0.07	0.11	0.02	0.00	0.03	0.07	0.14	93.07	18.44	0.02	0.00	9.23

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Historical Summary

Lifetime energy generation	:	247851.56 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.02 %
Cumulative Energy Availability Factor (EAF)	:	82.77 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.86 %
Cumulative Unit Capability Factor (UCF)	:	83.12 %	Cumulative Planned Unavailability Factor (PUF)	:	16.02 %
Cumulative Load Factor (LF)	:	84.58 %	Cumulative Externally cause unavailability (XUF)	:	0.36 %
Cumulative Operating Factor (OF)	:	83.41 %			

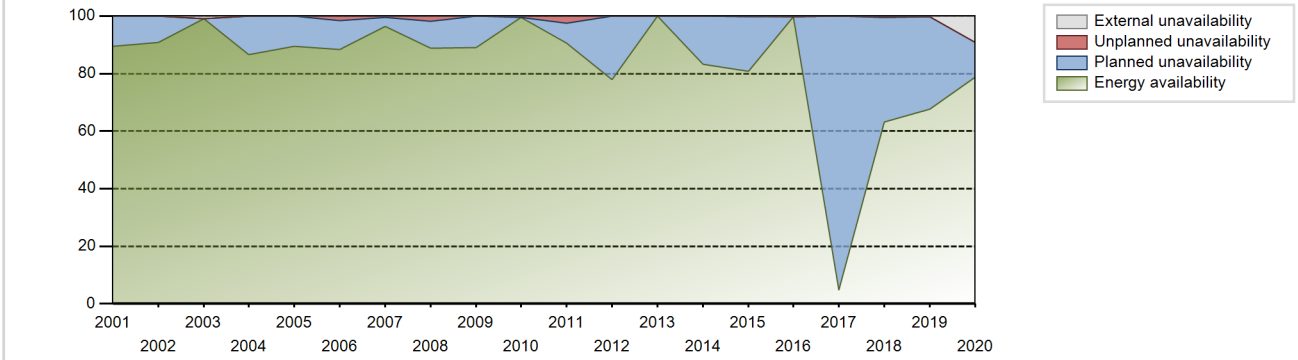
Electricity Production (net) [GWh]



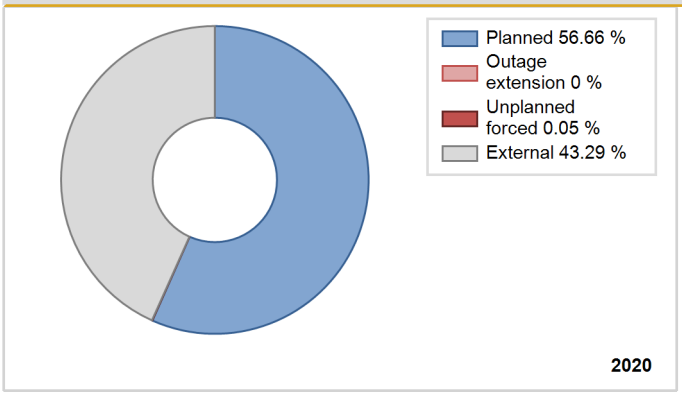
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	Data not provided										
1986	5611.72	6529	895	73.32	73.32	71.58	74.53	5.41	4.20	22.48	0.00
1987	5804.81	6665	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

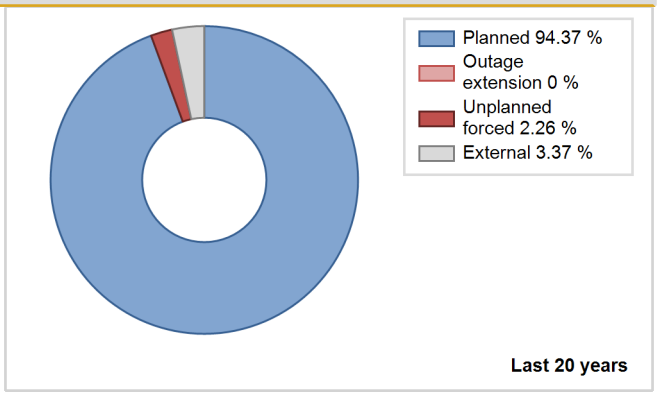
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 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	1040			1295		
D. Inspection, maintenance or repair without refuelling				18		
F. Major backfitting, refurbishment or upgrading activities with refuelling				27		
H. Nuclear regulatory requirements					4	
J. Grid limitation, failure or grid unavailability						3
L. Human factor related					8	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)			791			22
Subtotal	1040		791	1340	79	25
Total	**1831**			**1444**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		11
13. Reactor Auxiliary Systems		5
15. Reactor Cooling Systems		2
16. Steam generation systems		3
31. Turbine and auxiliaries		11
32. Feedwater and Main Steam System		6
35. All other I&C Systems		5
41. Main Generator Systems		29
42. Electrical Power Supply Systems		4
Total		**76**

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Highlights (2020)

25th Refueling and Maintenance (2019.9.6.~2020.2.13.)
Automatic scram due to main transformer PT failure by typhoon Maysak (2020.9.3.~2020.10.6.)

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2020 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	:	35 years

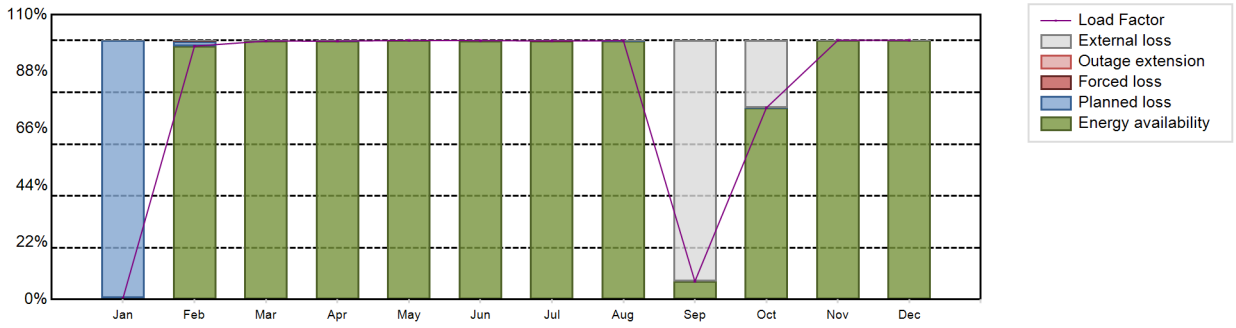
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.2
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	326
Fuel material	:	UO2	Number of SG	:	3
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.31
Average fuel enrichment [% of U235]	:	4.5	**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]	:	18210	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	6.53
Active core height/length [m]	:	3.658	Output voltage [kV]	:	22
Number of fissile fuel assemblies/bundles	:	151	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	17.83	Number of main condensate pumps	:	4
Number of control rod assemblies	:	28	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 (2020)

Net Energy Production	:	7250.24 GW(e).h	Forced Loss Rate (FLR)	:	0.08 %
Energy Availability Factor (EAF)	:	81.52 %	Unplanned Capability Loss Factor (UCL)	:	0.07 %
Unit Capability Factor (UCF)	:	91.37 %	Planned Unavailability Factor (PUF)	:	8.56 %
Load Factor (LF)	:	81.56 %	Externally cause unavailability (XUF)	:	9.84 %
Operating Factor (OF)	:	82.22 %	Total off-line time	:	1562 hours

Annual Summary



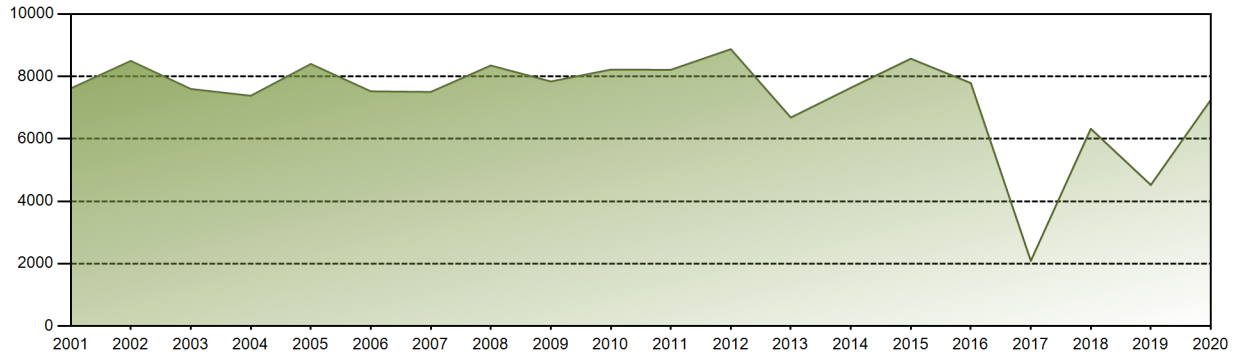
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	3.95	689.20	751.63	727.14	753.50	728.44	752.05	752.52	50.98	557.45	729.45	753.93	7250.24
EAF [%]	0.53	97.85	99.83	99.78	100.00	99.94	99.88	99.89	7.00	74.04	100.00	100.00	81.52
UCF [%]	0.53	97.86	99.83	99.79	100.00	100.00	99.95	100.00	100.00	100.00	100.00	100.00	91.37
LF [%]	0.53	97.85	99.83	99.79	100.08	99.97	99.88	99.95	7.00	74.04	100.11	100.13	81.56
OF [%]	1.88	100.00	100.00	100.00	100.00	100.00	100.00	100.00	7.08	78.09	100.00	100.00	82.22
FLR [%]	0.00	0.50	0.17	0.21	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.08
UCL [%]	0.00	0.49	0.17	0.21	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.07
PUF [%]	99.47	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.56
XUF [%]	0.00	0.01	0.00	0.00	0.00	0.06	0.07	0.11	93.00	25.96	0.00	0.00	9.84

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Historical Summary

Lifetime energy generation	:	248563.69 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.61 %
Cumulative Energy Availability Factor (EAF)	:	84.19 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.52 %
Cumulative Unit Capability Factor (UCF)	:	84.64 %	Cumulative Planned Unavailability Factor (PUF)	:	14.85 %
Cumulative Load Factor (LF)	:	86.15 %	Cumulative Externally cause unavailability (XUF)	:	0.44 %
Cumulative Operating Factor (OF)	:	84.8 %			

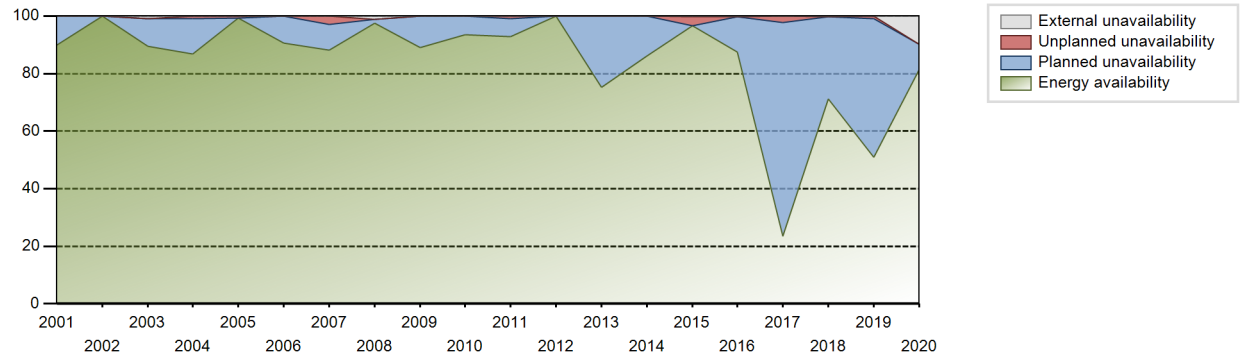
Electricity Production (net) [GWh]



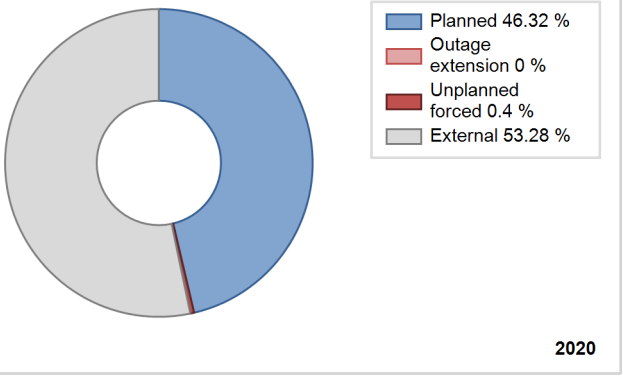
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	Data not provided										
1987	5860.82	6707	895	78.01	78.27	74.75	76.56	0.53	0.42	21.31	0.26
1988	5909.08	7006	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

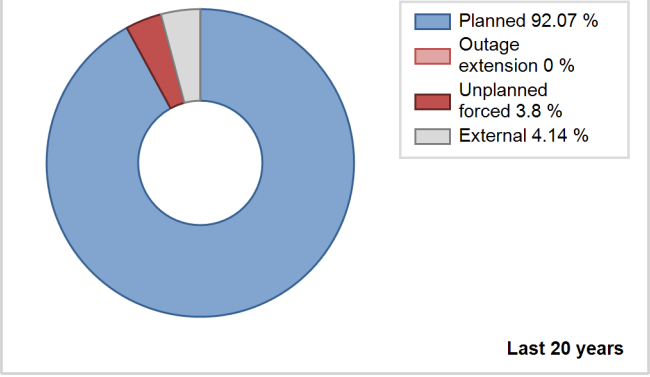
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 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	730			1196		
D. Inspection, maintenance or repair without refuelling				17		
E. Testing of plant systems or components					0	
F. Major backfitting, refurbishment or upgrading activities with refuelling				31		
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.)			832			27
Z. Other						0
Subtotal	730		832	1244	37	30
Total	**1562**			**1311**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		0
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		0
15. Reactor Cooling Systems		3
16. Steam generation systems		6
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		8
32. Feedwater and Main Steam System		5
33. Circulating Water System		2
34. Miscellaneous Systems		1
41. Main Generator Systems		0
42. Electrical Power Supply Systems		10
Total		**43**

Highlights (2020)

25th Refueling and Maintenance (2019.7.9.~2020.1.31.)
Automatic scram due to main transformer PT failure by typhoon Maysak (2020.9.3.~2020.10.7.)

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2020 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	:	1046 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	:	10 years

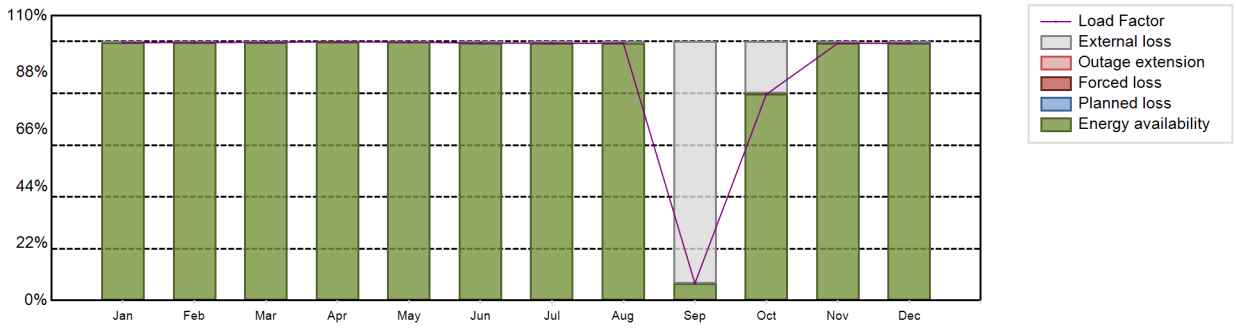
Design Characteristics

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	:	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 (2020)

Net Energy Production	:	7895.37 GW(e).h	Forced Loss Rate (FLR)	:	0.07 %
Energy Availability Factor (EAF)	:	90.24 %	Unplanned Capability Loss Factor (UCL)	:	0.07 %
Unit Capability Factor (UCF)	:	99.92 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	90.24 %	Externally cause unavailability (XUF)	:	9.68 %
Operating Factor (OF)	:	90.92 %	Total off-line time	:	798 hours

Annual Summary



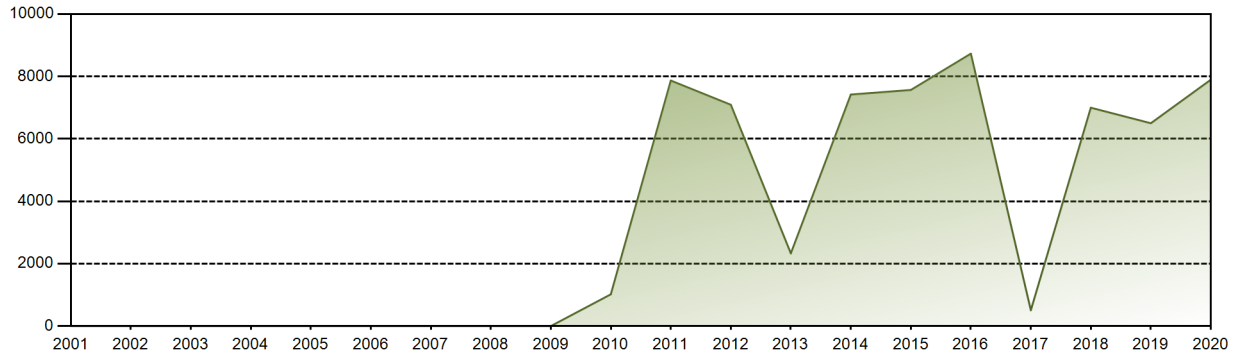
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	738.12	690.66	738.92	716.58	739.10	713.16	736.32	736.00	47.61	590.23	712.36	736.30	7895.37
EAF [%]	99.61	99.63	99.71	99.92	99.74	99.45	99.37	99.32	6.64	79.65	99.34	99.36	90.24
UCF [%]	100.00	100.00	99.99	100.00	100.00	99.99	100.00	100.00	100.00	99.75	99.68	99.67	99.92
LF [%]	99.61	99.63	99.72	99.92	99.74	99.45	99.37	99.32	6.64	79.65	99.34	99.36	90.24
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	6.81	82.93	100.00	100.00	90.92
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.32	0.31	0.07
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.32	0.31	0.07
PUF [%]	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00
XUF [%]	0.39	0.37	0.28	0.08	0.26	0.54	0.63	0.68	93.36	20.10	0.35	0.31	9.68

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Historical Summary

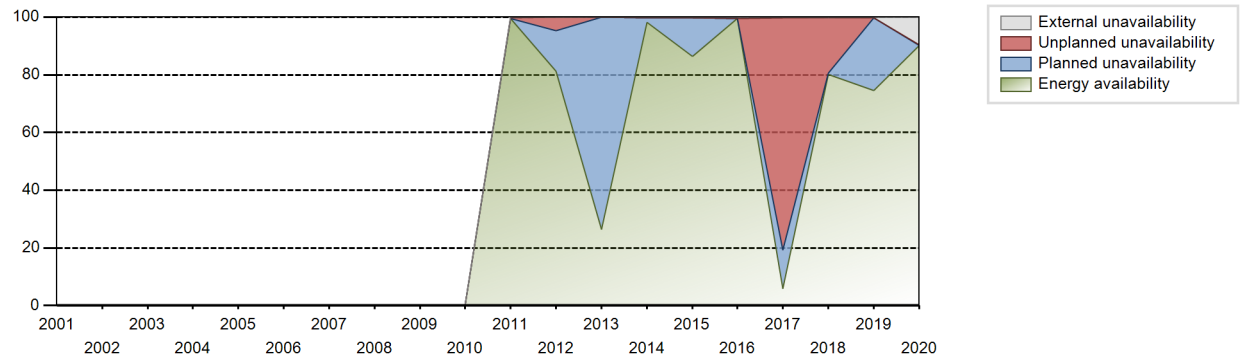
Lifetime energy generation	:	63921.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.66 %
Cumulative Energy Availability Factor (EAF)	:	73.79 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	10.61 %
Cumulative Unit Capability Factor (UCF)	:	74.98 %	Cumulative Planned Unavailability Factor (PUF)	:	14.41 %
Cumulative Load Factor (LF)	:	72.47 %	Cumulative Externally cause unavailability (XUF)	:	1.19 %
Cumulative Operating Factor (OF)	:	73.12 %			

Electricity Production (net) [GWh]



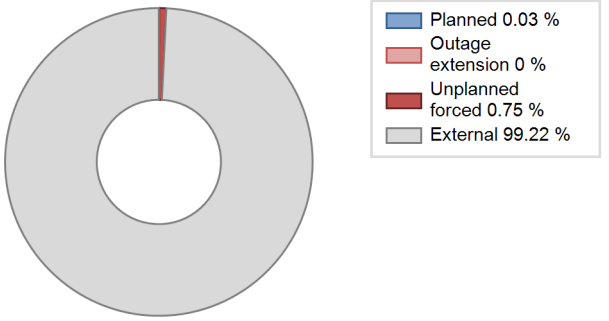
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2011	7867.03	8008	985	99.61	99.98	100.17	100.00	0.02	0.02	0.00	0.37
2012	7091.41	7220	997	81.24	81.31	80.97	82.19	5.45	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

Key Factors in Last 20 Years [%]

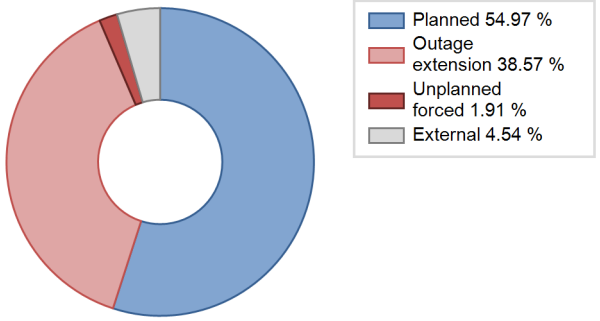


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2011 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					927	
C. Inspection, maintenance or repair combined with refuelling				1231		
E. Testing of plant systems or components				232		
J. Grid limitation, failure or grid unavailability						119
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)			799			81
Subtotal			799	1463	927	200
Total		**799**			**2590**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2011 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		38
15. Reactor Cooling Systems		837
42. Electrical Power Supply Systems		113
Total		**988**

Highlights (2020)

Automatic scram due to loss of offsite power and RCP trip by typhoon Maysak(2020.09.03 ~ 10.06)

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2020 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

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	:	2007-06-05
Grid Date	:	2012-01-28
Commercial Date	:	2012-07-20
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	:	180
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

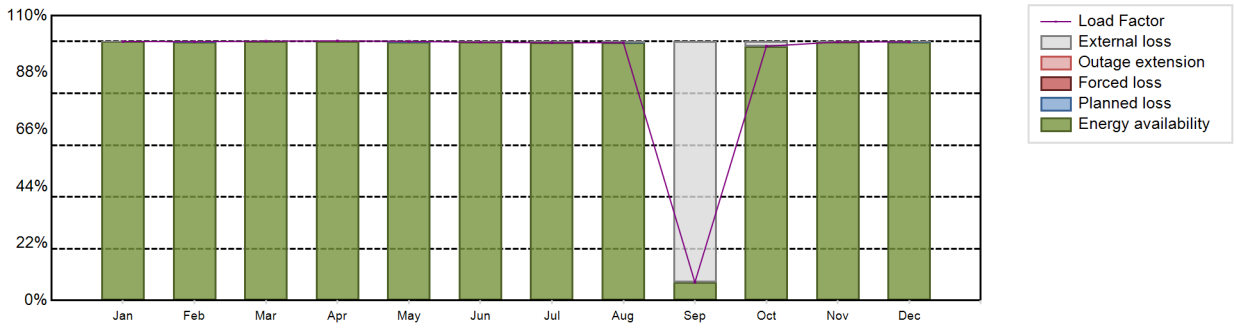
Operating coolant pressure [MPa]	:	17.237
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
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	:	2
Number of on-site safety related diesel generators	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	8062.54 GW(e).h
Energy Availability Factor (EAF)	:	92.1 %
Unit Capability Factor (UCF)	:	99.99 %
Load Factor (LF)	:	92.16 %
Operating Factor (OF)	:	92.52 %

Forced Loss Rate (FLR)	:	0.01 %
Unplanned Capability Loss Factor (UCL)	:	0.01 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	7.89 %
Total off-line time	:	657 hours

Annual Summary



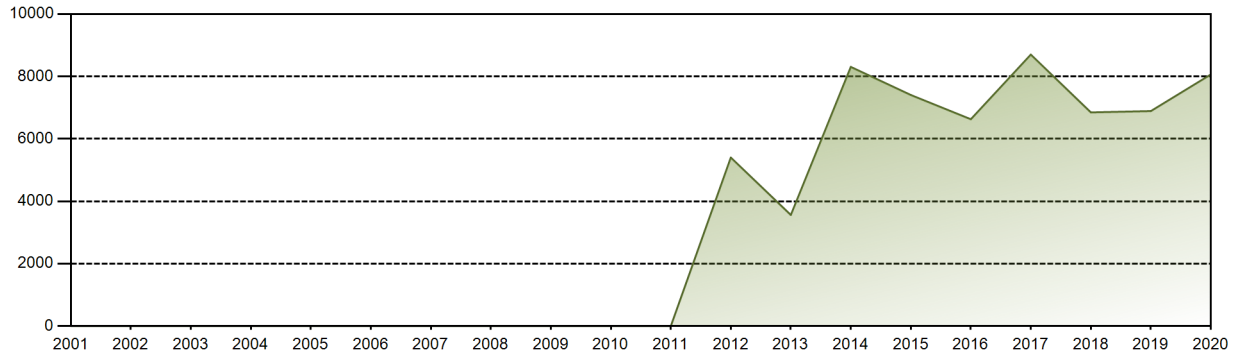
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	741.27	692.91	742.18	719.13	741.65	715.27	737.96	737.85	50.38	727.70	716.11	740.13	8062.54
EAF [%]	99.99	99.89	100.00	100.00	99.98	99.74	99.59	99.57	7.03	98.20	99.86	99.87	92.10
UCF [%]	100.00	99.89	100.00	100.00	99.99	100.00	100.00	99.99	100.00	100.00	100.00	99.99	99.99
LF [%]	100.03	99.96	100.16	100.28	100.09	99.74	99.59	99.57	7.03	98.20	99.86	99.88	92.16
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	8.75	100.00	100.00	100.00	92.52
FLR [%]	0.00	0.10	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	0.10	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	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
XUF [%]	0.01	0.01	0.00	0.00	0.01	0.26	0.41	0.42	92.97	1.80	0.14	0.12	7.89

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Historical Summary

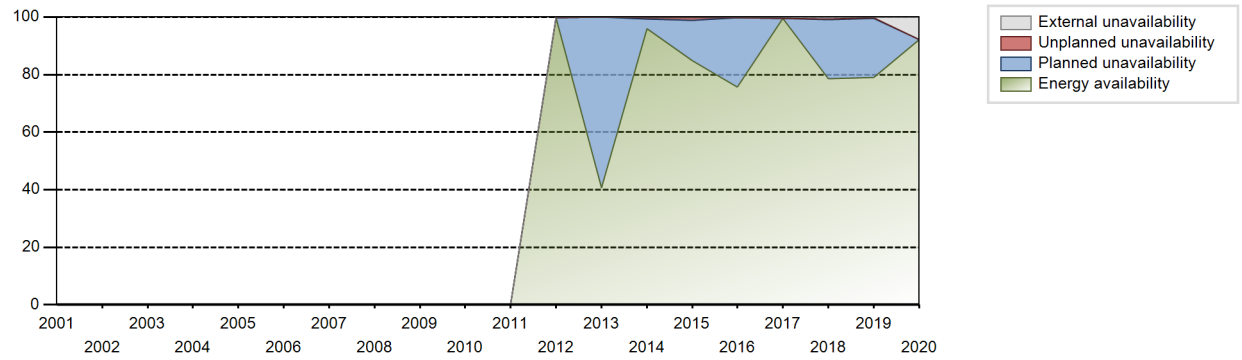
Lifetime energy generation	:	61796.71 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.26 %
Cumulative Energy Availability Factor (EAF)	:	81.71 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.22 %
Cumulative Unit Capability Factor (UCF)	:	82.91 %	Cumulative Planned Unavailability Factor (PUF)	:	16.87 %
Cumulative Load Factor (LF)	:	81.53 %	Cumulative Externally cause unavailability (XUF)	:	1.2 %
Cumulative Operating Factor (OF)	:	82.64 %			

Electricity Production (net) [GWh]

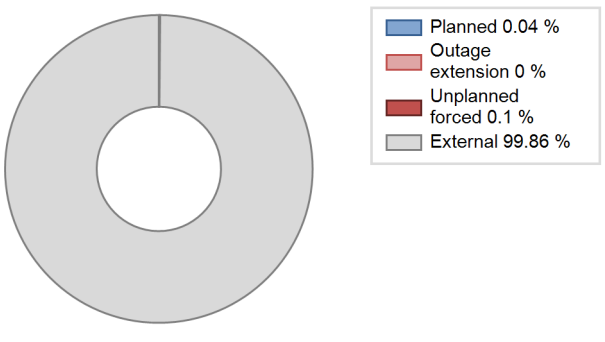


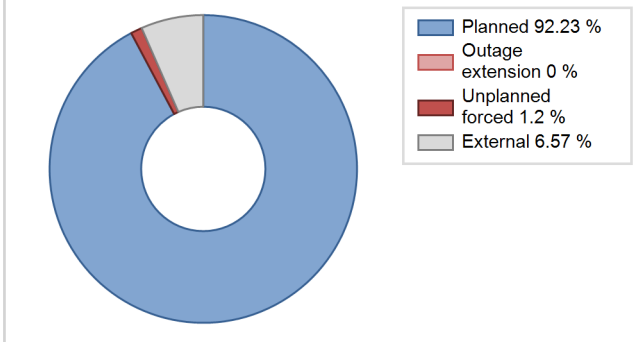
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2012	5400.28	5897	997	99.75	99.95	98.04	99.95	0.00	0.00	0.05	0.19
2013	3560.31	3569	1000	40.56	40.57	40.64	40.74	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2012 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling				1444		
E. Testing of plant systems or components				262		
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.)			657			78
Subtotal			657	1706		78
Total		**657**			**1784**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2012 to 2020 Average hours lost per reactor-year
42. Electrical Power Supply Systems		0
Total		**0**

Highlights (2020)

Automatic scram due to loss of offsite power and RCP trip by typhoon Maysak (2020.09.03 ~2020.09.30)

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2020 Operating Experience

KR-25 SHIN-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	:	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	:	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

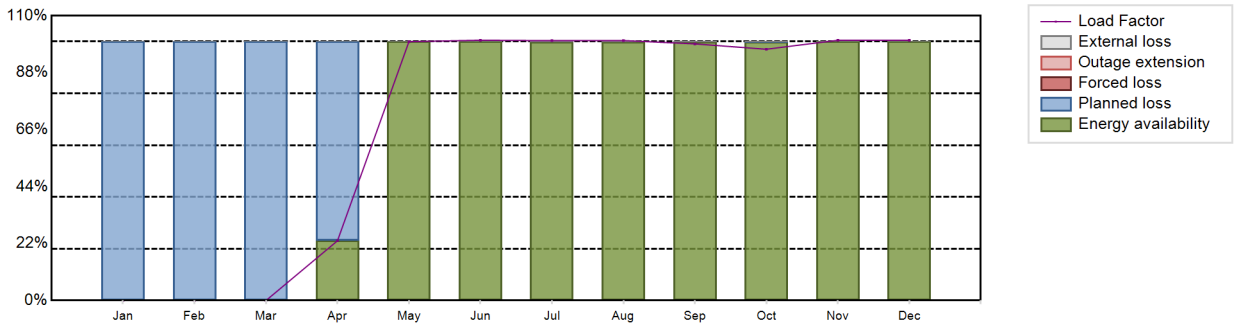
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	323.9
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.41
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP 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 (2020)

Net Energy Production	:	8544.98 GW(e).h
Energy Availability Factor (EAF)	:	68.81 %
Unit Capability Factor (UCF)	:	68.82 %
Load Factor (LF)	:	68.7 %
Operating Factor (OF)	:	69.67 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	31.18 %
Externally cause unavailability (XUF)	:	0.02 %
Total off-line time	:	2664 hours

Annual Summary



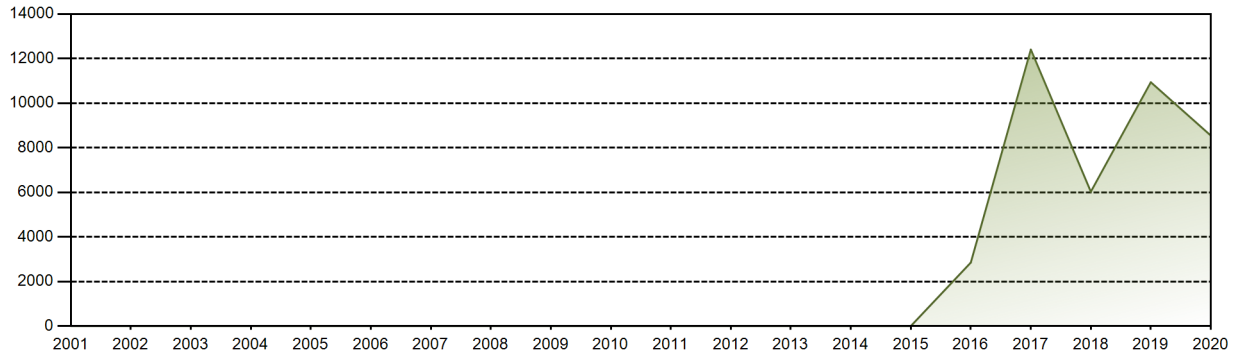
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	235.27	1053.23	1024.91	1057.34	1057.91	1010.46	1022.46	1024.71	1058.71	8544.98
EAF [%]	0.00	0.00	0.00	23.07	100.00	100.00	99.96	99.98	99.86	99.91	100.00	100.00	68.81
UCF [%]	0.00	0.00	0.00	23.07	100.00	100.00	99.96	100.00	100.00	99.96	100.00	100.00	68.82
LF [%]	0.00	0.00	0.00	23.08	99.97	100.53	100.36	100.42	99.11	97.05	100.51	100.49	68.70
OF [%]	0.00	0.00	0.00	33.33	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	69.67
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 [%]	100.00	100.00	100.00	76.93	0.00	0.00	0.04	0.00	0.00	0.04	0.00	0.00	31.18
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.14	0.05	0.00	0.00	0.02

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Historical Summary

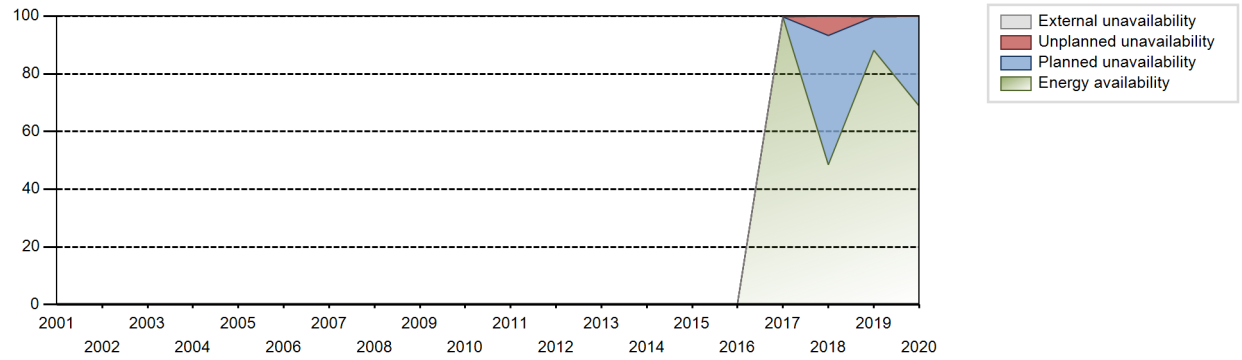
Lifetime energy generation	:	40767.9 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.15 %
Cumulative Energy Availability Factor (EAF)	:	76.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.68 %
Cumulative Unit Capability Factor (UCF)	:	76.47 %	Cumulative Planned Unavailability Factor (PUF)	:	21.85 %
Cumulative Load Factor (LF)	:	76.37 %	Cumulative Externally cause unavailability (XUF)	:	0.17 %
Cumulative Operating Factor (OF)	:	77.01 %			

Electricity Production (net) [GWh]

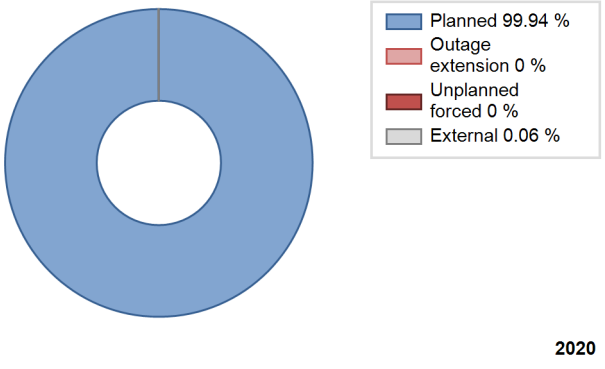


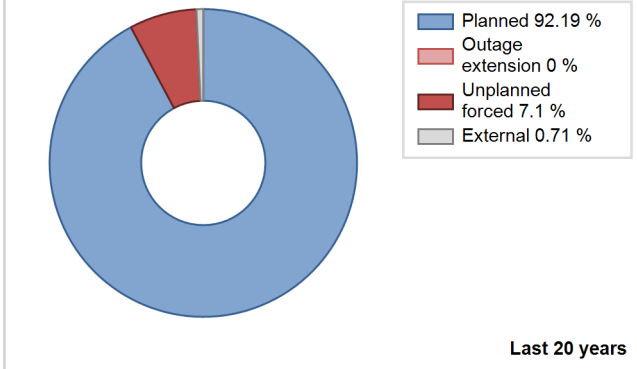
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	2851.25	2956	1383	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2017	12405.61	8760	1416	99.79	99.99	100.01	100.00	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					144	
C. Inspection, maintenance or repair combined with refuelling	2671			1875		
E. Testing of plant systems or components				1369		
Subtotal	2671			3244	144	
Total	**2671**			**3388**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		115
Total		**115**

Highlights (2020)

Refueling and Maintenance : '19.11.20 ~ '20.04.21

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2020 Operating Experience

KR-26 SHIN-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	:	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	:	1494 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	:	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]	:	2.66
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

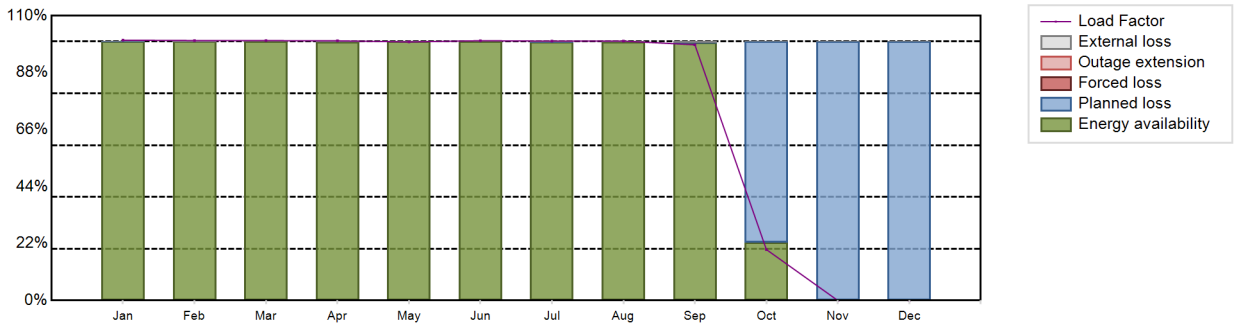
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	323.9
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.41
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP 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 (2020)

Net Energy Production	:	9543.62 GW(e).h
Energy Availability Factor (EAF)	:	76.73 %
Unit Capability Factor (UCF)	:	76.77 %
Load Factor (LF)	:	76.62 %
Operating Factor (OF)	:	77.16 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	23.23 %
Externally cause unavailability (XUF)	:	0.03 %
Total off-line time	:	2006 hours

Annual Summary



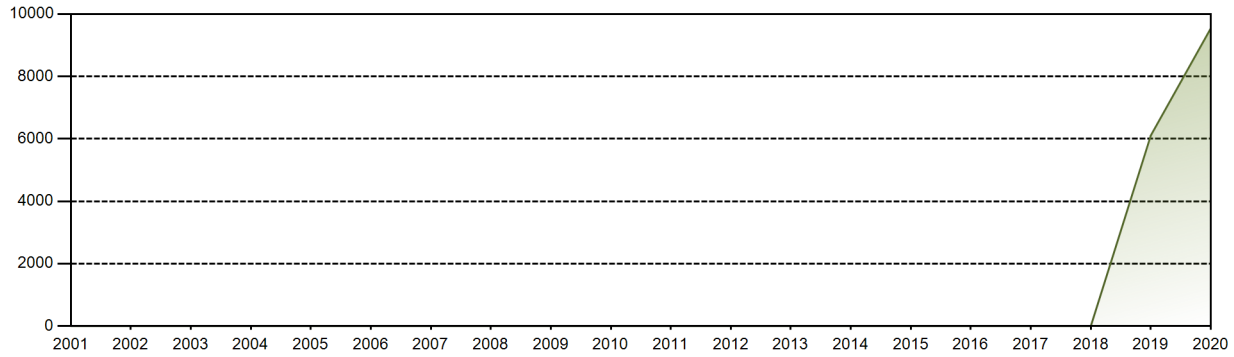
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	1060.89	990.95	1059.09	1024.15	1053.69	1024.58	1057.01	1056.99	1008.45	207.82	0.00	0.00	9543.62
EAF [%]	99.99	100.00	100.00	99.98	100.00	100.00	99.97	99.96	99.62	22.52	0.00	0.00	76.73
UCF [%]	99.99	100.00	100.00	99.98	100.00	100.00	99.98	100.00	99.98	22.52	0.00	0.00	76.77
LF [%]	100.56	100.41	100.39	100.31	99.88	100.35	100.19	100.19	98.77	19.70	0.00	0.00	76.62
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	27.15	0.00	0.00	77.16
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	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	0.02	0.00	0.00	0.02	0.00	0.02	77.48	100.00	100.00	23.23
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.36	0.00	0.00	0.00	0.03

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Historical Summary

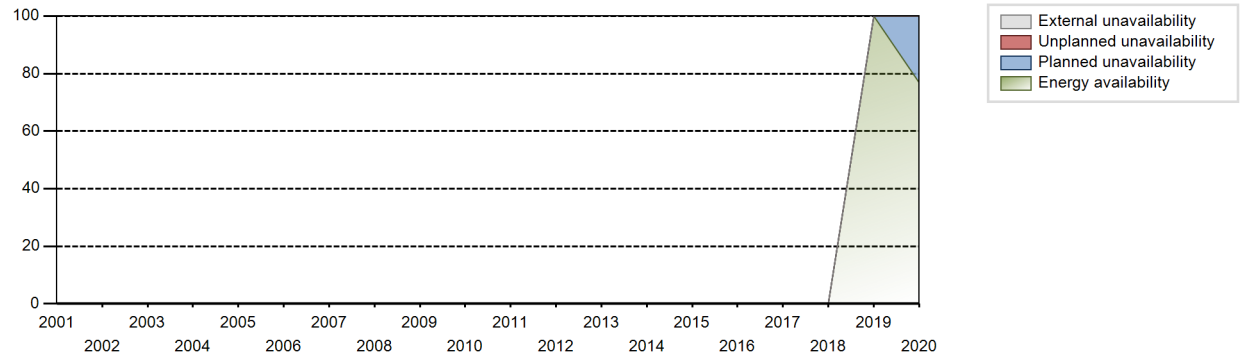
Lifetime energy generation	:	15651.02 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	82.54 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	82.57 %	Cumulative Planned Unavailability Factor (PUF)	:	17.43 %
Cumulative Load Factor (LF)	:	82.55 %	Cumulative Externally cause unavailability (XUF)	:	0.04 %
Cumulative Operating Factor (OF)	:	82.87 %			

Electricity Production (net) [GWh]

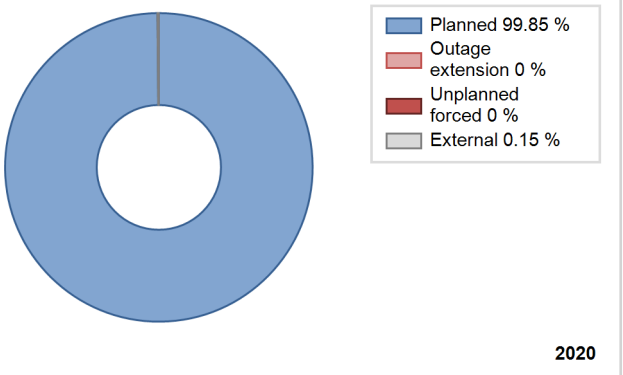


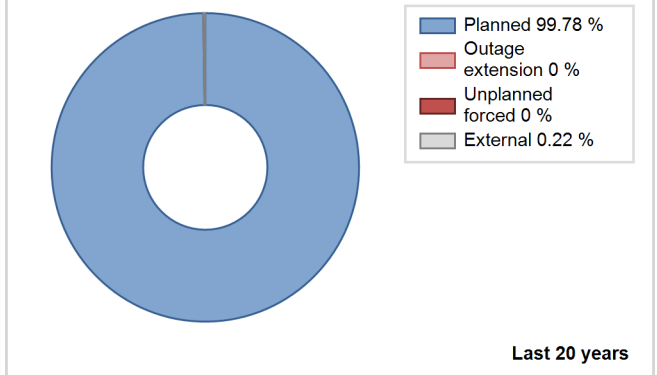
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2019	6107.40	4874	1418	99.95	100.00	100.34	100.00	0.00	0.00	0.00	0.05
2020	9543.62	6778	1418	76.73	76.77	76.62	77.16	0.00	0.00	23.23	0.03

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2019 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
C. Inspection, maintenance or repair combined with refuelling	2006			1505		
E. Testing of plant systems or components				918		
Subtotal	2006			2423		
Total	**2006**			**2423**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2019 to 2020
	Hours Lost	Average hours lost per reactor-year
Total		

Highlights (2020)

Refueling and Maintenance: '20.10.09 ~

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2020 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

Reactor type and model	:	PWR / OPR-1000
Thermal power	:	2825 MWth
Gross electrical power	:	1048 MWe
Reference unit power (net)	:	997 MWe

Key Dates

Construction Date	:	2007-11-20
Grid Date	:	2012-01-27
Commercial Date	:	2012-07-31
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	:	180
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

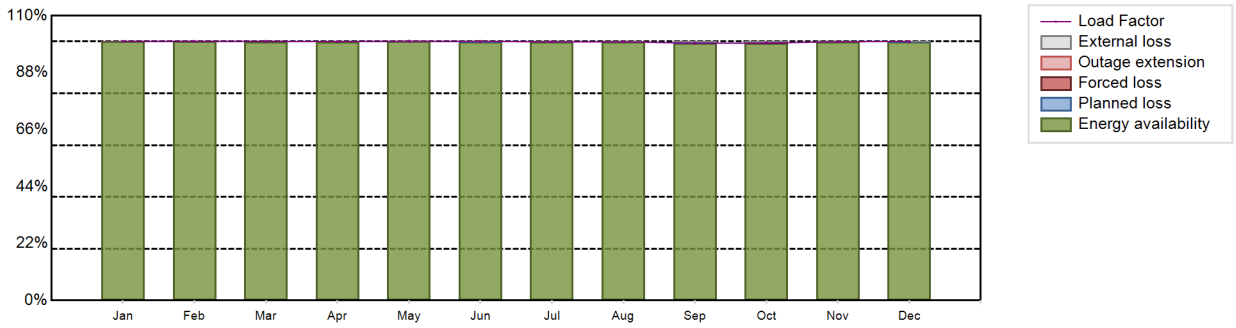
Operating coolant pressure [MPa]	:	17.237
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
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	:	none

Annual Production Results (2020)

Net Energy Production	:	8751.1 GW(e).h
Energy Availability Factor (EAF)	:	99.86 %
Unit Capability Factor (UCF)	:	99.99 %
Load Factor (LF)	:	99.93 %
Operating Factor (OF)	:	100 %

Forced Loss Rate (FLR)	:	0.01 %
Unplanned Capability Loss Factor (UCL)	:	0.01 %
Planned Unavailability Factor (PUF)	:	0.01 %
Externally cause unavailability (XUF)	:	0.13 %
Total off-line time	:	0 hours

Annual Summary



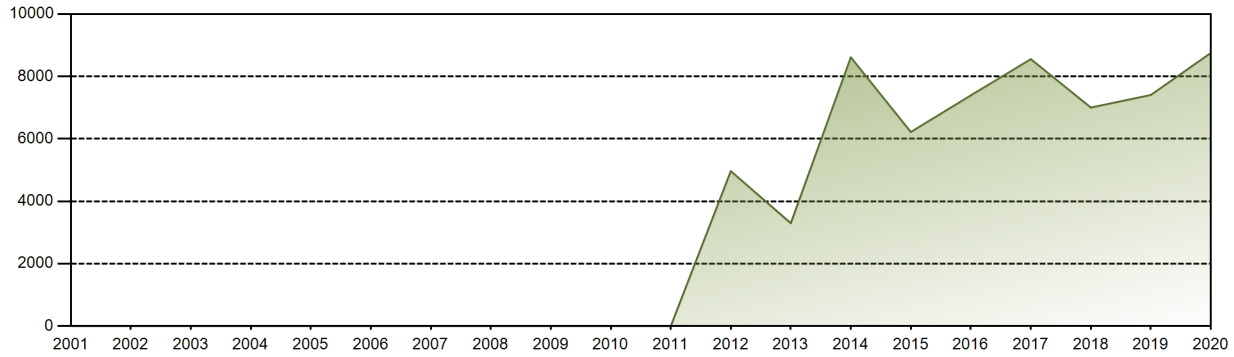
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	742.32	694.52	742.35	717.87	742.71	718.52	741.04	741.28	713.29	737.61	717.56	742.05	8751.10
EAF [%]	99.99	100.00	99.99	99.98	100.00	99.95	99.84	99.87	99.36	99.44	99.93	99.97	99.86
UCF [%]	99.99	100.00	99.99	99.99	100.00	99.99	100.00	100.00	99.98	99.95	100.00	99.98	99.99
LF [%]	100.07	100.09	100.08	100.00	100.13	100.09	99.90	99.93	99.37	99.44	99.96	100.04	99.93
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	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01
UCL [%]	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01
PUF [%]	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.02	0.01
XUF [%]	0.00	0.00	0.00	0.01	0.00	0.04	0.16	0.13	0.62	0.51	0.07	0.02	0.13

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Historical Summary

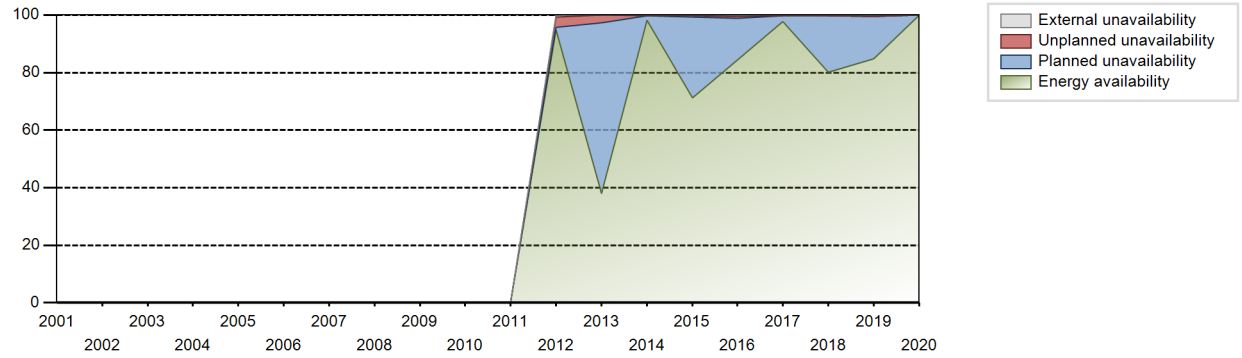
Lifetime energy generation	:	62194.4 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.73 %
Cumulative Energy Availability Factor (EAF)	:	82.46 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.61 %
Cumulative Unit Capability Factor (UCF)	:	82.73 %	Cumulative Planned Unavailability Factor (PUF)	:	16.66 %
Cumulative Load Factor (LF)	:	82.53 %	Cumulative Externally cause unavailability (XUF)	:	0.27 %
Cumulative Operating Factor (OF)	:	83.33 %			

Electricity Production (net) [GWh]

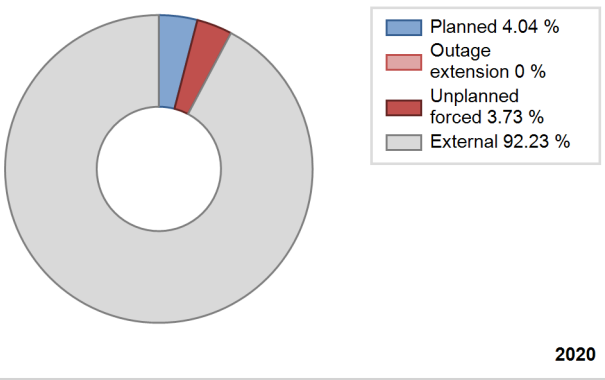


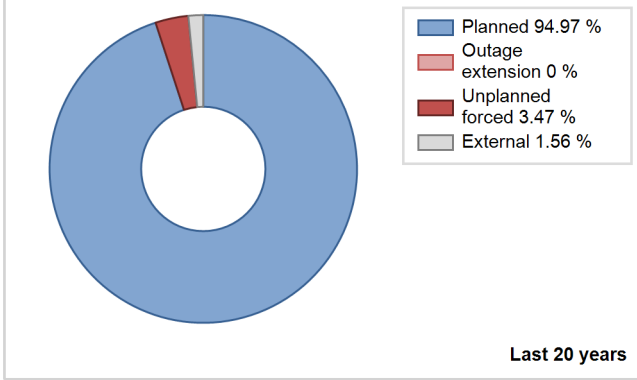
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2012	4964.62	6256	997	94.89	95.60	94.90	97.03	3.56	3.53	0.88	0.70
2013	3295.84	3353	991	37.93	37.94	37.97	38.28	6.51	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2012 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					39	
C. Inspection, maintenance or repair combined with refuelling				1424		
D. Inspection, maintenance or repair without refuelling				214		
Subtotal				1638	39	
Total		**0**			**1677**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2012 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		24
32. Feedwater and Main Steam System		12
Total		**36**

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2020 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	:	1052 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	:	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]	:	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

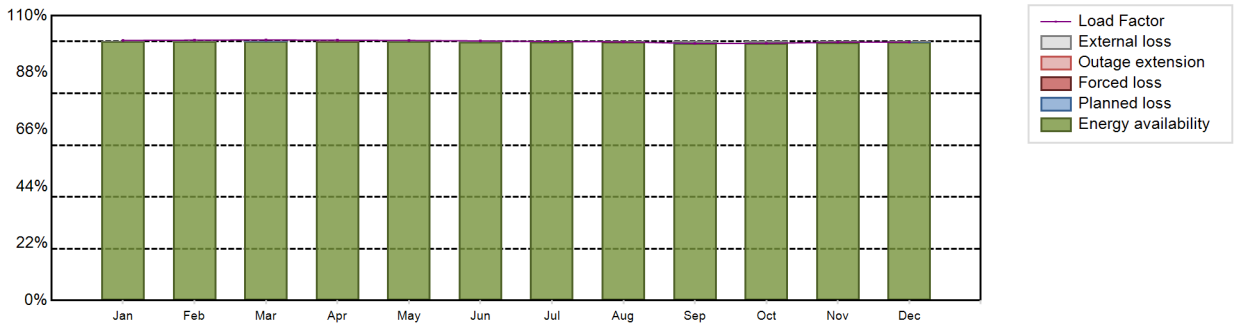
Operating coolant pressure [MPa]	:	17.237
Reactor outlet temperature [°C]	:	327.3
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.39
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
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	:	none

Annual Production Results (2020)

Net Energy Production	:	8729.35 GW(e).h
Energy Availability Factor (EAF)	:	99.82 %
Unit Capability Factor (UCF)	:	99.91 %
Load Factor (LF)	:	100.08 %
Operating Factor (OF)	:	100 %

Forced Loss Rate (FLR)	:	0.08 %
Unplanned Capability Loss Factor (UCL)	:	0.08 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0.09 %
Total off-line time	:	0 hours

Annual Summary



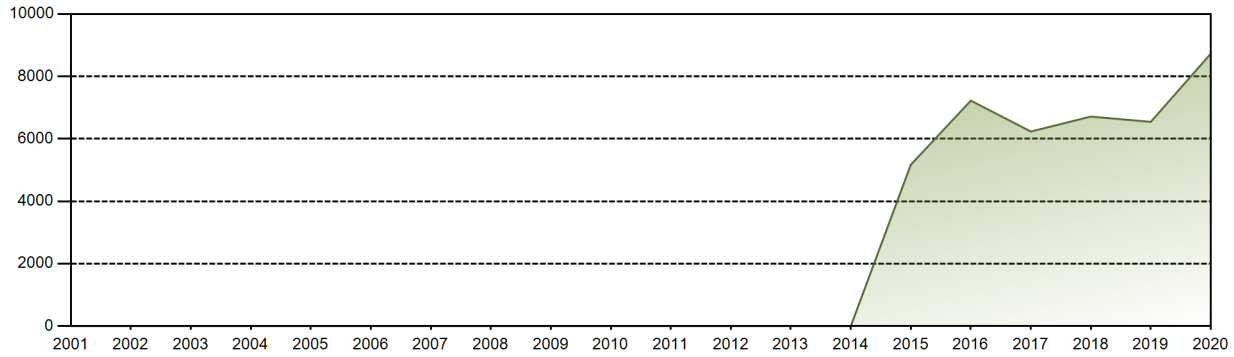
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	742.14	695.09	743.62	718.94	742.04	716.87	738.93	738.02	709.68	733.78	713.09	737.16	8729.35
EAF [%]	100.00	100.00	99.99	100.00	100.00	99.98	99.90	99.84	99.26	99.32	99.74	99.78	99.82
UCF [%]	100.00	100.00	99.99	100.00	100.00	99.99	100.00	99.95	99.63	99.78	99.81	99.78	99.91
LF [%]	100.45	100.57	100.65	100.56	100.44	100.27	100.02	99.90	99.26	99.32	99.74	99.78	100.08
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	0.05	0.35	0.22	0.19	0.21	0.08
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.35	0.22	0.19	0.21	0.08
PUF [%]	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01	0.00
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.01	0.10	0.11	0.37	0.46	0.07	0.00	0.09

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Historical Summary

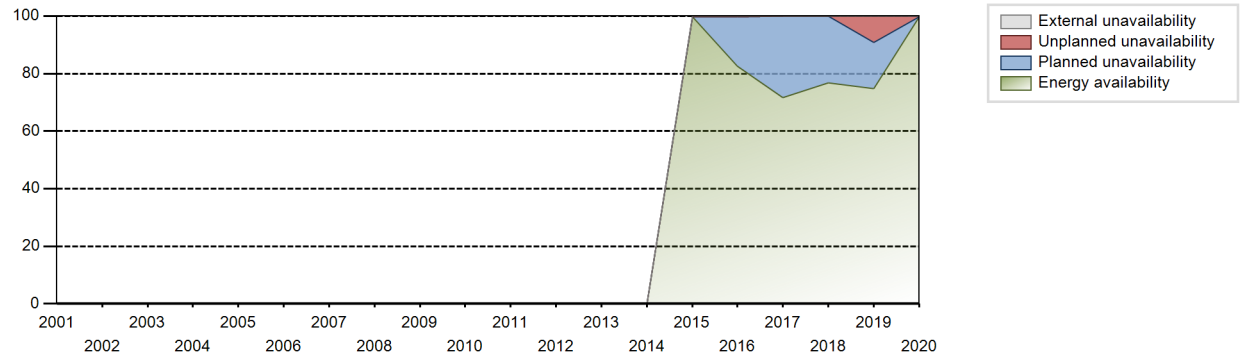
Lifetime energy generation	:	40614.25 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.04 %
Cumulative Energy Availability Factor (EAF)	:	82.59 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.72 %
Cumulative Unit Capability Factor (UCF)	:	82.69 %	Cumulative Planned Unavailability Factor (PUF)	:	15.59 %
Cumulative Load Factor (LF)	:	82.85 %	Cumulative Externally cause unavailability (XUF)	:	0.11 %
Cumulative Operating Factor (OF)	:	83.1 %			

Electricity Production (net) [GWh]

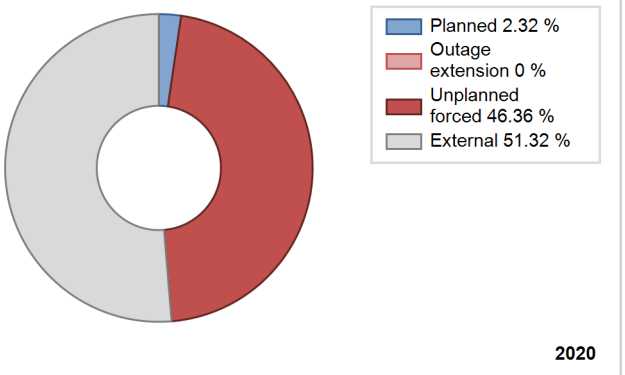


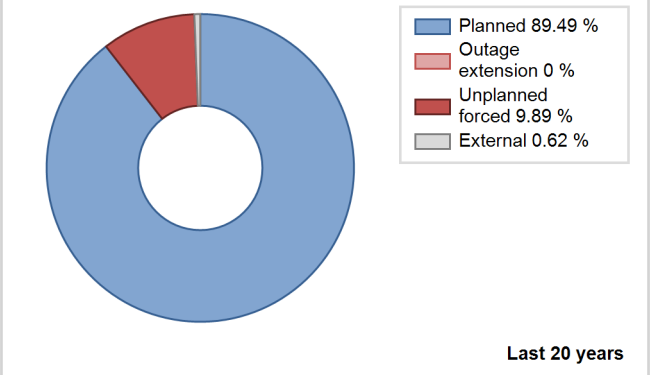
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2015	5169.24	5821	993	99.83	99.98	100.03	100.00	0.01	0.01	0.00	0.15
2016	7223.89	7328	993	82.55	82.78	82.82	83.42	0.03	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2015 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					143	
C. Inspection, maintenance or repair combined with refuelling				1342		
D. Inspection, maintenance or repair without refuelling				299		
Subtotal				1641	143	
Total		**0**			**1784**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2015 to 2020 Average hours lost per reactor-year
32. Feedwater and Main Steam System		131
Total		**131**

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2020 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	:	605 MWe
Reference unit power (net)	:	596 MWe

Key Dates

Construction Date	:	1992-09-25
Grid Date	:	1997-04-01
Commercial Date	:	1997-07-01
Age at end of year	:	23 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

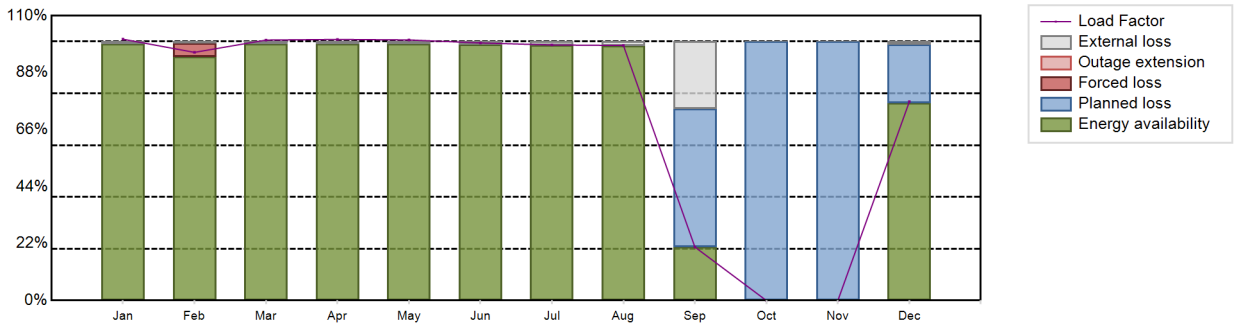
Operating coolant pressure [MPa]	:	10.5
Reactor outlet temperature [°C]	:	310
Number of SG	:	4
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.12
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	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	:	none

Annual Production Results (2020)

Net Energy Production	:	3900.78 GW(e).h
Energy Availability Factor (EAF)	:	73.73 %
Unit Capability Factor (UCF)	:	76.64 %
Load Factor (LF)	:	74.51 %
Operating Factor (OF)	:	74.66 %

Forced Loss Rate (FLR)	:	0.52 %
Unplanned Capability Loss Factor (UCL)	:	0.4 %
Planned Unavailability Factor (PUF)	:	22.95 %
Externally cause unavailability (XUF)	:	2.91 %
Total off-line time	:	2226 hours

Annual Summary



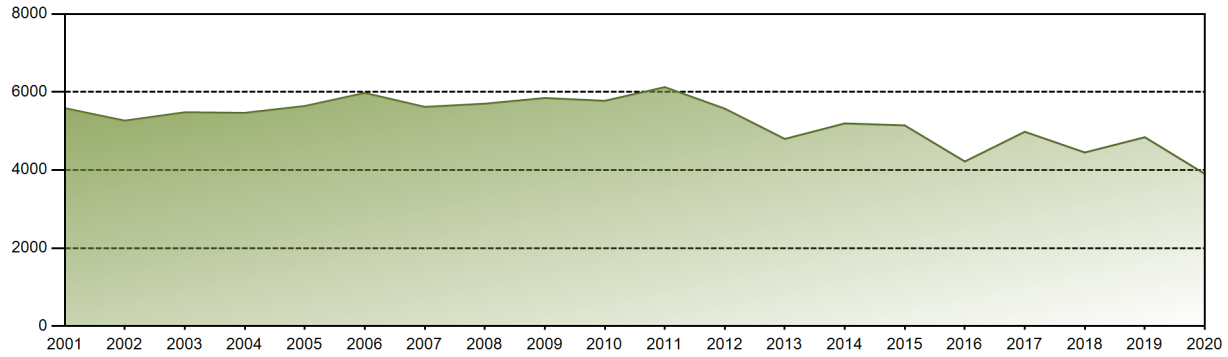
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	447.52	397.59	446.05	432.77	446.32	426.87	437.62	436.79	88.64	0.00	0.00	340.61	3900.78
EAF [%]	99.12	94.22	99.03	99.21	99.21	98.89	98.58	98.39	20.66	0.00	0.00	76.34	73.73
UCF [%]	100.00	94.94	100.00	100.00	100.00	100.00	100.00	100.00	46.67	0.00	0.00	77.37	76.64
LF [%]	100.92	95.85	100.59	100.85	100.65	99.48	98.69	98.50	20.66	0.00	0.00	76.81	74.51
OF [%]	100.00	95.26	100.00	100.00	100.00	100.00	100.00	100.00	21.25	0.00	0.00	78.23	74.66
FLR [%]	0.00	5.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
UCL [%]	0.00	5.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	53.33	100.00	100.00	22.63	22.95
XUF [%]	0.88	0.72	0.97	0.79	0.79	1.11	1.42	1.61	26.01	0.00	0.00	1.03	2.91

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Historical Summary

Lifetime energy generation	:	125301.1 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.27 %
Cumulative Energy Availability Factor (EAF)	:	89.39 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.25 %
Cumulative Unit Capability Factor (UCF)	:	90.58 %	Cumulative Planned Unavailability Factor (PUF)	:	9.17 %
Cumulative Load Factor (LF)	:	91.27 %	Cumulative Externally cause unavailability (XUF)	:	1.2 %
Cumulative Operating Factor (OF)	:	89.52 %			

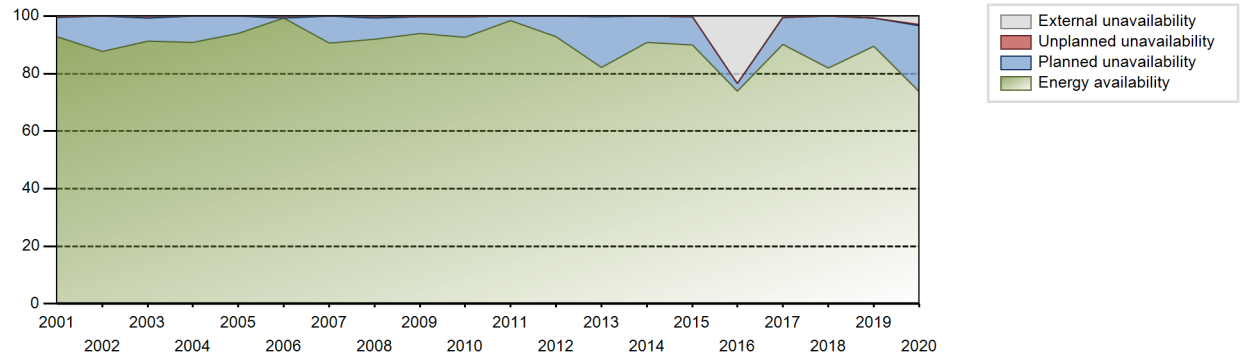
Electricity Production (net) [GWh]



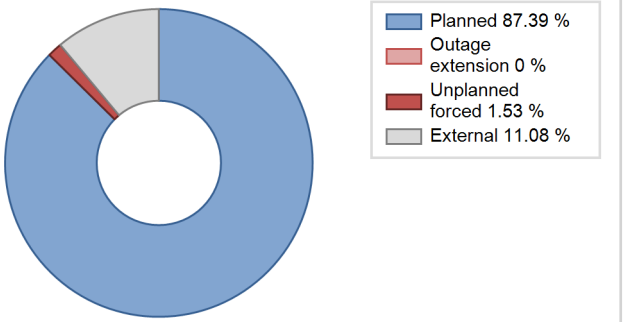
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1997	3294.95	5296	650	94.68	94.68	97.70	95.09	5.20	5.19	0.13	0.00
1998	4788.68	7144	650	81.01	81.02	84.10	81.55	0.00	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

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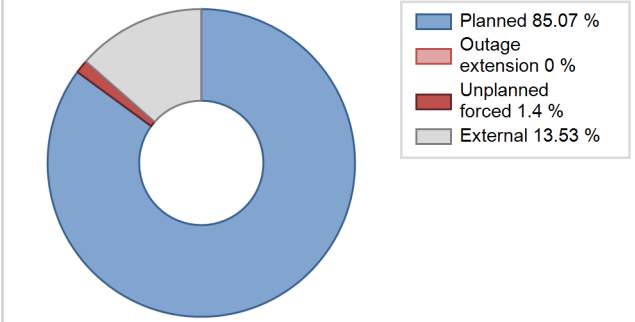
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1997 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		33			14	
C. Inspection, maintenance or repair combined with refuelling				181		
D. Inspection, maintenance or repair without refuelling	2010			624		
J. Grid limitation, failure or grid unavailability						3
L. Human factor related					2	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)			183			95
Subtotal	2010	33	183	805	16	98
Total	**2226**			**919**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1997 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems		2
16. Steam generation systems		2
31. Turbine and auxiliaries	33	3
32. Feedwater and Main Steam System		4
41. Main Generator Systems		2
42. Electrical Power Supply Systems		3
Total	**33**	**19**

Highlights (2020)

Turbine trip(False signal of turbin bearing high vibration, 2020.2.1~2020.2.2)
Turbine trip(transformer CT failure by typhoon Haishen, 2020.9.7~2020.9.14)
19th Overhaul(2020.9.15~2020.12.7)

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2020 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

Reactor type and model	:	PHWR / CANDU 6
Thermal power	:	2061 MWth
Gross electrical power	:	630 MWe
Reference unit power (net)	:	627 MWe

Key Dates

Construction Date	:	1994-03-17
Grid Date	:	1998-03-25
Commercial Date	:	1998-07-01
Age at end of year	:	22 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]	:	15
Part of the core refuelled [%]	:	96
Average discharge burnup [MWd/t]	:	7296
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

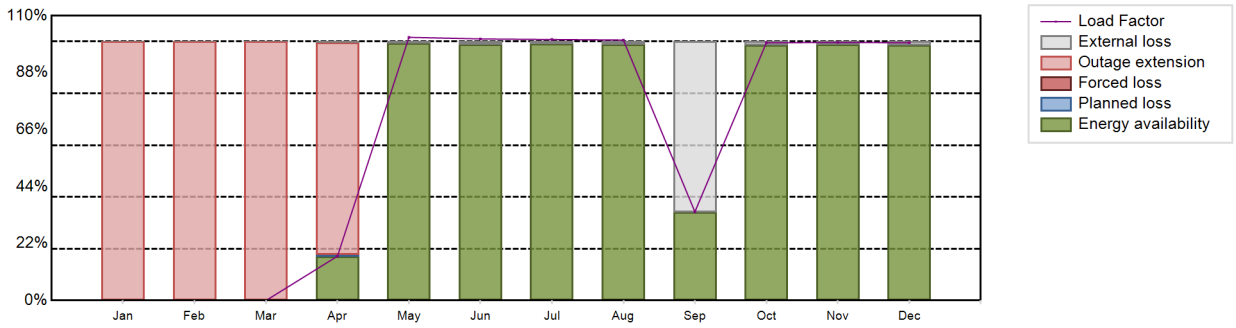
Operating coolant pressure [MPa]	:	10.5
Reactor outlet temperature [°C]	:	310
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.12
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	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	:	none

Annual Production Results (2020)

Net Energy Production	:	3480.85 GW(e).h
Energy Availability Factor (EAF)	:	62.27 %
Unit Capability Factor (UCF)	:	68.35 %
Load Factor (LF)	:	63.2 %
Operating Factor (OF)	:	63.09 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	31.58 %
Planned Unavailability Factor (PUF)	:	0.07 %
Externally cause unavailability (XUF)	:	6.08 %
Total off-line time	:	3242 hours

Annual Summary



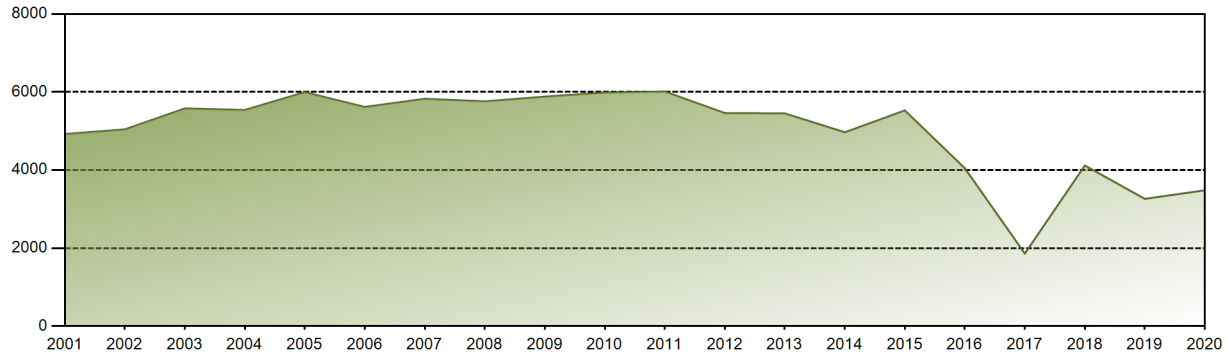
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	77.29	474.23	456.08	470.29	469.32	154.70	464.41	450.00	464.54	3480.85
EAF [%]	0.00	0.00	0.00	16.88	99.25	98.95	99.02	98.94	34.03	98.73	98.75	98.64	62.27
UCF [%]	0.00	0.00	0.00	17.16	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	68.35
LF [%]	0.00	0.00	0.00	17.12	101.66	101.03	100.82	100.61	34.27	99.55	99.68	99.58	63.20
OF [%]	0.00	0.00	0.00	17.92	100.00	100.00	100.00	100.00	35.14	100.00	100.00	100.00	63.09
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 [%]	100.00	100.00	100.00	81.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.58
PUF [%]	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
XUF [%]	0.00	0.00	0.00	0.28	0.75	1.05	0.98	1.06	65.97	1.27	1.25	1.36	6.08

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Historical Summary

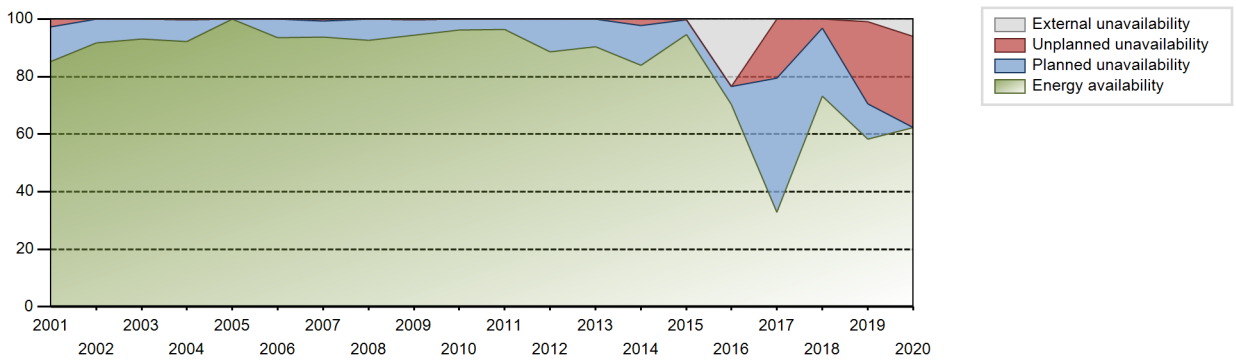
Lifetime energy generation	:	115865.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.02 %
Cumulative Energy Availability Factor (EAF)	:	85.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.89 %
Cumulative Unit Capability Factor (UCF)	:	86.64 %	Cumulative Planned Unavailability Factor (PUF)	:	9.47 %
Cumulative Load Factor (LF)	:	86.75 %	Cumulative Externally cause unavailability (XUF)	:	1.35 %
Cumulative Operating Factor (OF)	:	85.21 %			

Electricity Production (net) [GWh]



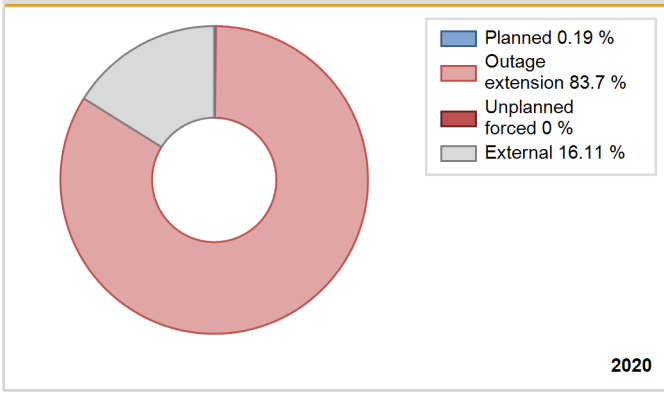
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1998	3460.26	5326	650	96.11	96.11	98.89	96.38	3.88	3.88	0.01	0.00
1999	4696.65	7008	650	80.23	80.24	82.48	80.00	0.00	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

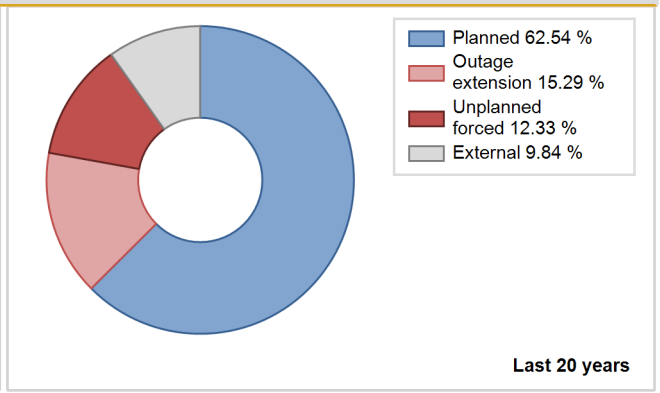
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1998 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		2775			355	
C. Inspection, maintenance or repair combined with refuelling				224		
D. Inspection, maintenance or repair without refuelling				622		
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.)			467			115
Subtotal		2775	467	846	355	116
Total		**3242**			**1317**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1998 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		9
14. Safety Systems		94
15. Reactor Cooling Systems		40
16. Steam generation systems	2775	200
21. Fuel Handling and Storage Facilities		2
35. All other I&C Systems		11
Total	**2775**	**356**

Highlights (2020)

Inspection and Maintenance(2019.09.10 ~ 2020.04.25)
Turbine trip due to main transformer CT failure by typhoon Haishen(2020.09.07 ~ 2020.09.26)

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2020 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

Reactor type and model	:	PHWR / CANDU 6
Thermal power	:	2061 MWth
Gross electrical power	:	597 MWe
Reference unit power (net)	:	600 MWe

Key Dates

Construction Date	:	1994-07-22
Grid Date	:	1999-05-21
Commercial Date	:	1999-10-01
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]	:	15
Part of the core refuelled [%]	:	96
Average discharge burnup [MWd/t]	:	7296
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

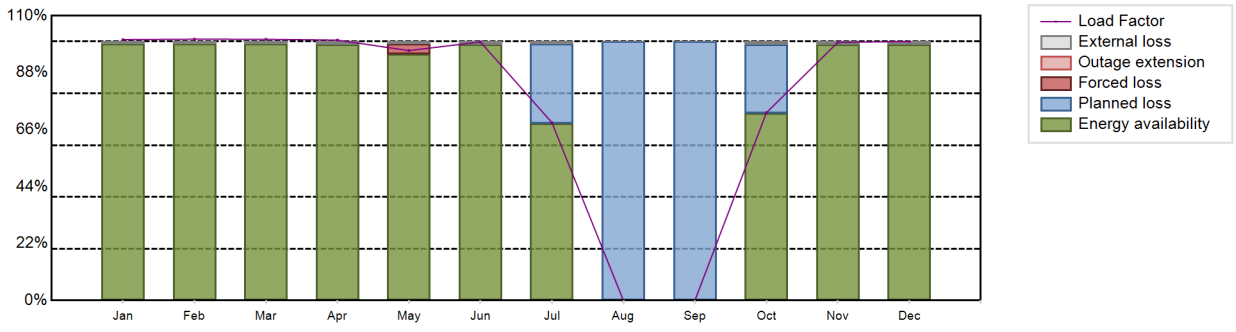
Operating coolant pressure [MPa]	:	10.5
Reactor outlet temperature [°C]	:	310
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.12
Secondary systems		
Number of turbine-generators per unit/reactor	:	4
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	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	:	none

Annual Production Results (2020)

Net Energy Production	:	4126.51 GW(e).h
Energy Availability Factor (EAF)	:	77.26 %
Unit Capability Factor (UCF)	:	78.12 %
Load Factor (LF)	:	78.3 %
Operating Factor (OF)	:	78.23 %

Forced Loss Rate (FLR)	:	0.45 %
Unplanned Capability Loss Factor (UCL)	:	0.35 %
Planned Unavailability Factor (PUF)	:	21.53 %
Externally cause unavailability (XUF)	:	0.85 %
Total off-line time	:	1912 hours

Annual Summary



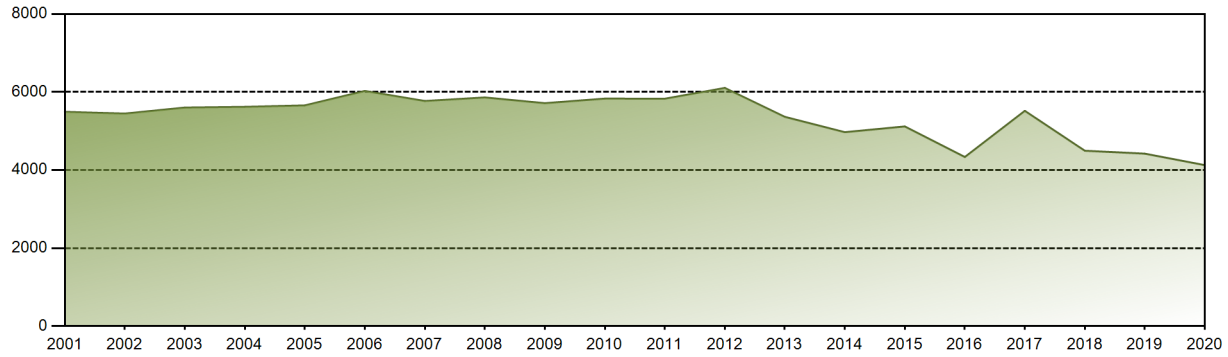
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	449.91	421.54	450.48	434.44	430.90	431.45	306.66	0.00	0.00	323.76	430.84	446.53	4126.51
EAF [%]	99.02	99.04	99.07	98.92	95.05	98.80	68.24	0.00	0.00	72.32	98.87	98.84	77.26
UCF [%]	100.00	100.00	100.00	100.00	95.86	100.00	69.07	0.00	0.00	73.47	100.00	100.00	78.12
LF [%]	100.79	100.94	100.91	100.57	96.53	99.87	68.70	0.00	0.00	72.53	99.73	100.03	78.30
OF [%]	100.00	100.00	100.00	100.00	96.24	100.00	69.22	0.00	0.00	74.33	100.00	100.00	78.23
FLR [%]	0.00	0.00	0.00	0.00	4.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
UCL [%]	0.00	0.00	0.00	0.00	4.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	30.93	100.00	100.00	26.53	0.00	0.00	21.53
XUF [%]	0.98	0.96	0.93	1.08	0.82	1.20	0.83	0.00	0.00	1.15	1.13	1.16	0.85

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Historical Summary

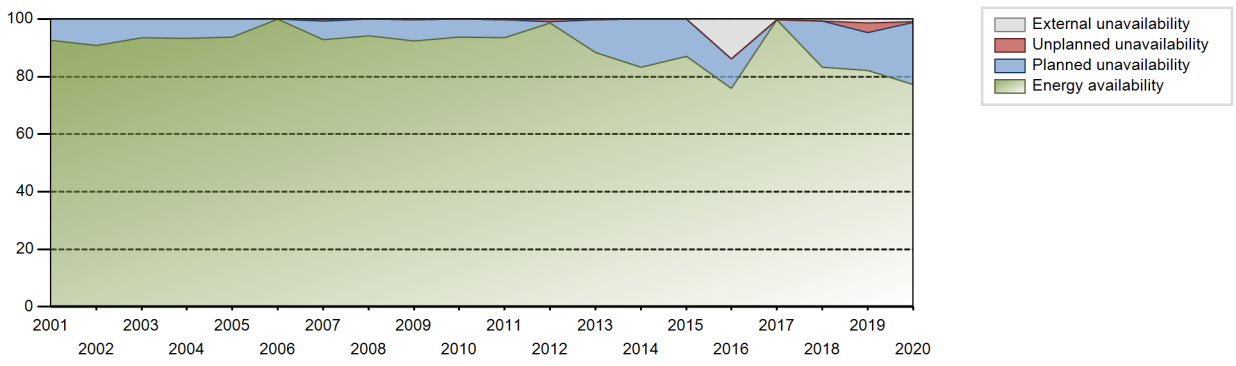
Lifetime energy generation	:	116709.69 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.12 %
Cumulative Energy Availability Factor (EAF)	:	90.61 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.26 %
Cumulative Unit Capability Factor (UCF)	:	91.43 %	Cumulative Planned Unavailability Factor (PUF)	:	8.32 %
Cumulative Load Factor (LF)	:	92.37 %	Cumulative Externally cause unavailability (XUF)	:	0.82 %
Cumulative Operating Factor (OF)	:	90.78 %			

Electricity Production (net) [GWh]



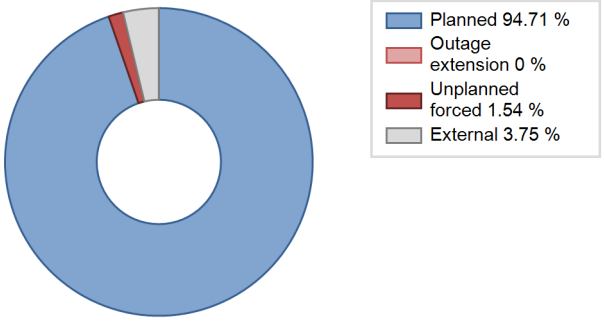
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1999	1489.23	2208	650	99.89	99.89	103.76	100.00	0.00	0.00	0.11	0.00
2000	5423.32	8033	650	91.36	91.36	94.99	91.45	0.10	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

Key Factors in Last 20 Years [%]

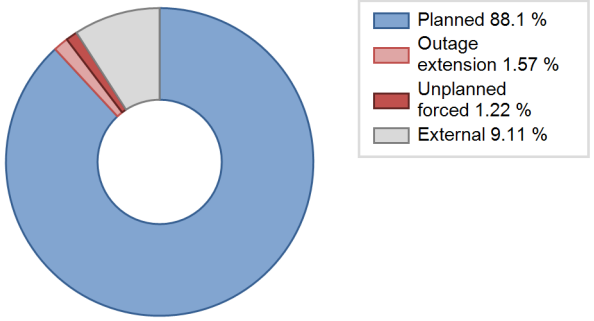


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1999 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		28			22	
C. Inspection, maintenance or repair combined with refuelling				93		
D. Inspection, maintenance or repair without refuelling	1884			642		
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.)						56
Subtotal	1884	28		735	22	58
Total	**1912**			**815**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1999 to 2020 Average hours lost per reactor-year
13. Reactor Auxiliary Systems		2
15. Reactor Cooling Systems		14
16. Steam generation systems		1
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries		0
41. Main Generator Systems	28	1
42. Electrical Power Supply Systems		2
Total	**28**	**24**

Highlights (2020)

Inspection and Maintenance(2020.07.22 ~ 2020.10.08)
Turbine trip due to exciter's control PCB failure(2020.05.07 ~ 2020.05.08)

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2020 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

Reactor type and model	:	BWR / BWR-5
Thermal power	:	2317 MWth
Gross electrical power	:	805 MWe
Reference unit power (net)	:	777 MWe

Key Dates

Construction Date	:	1976-10-01
Grid Date	:	1989-04-13
Commercial Date	:	1990-07-29
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]	:	3.81
Refuelling frequency [month]	:	17.5
Part of the core refuelled [%]	:	28.83
Average discharge burnup [MWd/t]	:	42635.75
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

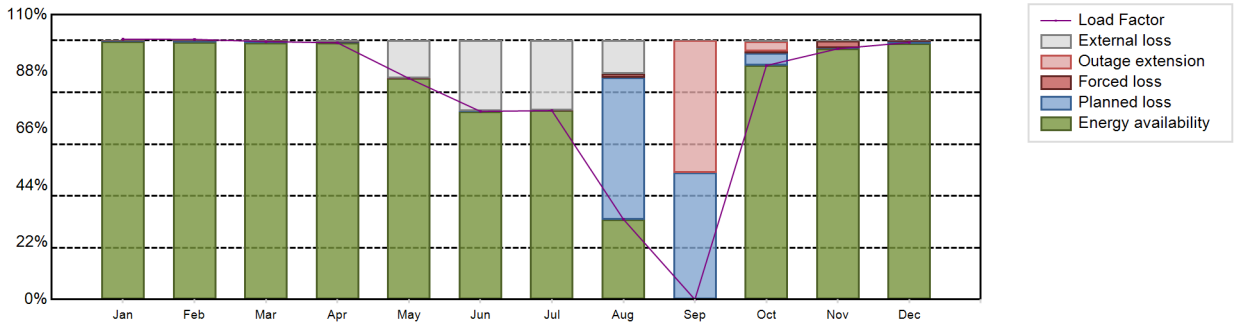
Operating coolant pressure [MPa]	:	7.2
Reactor outlet temperature [°C]	:	278
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.31
Secondary systems		
Number of turbine-generators per unit/reactor	:	3
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	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 (2020)

Net Energy Production	:	5394.16 GW(e).h
Energy Availability Factor (EAF)	:	78.8 %
Unit Capability Factor (UCF)	:	85.69 %
Load Factor (LF)	:	79.03 %
Operating Factor (OF)	:	86.85 %

Forced Loss Rate (FLR)	:	0.57 %
Unplanned Capability Loss Factor (UCL)	:	4.99 %
Planned Unavailability Factor (PUF)	:	9.32 %
Externally cause unavailability (XUF)	:	6.88 %
Total off-line time	:	1155 hours

Annual Summary



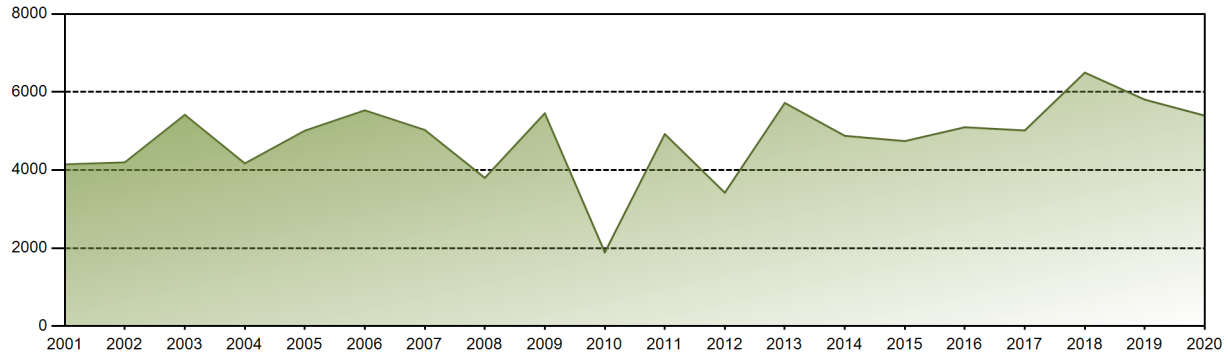
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	581.25	543.30	575.85	553.90	493.65	406.49	421.72	179.19	0.00	523.09	541.77	573.96	5394.16
EAF [%]	99.65	99.36	99.14	99.15	85.39	72.66	72.95	31.00	0.00	90.50	96.84	98.83	78.80
UCF [%]	99.65	99.36	99.14	99.46	99.88	99.95	99.82	43.79	0.00	90.85	96.89	98.83	85.69
LF [%]	100.55	100.46	99.61	99.15	85.39	72.66	72.95	31.00	0.00	90.36	96.84	99.29	79.03
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	45.43	0.00	96.11	100.00	100.00	86.85
FLR [%]	0.00	0.23	0.05	0.21	0.07	0.00	0.06	3.21	0.00	0.89	2.76	0.29	0.57
UCL [%]	0.00	0.23	0.05	0.21	0.07	0.00	0.06	1.45	51.00	4.59	2.75	0.29	4.99
PUF [%]	0.34	0.41	0.81	0.32	0.05	0.05	0.12	54.76	49.00	4.56	0.35	0.88	9.32
XUF [%]	0.00	0.00	0.00	0.31	14.49	27.29	26.87	12.79	0.00	0.35	0.05	0.00	6.88

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Historical Summary

Lifetime energy generation	:	141120.32 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.61 %
Cumulative Energy Availability Factor (EAF)	:	80.04 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.48 %
Cumulative Unit Capability Factor (UCF)	:	81.35 %	Cumulative Planned Unavailability Factor (PUF)	:	10.17 %
Cumulative Load Factor (LF)	:	77.91 %	Cumulative Externally cause unavailability (XUF)	:	1.31 %
Cumulative Operating Factor (OF)	:	83.54 %			

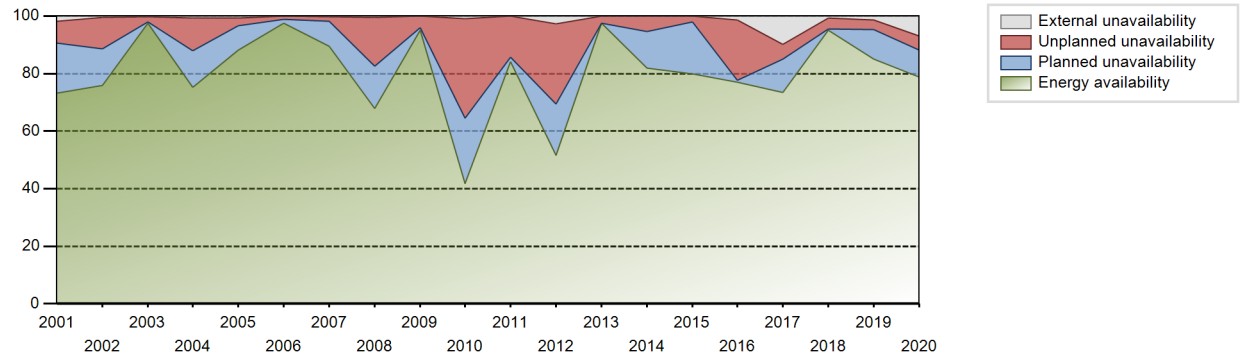
Electricity Production (net) [GWh]



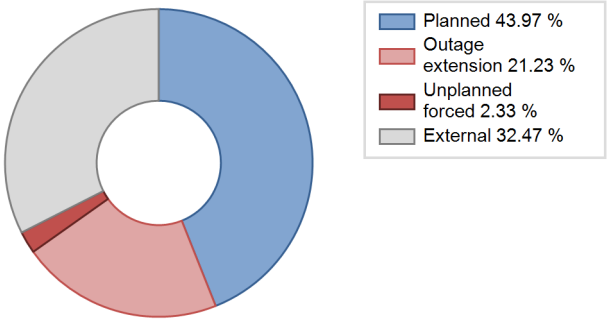
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	2775.82	5370	640	87.58	87.58	86.55	96.68	11.65	11.55	0.87	0.00
1991	4062.09	7022	640	74.45	74.45	72.45	80.16	2.12	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

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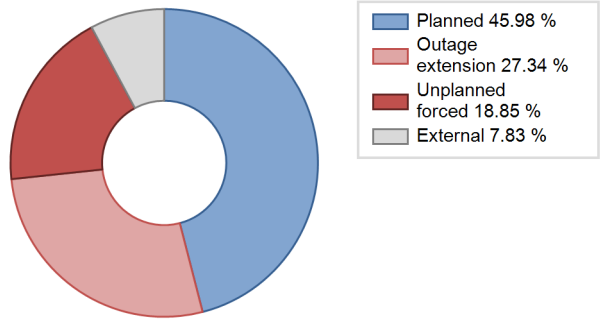
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			1990 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		395			520	
B. Refuelling without maintenance				23		
C. Inspection, maintenance or repair combined with refuelling	758			723	18	
D. Inspection, maintenance or repair without refuelling				161		
E. Testing of plant systems or components				69	5	
J. Grid limitation, failure or grid unavailability						31
L. Human factor related					87	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						2
Z. Other					35	
Subtotal	758	395		976	665	33
Total	**1153**			**1674**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1990 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		10
12. Reactor I&C Systems		71
13. Reactor Auxiliary Systems		44
14. Safety Systems		5
15. Reactor Cooling Systems		24
17. Safety I&C Systems (excluding reactor I&C)		3
21. Fuel Handling and Storage Facilities		74
31. Turbine and auxiliaries	395	94
32. Feedwater and Main Steam System		73
33. Circulating Water System		1
35. All other I&C Systems		21
41. Main Generator Systems		17
42. Electrical Power Supply Systems		170
Total	**395**	**607**

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2020 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	:	26 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

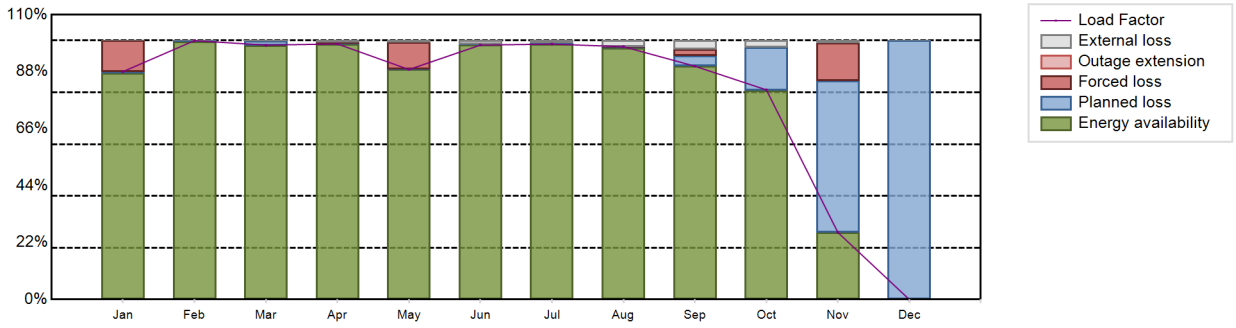
Operating coolant pressure [MPa]	:	7.2
Reactor outlet temperature [°C]	:	278
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.31
Secondary systems		
Number of turbine-generators per unit/reactor	:	3
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	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 (2020)

Net Energy Production	:	5470.11 GW(e).h
Energy Availability Factor (EAF)	:	80.23 %
Unit Capability Factor (UCF)	:	81.31 %
Load Factor (LF)	:	80.36 %
Operating Factor (OF)	:	84.65 %

Forced Loss Rate (FLR)	:	3.99 %
Unplanned Capability Loss Factor (UCL)	:	3.38 %
Planned Unavailability Factor (PUF)	:	15.31 %
Externally cause unavailability (XUF)	:	1.08 %
Total off-line time	:	1348 hours

Annual Summary



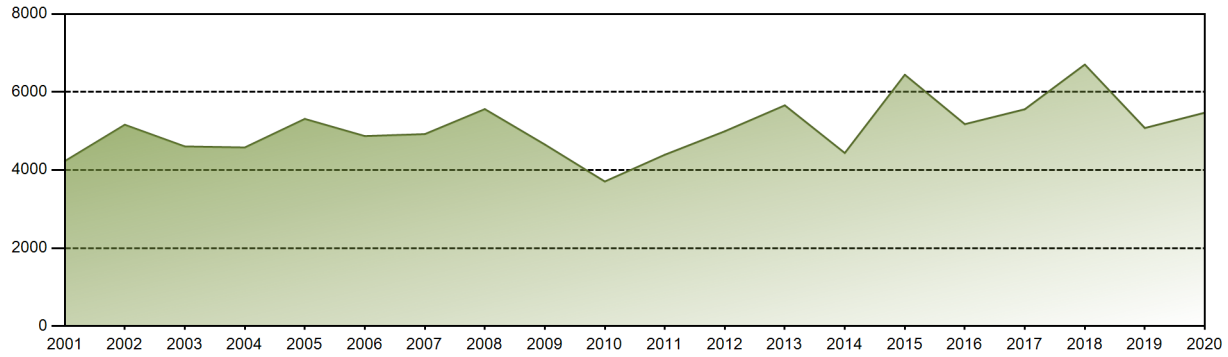
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	507.52	539.31	566.45	550.03	512.23	548.31	568.80	563.08	502.85	466.88	144.64	0.00	5470.11
EAF [%]	87.57	99.52	98.24	98.71	88.84	98.26	98.65	97.12	90.12	80.84	25.92	0.00	80.23
UCF [%]	87.57	99.52	98.31	99.32	89.49	99.64	99.60	99.47	93.54	83.55	26.73	0.00	81.31
LF [%]	88.02	99.98	98.24	98.71	88.84	98.26	98.65	97.66	90.12	80.97	25.92	0.00	80.36
OF [%]	89.92	100.00	100.00	100.00	91.67	100.00	100.00	100.00	100.00	100.00	35.14	0.00	84.65
FLR [%]	12.12	0.00	0.00	0.51	10.42	0.00	0.00	0.20	2.50	0.00	35.69	0.00	3.99
UCL [%]	12.08	0.00	0.00	0.51	10.41	0.00	0.00	0.20	2.40	0.00	14.83	0.00	3.38
PUF [%]	0.35	0.48	1.69	0.17	0.10	0.36	0.40	0.33	4.06	16.45	58.44	100.00	15.31
XUF [%]	0.00	0.00	0.07	0.61	0.65	1.38	0.95	2.34	3.42	2.71	0.81	0.00	1.08

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Historical Summary

Lifetime energy generation	:	126629.62 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.35 %
Cumulative Energy Availability Factor (EAF)	:	83.08 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.22 %
Cumulative Unit Capability Factor (UCF)	:	84.07 %	Cumulative Planned Unavailability Factor (PUF)	:	10.71 %
Cumulative Load Factor (LF)	:	81.15 %	Cumulative Externally cause unavailability (XUF)	:	1 %
Cumulative Operating Factor (OF)	:	86.46 %			

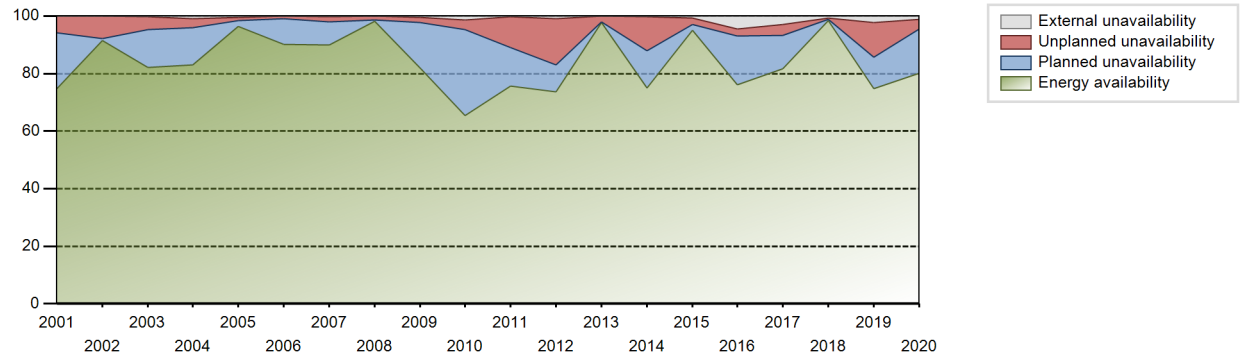
Electricity Production (net) [GWh]



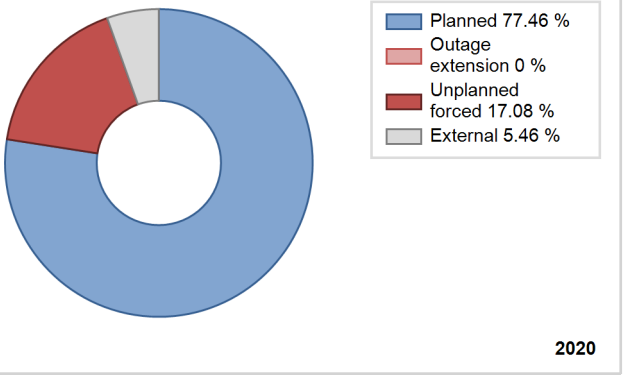
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1995	3379.40	5687	628	84.48	85.92	84.48	89.28	7.13	6.59	7.49	1.44
1996	3668.41	6657	619	70.97	71.67	67.47	75.79	3.52	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

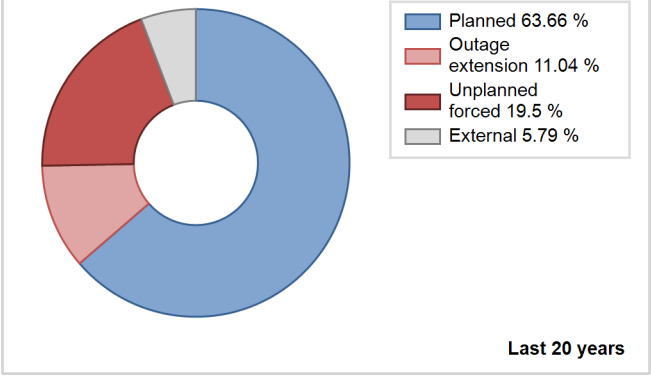
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1995 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		221			294	
B. Refuelling without maintenance				25		
C. Inspection, maintenance or repair combined with refuelling	1128			738		
D. Inspection, maintenance or repair without refuelling				23		
E. Testing of plant systems or components				35		
J. Grid limitation, failure or grid unavailability						4
L. Human factor related					2	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						6
Z. Other					47	
Subtotal	1128	221		821	343	10
Total	**1349**			**1174**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1995 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		7
12. Reactor I&C Systems	221	27
13. Reactor Auxiliary Systems		7
14. Safety Systems		2
15. Reactor Cooling Systems		4
16. Steam generation systems		2
21. Fuel Handling and Storage Facilities		18
31. Turbine and auxiliaries		50
32. Feedwater and Main Steam System		32
33. Circulating Water System		12
34. Miscellaneous Systems		3
35. All other I&C Systems		1
41. Main Generator Systems		28
42. Electrical Power Supply Systems		99
Total	**221**	**292**

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2020 Operating Experience

NL-2 BORSSELE NETHERLANDS



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	:	47 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

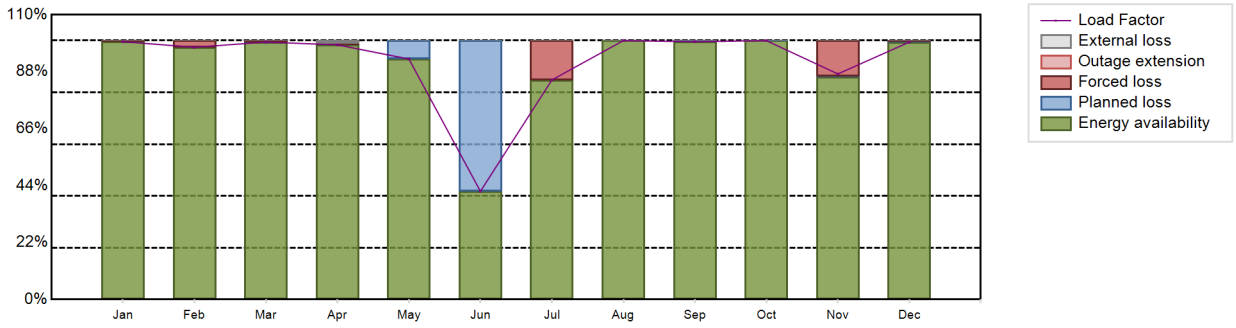
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	313
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.49
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP cylinder 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 (2020)

Net Energy Production	:	3885.68 GW(e).h
Energy Availability Factor (EAF)	:	91.69 %
Unit Capability Factor (UCF)	:	91.79 %
Load Factor (LF)	:	91.78 %
Operating Factor (OF)	:	92.21 %

Forced Loss Rate (FLR)	:	2.93 %
Unplanned Capability Loss Factor (UCL)	:	2.77 %
Planned Unavailability Factor (PUF)	:	5.44 %
Externally cause unavailability (XUF)	:	0.1 %
Total off-line time	:	684 hours

Annual Summary



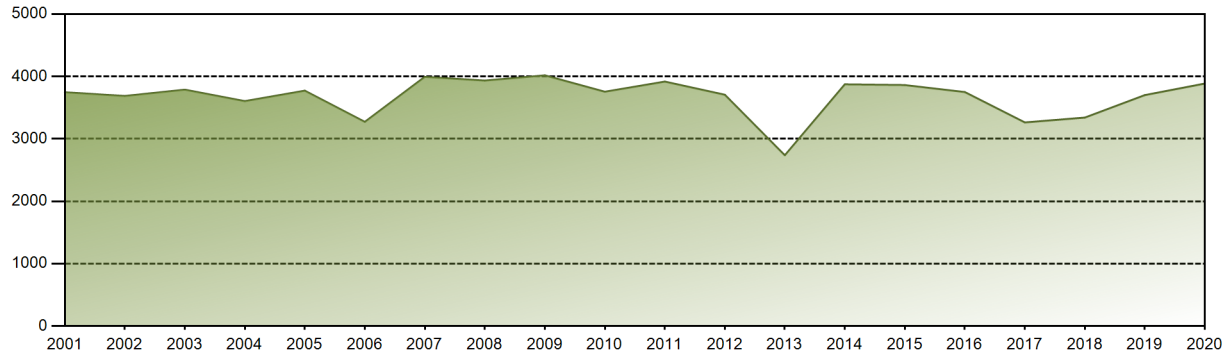
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	357.07	326.83	356.55	341.32	333.06	145.08	304.14	358.61	345.52	358.56	302.38	356.55	3885.68
EAF [%]	99.57	97.42	99.43	98.35	92.88	41.81	84.81	100.00	99.56	99.99	86.06	99.43	91.69
UCF [%]	99.57	97.42	99.43	99.58	92.88	41.81	84.81	100.00	99.56	99.99	86.06	99.43	91.79
LF [%]	99.57	97.42	99.43	98.35	92.88	41.81	84.81	100.00	99.56	99.99	87.13	99.43	91.78
OF [%]	100.00	100.00	100.00	100.00	92.88	41.81	84.81	100.00	100.00	100.00	86.25	100.00	92.21
FLR [%]	0.43	2.58	0.56	0.42	0.00	0.00	15.19	0.00	0.00	0.00	13.78	0.41	2.93
UCL [%]	0.43	2.58	0.56	0.42	0.00	0.00	15.19	0.00	0.00	0.00	13.75	0.41	2.77
PUF [%]	0.00	0.00	0.01	0.00	7.12	58.19	0.00	0.00	0.44	0.01	0.19	0.16	5.44
XUF [%]	0.00	0.00	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10

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Historical Summary

Lifetime energy generation	:	159912.68 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.22 %
Cumulative Energy Availability Factor (EAF)	:	84.83 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.16 %
Cumulative Unit Capability Factor (UCF)	:	85.32 %	Cumulative Planned Unavailability Factor (PUF)	:	10.51 %
Cumulative Load Factor (LF)	:	84.21 %	Cumulative Externally cause unavailability (XUF)	:	0.5 %
Cumulative Operating Factor (OF)	:	86.06 %			

Electricity Production (net) [GWh]

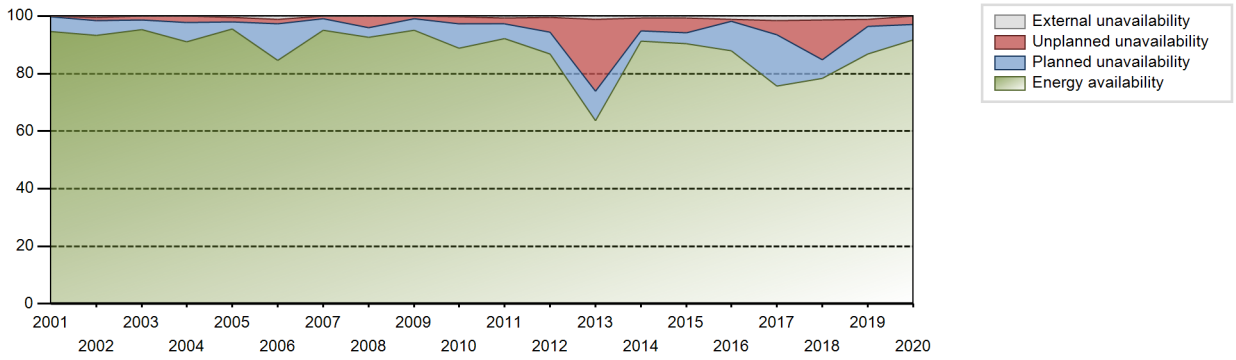


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	665.30	2682	448	47.75	47.75	47.72	71.31	52.25	52.25	0.00	0.00
1974	2993.70	6840	477	71.63	71.63	71.64	78.08	12.52	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	481	87.83	87.83	81.21	88.03	0.78	0.69	11.48	0.00
1990	2885.86	6636	481	75.65	75.65	68.49	75.75	0.01	0.00	24.35	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

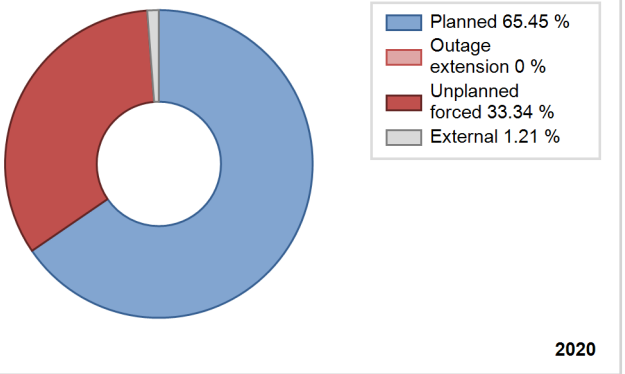
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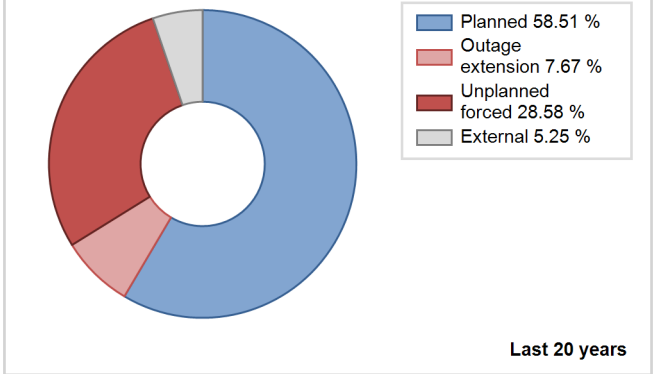
2010	3754.88	7807	482	88.86	89.09	88.93	89.12	1.78	2.55	8.36	0.23
2011	3917.24	8092	482	92.08	92.86	92.77	92.37	1.53	1.89	5.25	0.78
2012	3706.68	7722	482	86.89	87.43	87.55	87.91	5.52	5.10	7.47	0.54
2013	2736.93	5737	482	63.71	64.84	64.81	65.48	26.51	25.02	10.15	1.12
2014	3873.51	8054	482	91.18	91.95	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		212			231	
B.	Refuelling without maintenance				23		
C.	Inspection, maintenance or repair combined with refuelling	472			724	20	
D.	Inspection, maintenance or repair without refuelling				40		
E.	Testing of plant systems or components					19	
F.	Major backfitting, refurbishment or upgrading activities with refuelling				22		
J.	Grid limitation, failure or grid unavailability						2
L.	Human factor related					3	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						4
Z.	Other				14	3	
Subtotal		472	212		823	276	6
Total		**684**			**1105**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		32
13. Reactor Auxiliary Systems		6
14. Safety Systems		28
15. Reactor Cooling Systems		18
16. Steam generation systems	113	31
31. Turbine and auxiliaries		19
32. Feedwater and Main Steam System	99	29
33. Circulating Water System		7
34. Miscellaneous Systems		23
41. Main Generator Systems		43
42. Electrical Power Supply Systems		18
Total	**212**	**256**

Highlights (2020)

none

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2020 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

Reactor type and model	:	PWR / CNP-300
Thermal power	:	999 MWth
Gross electrical power	:	325 MWe
Reference unit power (net)	:	300 MWe

Key Dates

Construction Date	:	1993-08-01
Grid Date	:	2000-06-13
Commercial Date	:	2000-09-15
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]	:	3.4
Refuelling frequency [month]	:	14
Part of the core refuelled [%]	:	33
Average discharge burnup [MWd/t]	:	30000
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

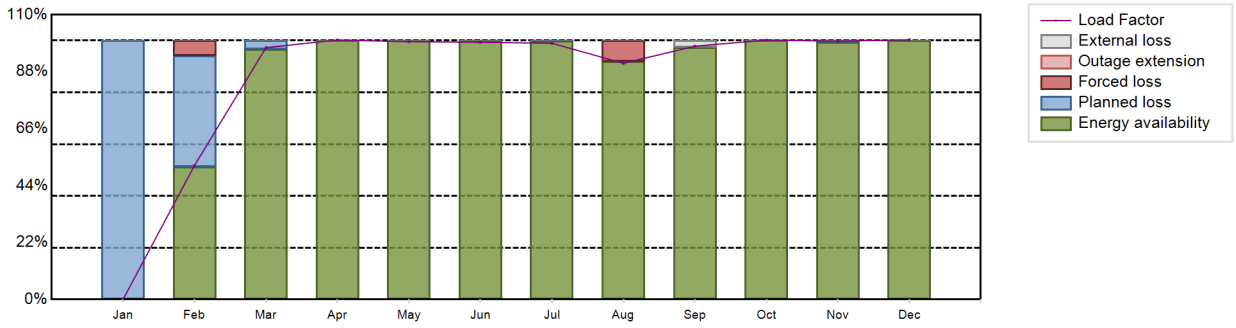
Operating coolant pressure [MPa]	:	15.2
Reactor outlet temperature [°C]	:	315.5
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.26
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
HP 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 (2020)

Net Energy Production	:	2277.56 GW(e).h
Energy Availability Factor (EAF)	:	86.43 %
Unit Capability Factor (UCF)	:	86.65 %
Load Factor (LF)	:	86.43 %
Operating Factor (OF)	:	87.45 %

Forced Loss Rate (FLR)	:	1.31 %
Unplanned Capability Loss Factor (UCL)	:	1.15 %
Planned Unavailability Factor (PUF)	:	12.2 %
Externally cause unavailability (XUF)	:	0.22 %
Total off-line time	:	1102 hours

Annual Summary



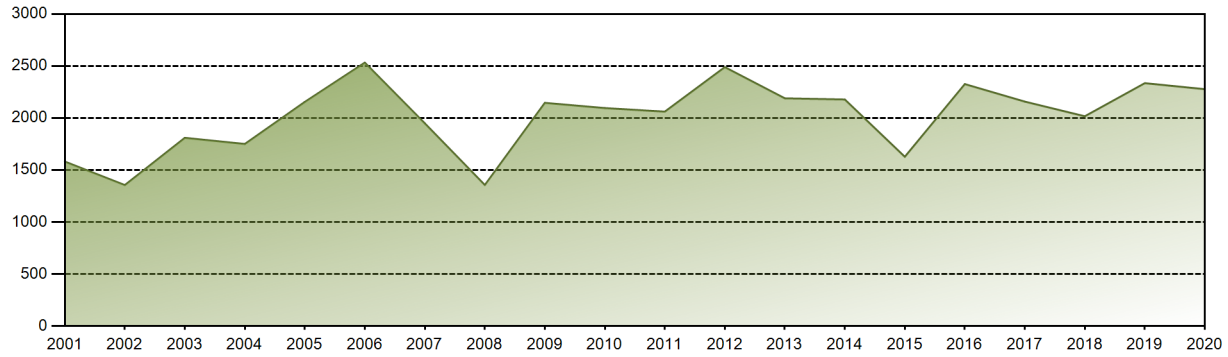
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	108.09	217.12	216.51	222.25	214.62	220.91	203.63	211.32	223.65	215.56	223.91	2277.56
EAF [%]	0.00	51.30	96.74	100.00	100.00	100.00	99.74	91.96	97.37	100.00	99.46	100.00	86.43
UCF [%]	0.00	51.30	96.74	100.00	100.00	100.00	99.74	91.96	100.00	100.00	99.46	100.00	86.65
LF [%]	0.00	51.77	97.28	100.23	99.57	99.36	98.97	91.23	97.83	100.20	99.80	100.32	86.43
OF [%]	0.00	56.47	100.00	100.00	100.00	100.00	100.00	92.61	100.00	100.00	100.00	100.00	87.45
FLR [%]	0.00	10.31	0.00	0.00	0.00	0.00	0.00	8.04	0.00	0.00	0.00	0.00	1.31
UCL [%]	0.00	5.90	0.00	0.00	0.00	0.00	0.00	8.04	0.00	0.00	0.00	0.00	1.15
PUF [%]	100.00	42.80	3.26	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.54	0.00	12.20
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.63	0.00	0.00	0.00	0.22

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Historical Summary

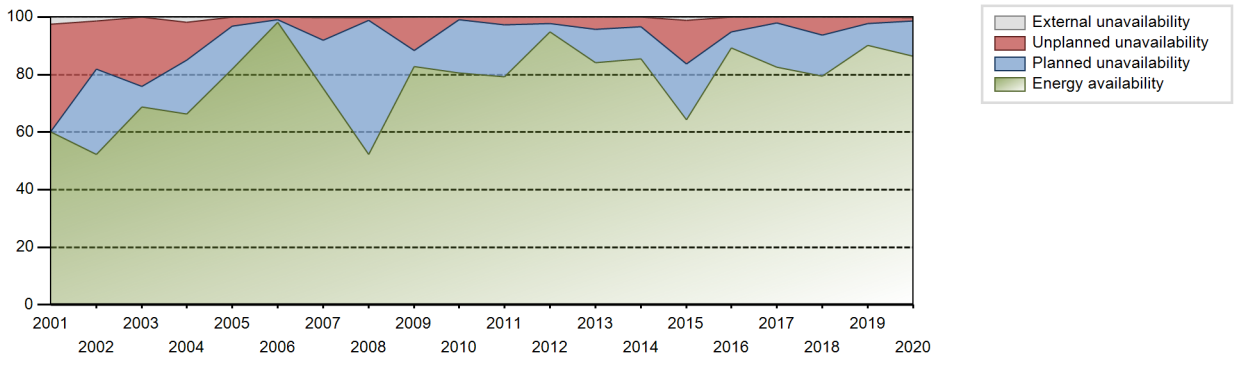
Lifetime energy generation	:	41135.46 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.24 %
Cumulative Energy Availability Factor (EAF)	:	77.64 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.2 %
Cumulative Unit Capability Factor (UCF)	:	78.02 %	Cumulative Planned Unavailability Factor (PUF)	:	13.78 %
Cumulative Load Factor (LF)	:	76.68 %	Cumulative Externally cause unavailability (XUF)	:	0.38 %
Cumulative Operating Factor (OF)	:	79.7 %			

Electricity Production (net) [GWh]



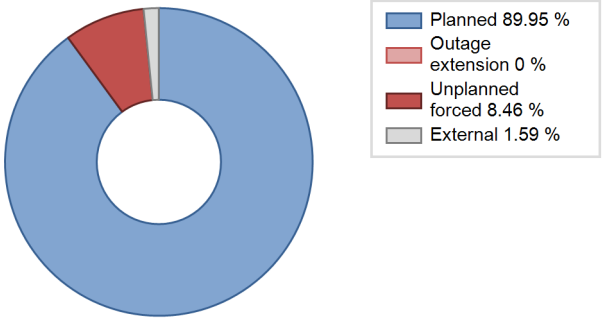
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2000	529.15	1860	300	72.19	72.19	68.69	72.43	19.54	17.53	10.28	0.00
2001	1581.75	5918	300	60.06	62.44	60.19	67.56	37.40	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

Key Factors in Last 20 Years [%]

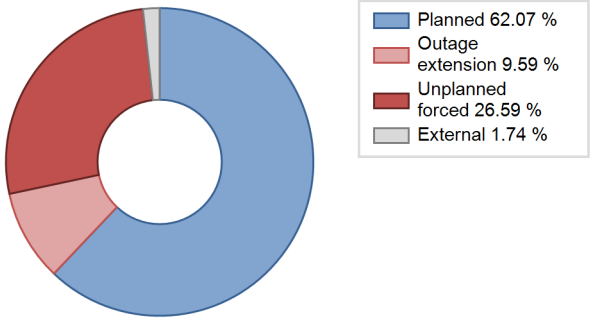


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2000 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		68			529	
C. Inspection, maintenance or repair combined with refuelling	1034			1042	7	
D. Inspection, maintenance or repair without refuelling				67		
E. Testing of plant systems or components				4	1	
J. Grid limitation, failure or grid unavailability						94
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						15
L. Human factor related					5	
P. Fire					6	
Z. Other					23	
Subtotal	1034	68		1113	571	109
Total	**1102**			**1793**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2000 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		44
12. Reactor I&C Systems		27
13. Reactor Auxiliary Systems		8
14. Safety Systems		41
15. Reactor Cooling Systems		124
16. Steam generation systems		7
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries	68	137
32. Feedwater and Main Steam System		27
33. Circulating Water System		8
35. All other I&C Systems		2
41. Main Generator Systems		35
42. Electrical Power Supply Systems		102
Total	**68**	**564**

Highlights (2020)

in the year 2020. plant faced one auto scram and refueling outage continued from Dec 2019 to Feb 2020.

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2020 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

Reactor type and model	:	PWR / CNP-300
Thermal power	:	999 MWth
Gross electrical power	:	325 MWe
Reference unit power (net)	:	300 MWe

Key Dates

Construction Date	:	2005-12-28
Grid Date	:	2011-03-14
Commercial Date	:	2011-05-18
Age at end of year	:	9 years

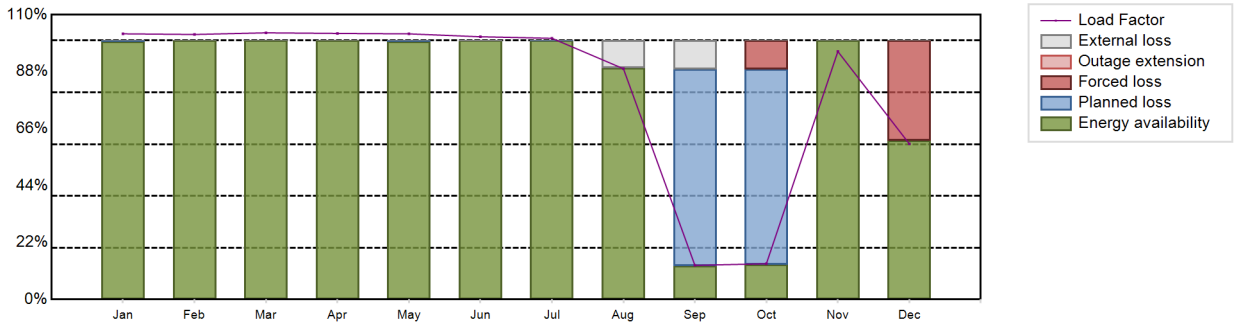
Design Characteristics

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 (2020)

Net Energy Production	:	2167.47 GW(e).h
Energy Availability Factor (EAF)	:	81.33 %
Unit Capability Factor (UCF)	:	83.13 %
Load Factor (LF)	:	82.25 %
Operating Factor (OF)	:	84.01 %
Forced Loss Rate (FLR)	:	4.82 %
Unplanned Capability Loss Factor (UCL)	:	4.21 %
Planned Unavailability Factor (PUF)	:	12.66 %
Externally cause unavailability (XUF)	:	1.8 %
Total off-line time	:	1405 hours

Annual Summary



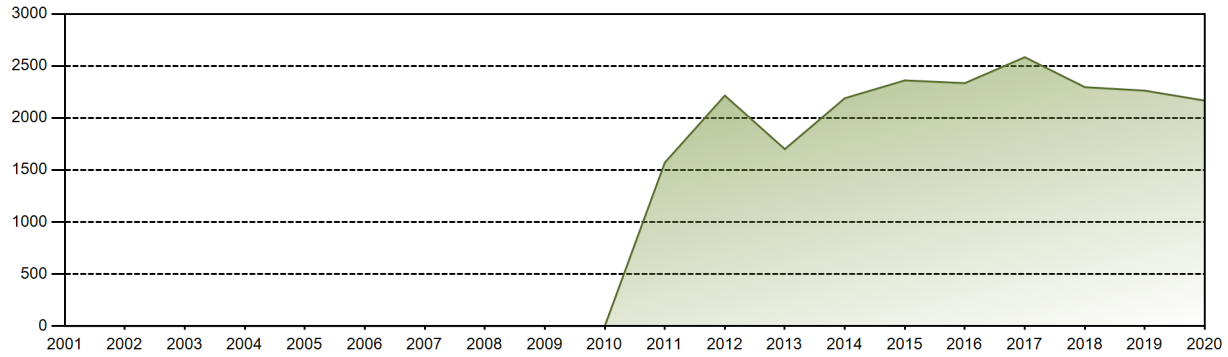
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	229.02	213.74	229.90	221.97	229.01	219.20	225.20	198.97	28.52	30.83	206.91	134.19	2167.47
EAF [%]	99.65	100.00	100.00	100.00	99.72	99.99	100.00	89.39	13.06	13.55	100.00	61.36	81.33
UCF [%]	99.65	100.00	100.00	100.00	99.72	100.00	100.00	100.00	24.07	13.55	100.00	61.36	83.13
LF [%]	102.61	102.37	103.00	102.76	102.60	101.48	100.90	89.14	13.20	13.81	95.79	60.12	82.25
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	24.44	20.16	100.00	64.11	84.01
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.93	0.00	38.64	4.82
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.05	0.00	38.64	4.21
PUF [%]	0.35	0.00	0.00	0.00	0.28	0.00	0.00	0.00	75.93	75.40	0.00	0.00	12.66
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.01	0.00	10.61	11.01	0.00	0.00	0.00	1.80

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Historical Summary

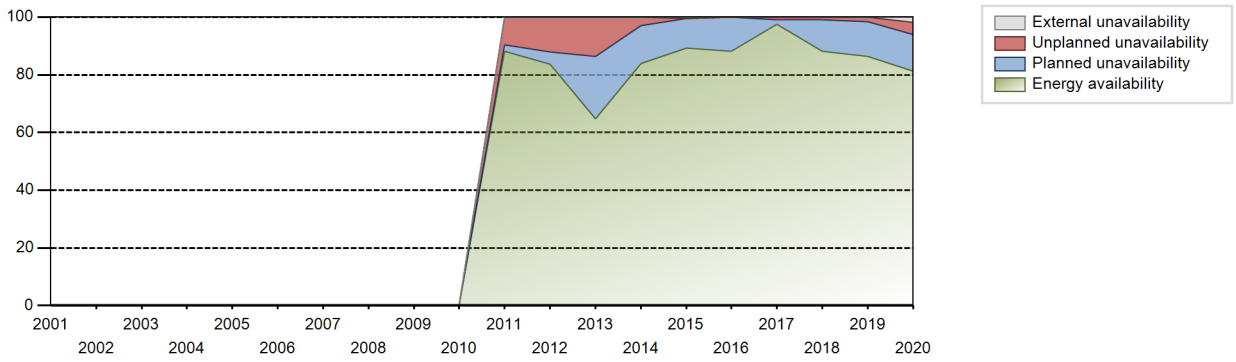
Lifetime energy generation	:	21686.37 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.81 %
Cumulative Energy Availability Factor (EAF)	:	85.01 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.37 %
Cumulative Unit Capability Factor (UCF)	:	85.26 %	Cumulative Planned Unavailability Factor (PUF)	:	10.36 %
Cumulative Load Factor (LF)	:	84.99 %	Cumulative Externally cause unavailability (XUF)	:	0.25 %
Cumulative Operating Factor (OF)	:	86.74 %			

Electricity Production (net) [GWh]



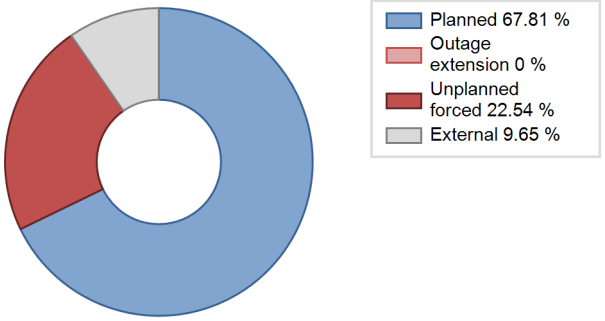
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2011	1570.98	5766	300	88.25	88.25	85.28	86.94	7.81	9.56	2.19	0.00
2012	2215.76	7864	300	83.74	83.77	84.08	89.53	12.44	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

Key Factors in Last 20 Years [%]

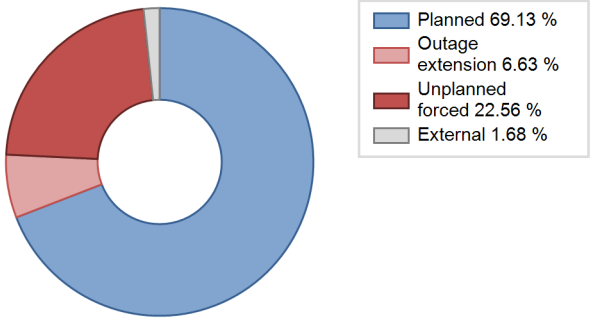


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2011 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		306			335	
C. Inspection, maintenance or repair combined with refuelling	1100			764		
D. Inspection, maintenance or repair without refuelling				11		
J. Grid limitation, failure or grid unavailability						69
Subtotal	1100	306		775	335	69
Total	**1406**			**1179**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2011 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems	131	33
15. Reactor Cooling Systems		85
16. Steam generation systems	18	19
31. Turbine and auxiliaries		38
32. Feedwater and Main Steam System		13
33. Circulating Water System		4
41. Main Generator Systems	20	54
42. Electrical Power Supply Systems	136	81
Total	**305**	**327**

Highlights (2020)

In the year 2020, plant achieved 82% load factor and Operation Factor was 82%.
Plant faced w auto scram and and Refueling outage in September 2020

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2020 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	:	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]	:	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

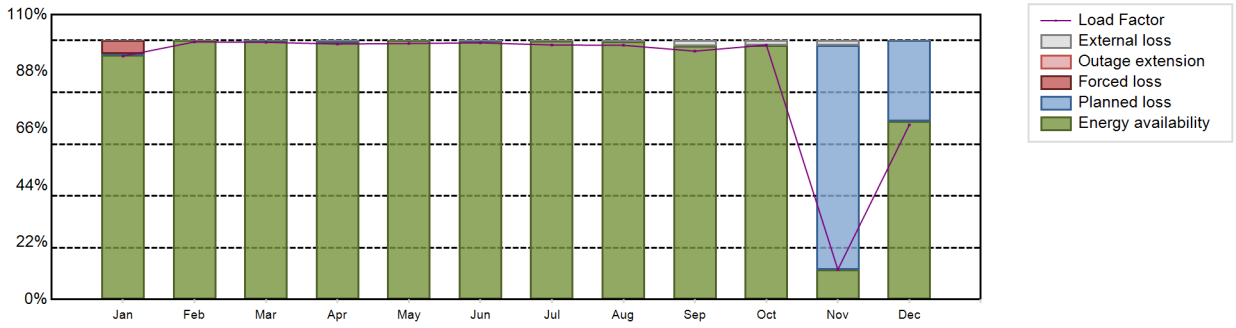
Operating coolant pressure [MPa]	:	15.2
Reactor outlet temperature [°C]	:	315.5
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.26
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
HP 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 (2020)

Net Energy Production	:	2444.19 GW(e).h
Energy Availability Factor (EAF)	:	89.15 %
Unit Capability Factor (UCF)	:	89.7 %
Load Factor (LF)	:	88.33 %
Operating Factor (OF)	:	90.29 %

Forced Loss Rate (FLR)	:	0.49 %
Unplanned Capability Loss Factor (UCL)	:	0.44 %
Planned Unavailability Factor (PUF)	:	9.86 %
Externally cause unavailability (XUF)	:	0.55 %
Total off-line time	:	853 hours

Annual Summary



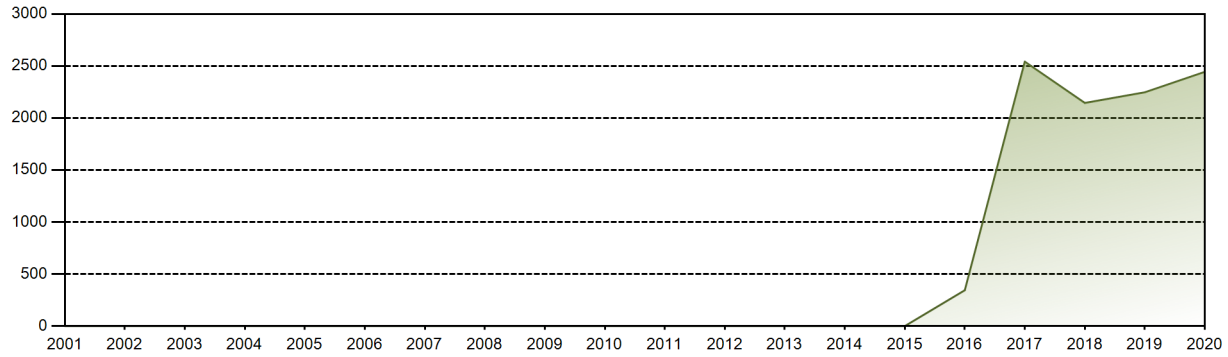
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	220.25	218.11	232.77	223.78	231.75	224.80	230.39	230.12	217.53	230.39	26.25	158.04	2444.19
EAF [%]	94.30	100.00	99.85	99.42	100.00	99.76	99.77	99.72	97.89	98.05	11.44	68.72	89.15
UCF [%]	94.30	100.00	99.85	99.42	100.00	100.00	100.00	100.00	100.00	100.00	13.30	68.72	89.70
LF [%]	93.98	99.48	99.32	98.67	98.88	99.12	98.31	98.19	95.91	98.31	11.58	67.44	88.33
OF [%]	96.77	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	14.03	71.77	90.29
FLR [%]	5.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49
UCL [%]	5.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44
PUF [%]	0.48	0.00	0.15	0.58	0.00	0.00	0.00	0.00	0.00	0.00	86.70	31.28	9.86
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.24	0.23	0.28	2.11	1.95	1.86	0.00	0.55

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Historical Summary

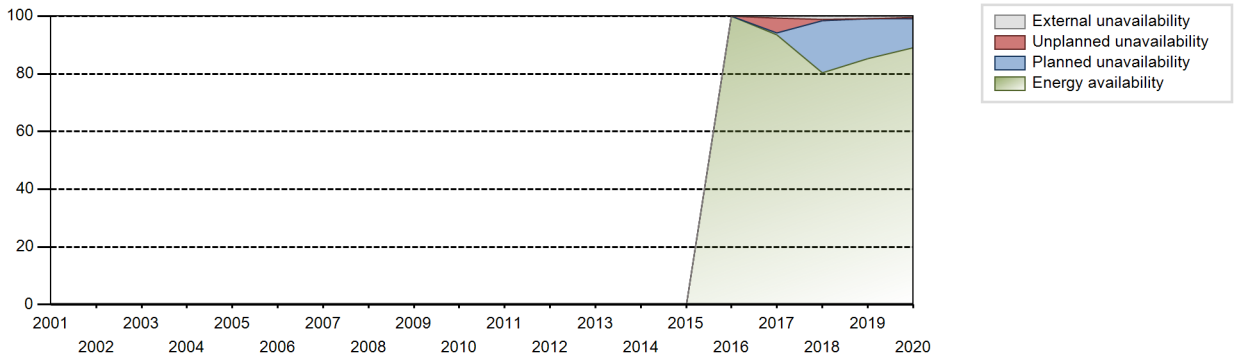
Lifetime energy generation	:	9733.99 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.72 %
Cumulative Energy Availability Factor (EAF)	:	87.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.55 %
Cumulative Unit Capability Factor (UCF)	:	88.13 %	Cumulative Planned Unavailability Factor (PUF)	:	10.32 %
Cumulative Load Factor (LF)	:	85.18 %	Cumulative Externally cause unavailability (XUF)	:	0.79 %
Cumulative Operating Factor (OF)	:	88.22 %			

Electricity Production (net) [GWh]

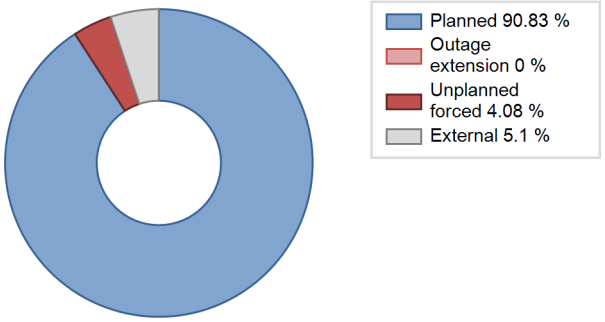


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	344.98	1436	315	100.00	100.00	97.84	100.00	0.00	0.00	0.00	0.00
2017	2542.08	8256	315	93.53	94.13	92.12	94.25	5.36	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

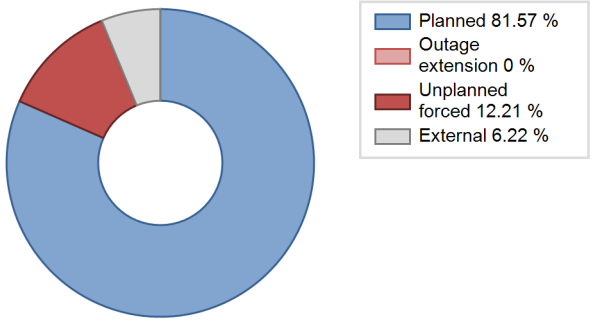
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		32			123	
C. Inspection, maintenance or repair combined with refuelling	829			875		
J. Grid limitation, failure or grid unavailability						58
Subtotal	829	32		875	123	58
Total	**861**			**1056**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		42
15. Reactor Cooling Systems		8
16. Steam generation systems	32	56
31. Turbine and auxiliaries		10
33. Circulating Water System		7
Total	**32**	**123**

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2020 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	:	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]	:	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

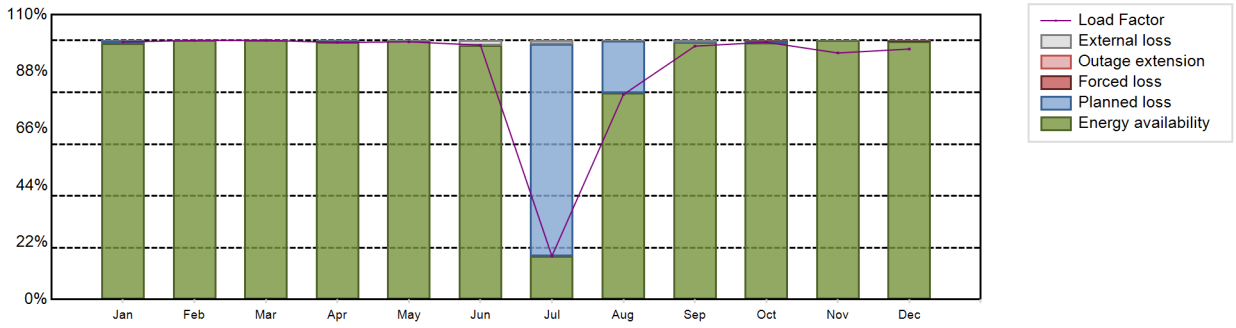
Operating coolant pressure [MPa]	:	15.2
Reactor outlet temperature [°C]	:	315.5
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.26
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	2474.85 GW(e).h
Energy Availability Factor (EAF)	:	90.76 %
Unit Capability Factor (UCF)	:	91.09 %
Load Factor (LF)	:	90.01 %
Operating Factor (OF)	:	91.85 %

Forced Loss Rate (FLR)	:	0.05 %
Unplanned Capability Loss Factor (UCL)	:	0.05 %
Planned Unavailability Factor (PUF)	:	8.86 %
Externally cause unavailability (XUF)	:	0.34 %
Total off-line time	:	716 hours

Annual Summary



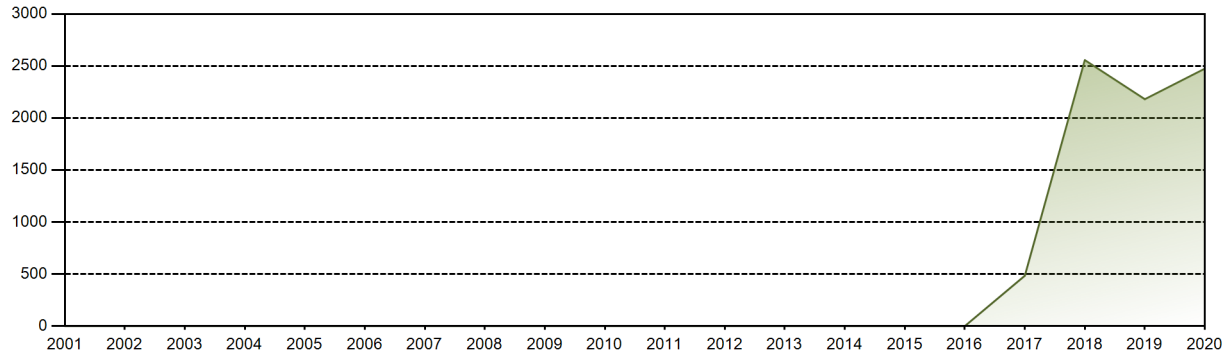
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	231.68	218.01	233.13	223.70	231.79	221.39	39.03	184.31	220.52	231.40	214.57	225.32	2474.85
EAF [%]	98.78	99.99	100.00	99.36	99.97	98.22	16.69	79.71	99.33	99.19	100.00	99.54	90.76
UCF [%]	98.78	100.00	100.00	99.36	100.00	100.00	18.12	79.88	99.96	99.19	100.00	99.54	91.09
LF [%]	99.49	100.07	100.11	99.26	99.54	98.24	16.76	79.15	97.85	99.37	95.21	96.76	90.01
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	20.16	83.60	100.00	100.00	100.00	100.00	91.85
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.46	0.05
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.46	0.05
PUF [%]	1.22	0.00	0.00	0.64	0.00	0.00	81.88	20.12	0.04	0.70	0.00	0.00	8.86
XUF [%]	0.00	0.01	0.00	0.00	0.03	1.78	1.43	0.17	0.63	0.00	0.00	0.00	0.34

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Historical Summary

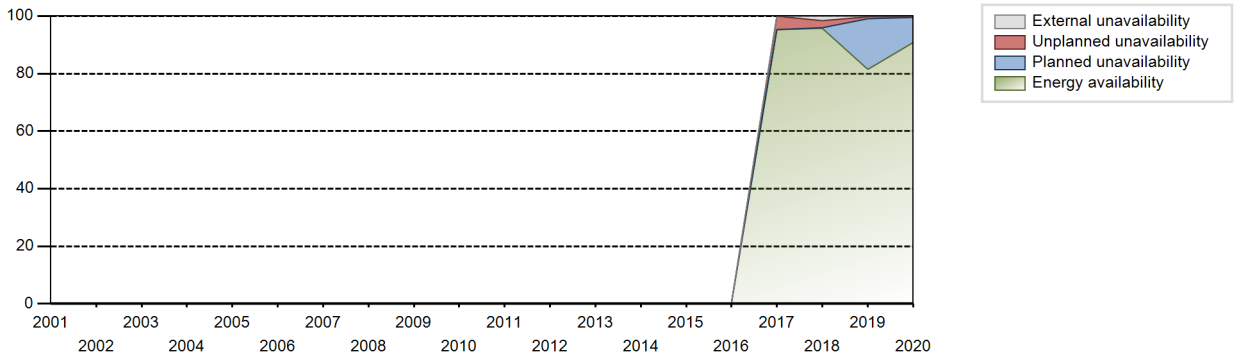
Lifetime energy generation	:	7698.85 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.52 %
Cumulative Energy Availability Factor (EAF)	:	89.8 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.4 %
Cumulative Unit Capability Factor (UCF)	:	90.47 %	Cumulative Planned Unavailability Factor (PUF)	:	8.13 %
Cumulative Load Factor (LF)	:	83.54 %	Cumulative Externally cause unavailability (XUF)	:	0.68 %
Cumulative Operating Factor (OF)	:	86.28 %			

Electricity Production (net) [GWh]

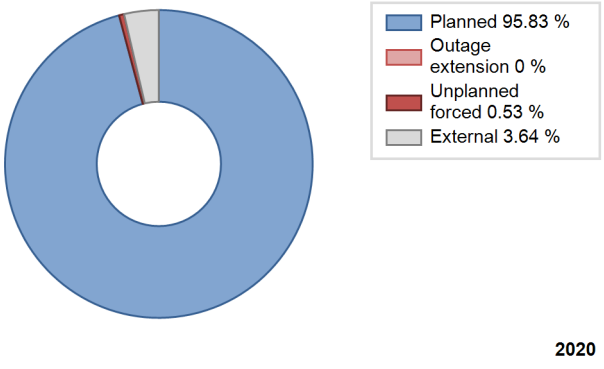


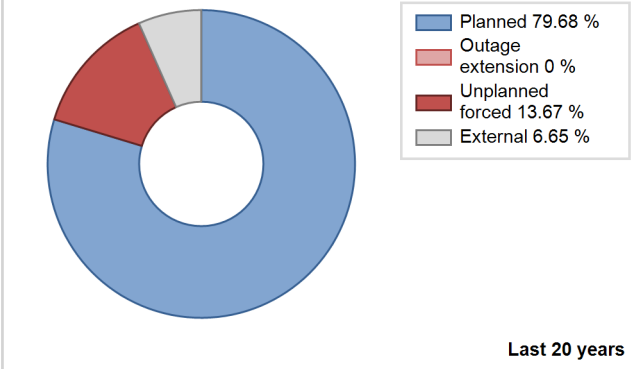
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2017	484.17	1946	313	95.21	95.22	35.01	38.13	4.78	4.78	0.00	0.01
2018	2557.08	8452	313	95.74	97.25	93.26	96.48	2.63	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2017 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					95	
C. Inspection, maintenance or repair combined with refuelling	716			676		
J. Grid limitation, failure or grid unavailability						434
Subtotal	716			676	95	434
Total	**716**			**1205**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2017 to 2020
	Hours Lost	Average hours lost per reactor-year
31. Turbine and auxiliaries		28
41. Main Generator Systems		58
Total		**86**

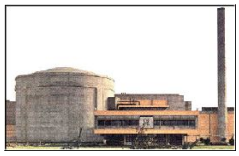
Highlights (2020)

In the year 2020, plant load factor was 90% and operating factor was 92%
Refueling outage was started in the month of July

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2020 Operating Experience

PK-1 KANUPP-1 PAKISTAN



Status at end of year	:	**Operational**
Operator	:	PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
Owner	:	PAEC (PAKISTAN ATOMIC ENERGY COMMISSION)
Reactor Supplier	:	CGE (CANADIAN GENERAL ELECTRIC)
Turbine Supplier	:	HITACHI (HITACHI, LTD.)

Reactor Unit Details

Reactor type and model	:	PHWR / CANDU-137 MW
Thermal power	:	337 MWth
Gross electrical power	:	100 MWe
Reference unit power (net)	:	90 MWe

Key Dates

Construction Date	:	1966-08-01
Grid Date	:	1971-10-18
Commercial Date	:	1972-12-07
Age at end of year	:	49 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]	:	12
Part of the core refuelled [%]	:	-
Average discharge burnup [MWd/t]	:	8650
Active core diameter [m]	:	3.82
Active core height/length [m]	:	4.87
Number of fissile fuel assemblies/bundles	:	2277
Fuel linear heat generation rate [kW/m]	:	4.13
Number of control rod assemblies	:	4
Number of external reactor coolant loops	:	2
Coolant type	:	D2O

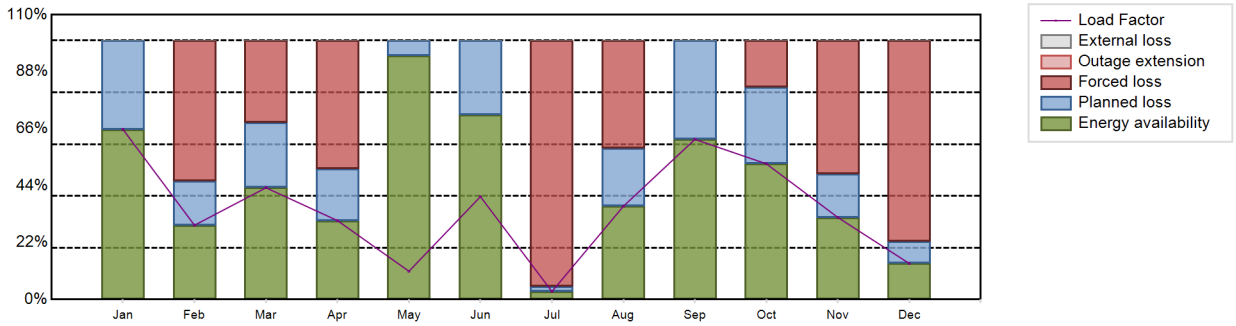
Operating coolant pressure [MPa]	:	10.6
Reactor outlet temperature [°C]	:	293
Number of SG	:	6
Containment type	:	-
Containment design pressure [MPa]	:	0.19
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	3.87
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	:	DS

Annual Production Results (2020)

Net Energy Production	:	274.92 GW(e).h
Energy Availability Factor (EAF)	:	44.41 %
Unit Capability Factor (UCF)	:	44.41 %
Load Factor (LF)	:	34.78 %
Operating Factor (OF)	:	55.43 %
Equivalent non-electrical energy generated (NEG)	:	0 GW(e).h

Forced Loss Rate (FLR)	:	44.02 %
Unplanned Capability Loss Factor (UCL)	:	34.93 %
Planned Unavailability Factor (PUF)	:	20.66 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	3915 hours

Annual Summary



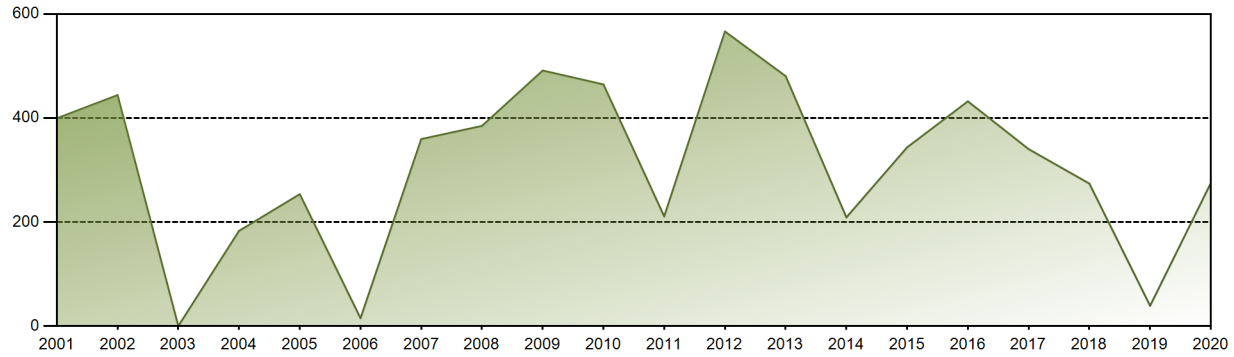
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	43.99	17.98	28.90	19.75	7.31	25.75	2.08	24.12	40.08	35.10	20.54	9.31	274.92
EAF [%]	65.70	28.70	43.17	30.49	94.15	71.33	3.10	36.02	61.85	52.42	31.70	13.90	44.41
UCF [%]	65.70	28.70	43.17	30.49	94.15	71.33	3.10	36.02	61.85	52.42	31.70	13.90	44.41
LF [%]	65.70	28.70	43.17	30.49	10.92	39.74	3.10	36.02	61.85	52.42	31.70	13.90	34.78
OF [%]	100.00	45.69	68.28	50.42	16.80	68.47	5.11	58.33	100.00	81.99	48.47	22.45	55.43
FLR [%]	0.00	65.44	42.36	61.89	0.00	0.00	96.83	53.63	0.00	25.52	61.90	84.80	44.02
UCL [%]	0.00	54.33	31.72	49.52	0.00	0.00	94.89	41.66	0.00	17.96	51.50	77.56	34.93
PUF [%]	34.30	16.97	25.11	20.00	5.85	28.67	2.01	22.32	38.15	29.62	16.80	8.54	20.66
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

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Historical Summary

Lifetime energy generation	:	14786.02 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	43.94 %
Cumulative Energy Availability Factor (EAF)	:	31.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	25.66 %
Cumulative Unit Capability Factor (UCF)	:	32.74 %	Cumulative Planned Unavailability Factor (PUF)	:	41.6 %
Cumulative Load Factor (LF)	:	29.47 %	Cumulative Externally cause unavailability (XUF)	:	0.89 %
Cumulative Operating Factor (OF)	:	55.7 %			

Electricity Production (net) [GWh]

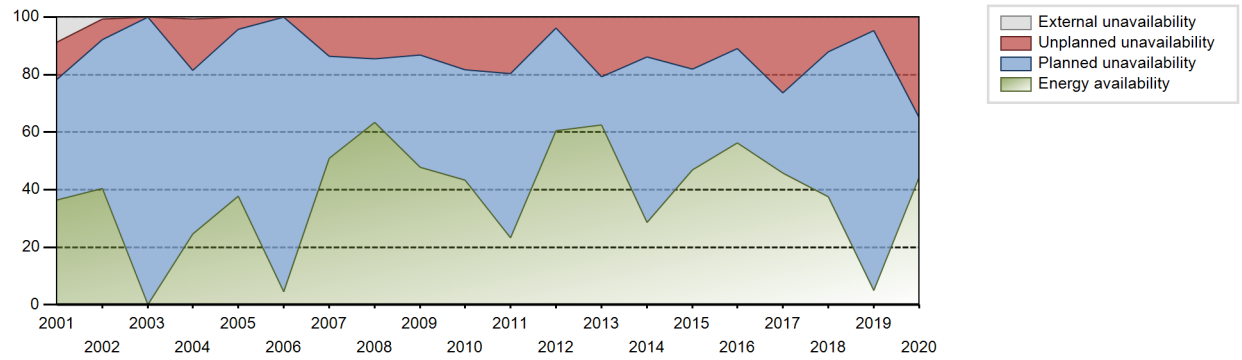


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1972	232.70	3737	137	38.70	38.70	38.65	80.24	61.30	61.30	0.00	0.00
1973	394.80	6197	126	35.60	42.56	35.77	70.74	41.76	30.52	26.92	6.96
1974	583.90	6749	126	52.75	52.75	52.90	77.04	25.84	18.38	28.87	0.00
1975	494.90	6375	126	44.83	44.83	44.84	72.77	47.38	40.37	14.80	0.00
1976	487.30	6026	137	40.49	40.49	40.49	68.60	59.51	59.51	0.00	0.00
1977	339.40	5290	126	30.74	30.74	30.75	60.39	58.92	44.09	25.16	0.00
1978	228.40	4473	125	20.88	20.88	20.86	51.06	71.93	53.51	25.61	0.00
1979	29.60	802	125	2.70	2.70	2.70	9.16	83.28	13.46	83.84	0.00
1980	67.90	2427	125	6.17	6.17	6.18	27.63	92.43	75.36	18.47	0.00
1981	192.20	5379	125	17.55	17.55	17.55	61.40	80.60	72.90	9.55	0.00
1982	70.90	1801	125	6.48	6.48	6.47	20.56	90.55	62.08	31.45	0.00
1983	194.00	4754	125	17.70	17.70	17.72	54.27	44.34	14.11	68.19	0.00
1984	290.65	5592	137	24.90	26.94	24.15	63.66	9.51	2.83	70.23	2.04
1985	261.96	3895	137	21.83	22.69	21.83	44.46	50.85	23.47	53.83	0.87
1986	476.22	7211	125	43.49	44.00	43.49	82.32	56.00	56.00	0.00	0.51
1987	274.77	4541	125	25.09	25.58	25.09	51.84	59.64	37.80	36.61	0.49
1988	171.41	2962	125	15.60	16.21	15.61	33.72	53.71	18.82	64.97	0.61
1989	60.86	1145	125	5.56	5.56	5.56	13.07	70.79	13.47	80.97	0.00
1990	375.91	5331	125	34.33	34.33	34.33	60.86	60.06	51.62	14.05	0.00
1991	370.30	6126	125	33.82	34.79	33.82	69.93	65.21	65.21	0.00	0.97
1992	499.74	6396	125	45.51	45.51	45.51	72.81	47.81	41.70	12.79	0.00
1993	369.60	4620	125	33.75	35.76	33.75	52.74	42.71	26.67	37.57	2.01
1994	523.64	7518	125	47.82	53.56	47.82	85.82	13.63	8.45	37.99	5.74
1995	461.04	7520	125	42.10	44.03	42.10	85.84	55.97	55.97	0.00	1.93
1996	310.86	5291	125	28.31	32.59	28.31	60.23	41.29	22.93	44.48	4.28
1997	386.12	6391	125	35.26	36.84	35.26	72.96	24.77	12.13	51.02	1.58
1998	353.35	4799	125	29.74	31.34	32.27	54.78	25.91	10.96	57.70	1.60
1999	68.99	1046	125	11.93	11.93	6.30	11.94	10.30	1.37	86.70	0.00
2000	368.31	5078	125	33.54	34.62	33.54	57.81	20.65	9.01	56.37	1.08
2001	399.46	6049	125	36.48	45.11	36.48	69.05	22.49	13.09	41.80	8.63
2002	444.02	6601	125	40.55	41.27	40.55	75.35	14.70	7.11	51.62	0.72
2003	0.00	0	125	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
2004	183.00	6467	125	24.71	25.51	16.67	73.62	41.12	17.81	56.68	0.79
2005	253.56	6633	125	37.74	37.74	23.16	75.72	10.07	4.23	58.04	0.00
2006	14.99	408	125	4.59	4.59	1.37	4.66	0.00	0.00	95.41	0.00
2007	359.51	5989	125	50.88	50.88	32.83	68.37	21.07	13.58	35.54	0.00
2008	384.80	5026	125	63.36	63.36	35.05	57.22	18.59	14.47	22.17	0.00

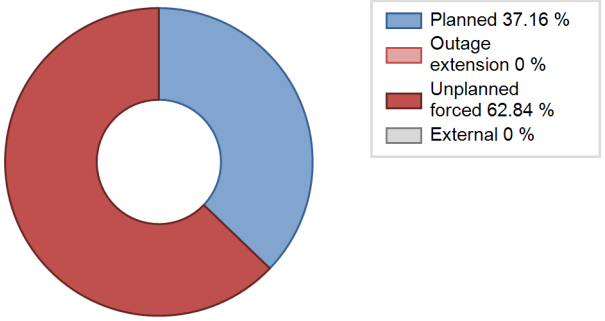
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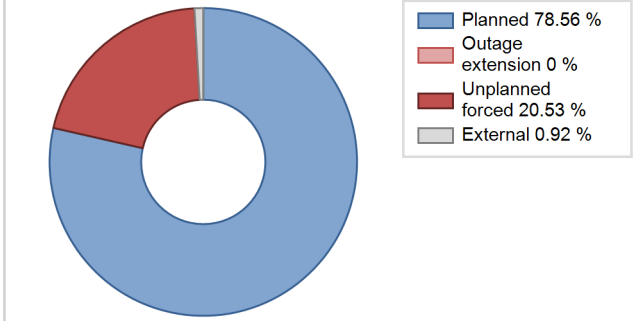
2009	491.31	6282	125	47.76	47.76	44.87	71.71	21.70	13.23	39.00	0.00
2010	464.57	6063	125	43.35	43.35	42.43	69.21	29.77	18.37	38.28	0.00
2011	210.77	2768	125	23.32	23.32	19.25	31.60	45.86	19.76	56.92	0.00
2012	566.40	7678	125	60.43	60.43	51.58	87.41	5.84	3.75	35.82	0.00
2013	480.47	6802	90	62.59	62.59	60.94	77.65	24.85	20.70	16.72	0.00
2014	208.95	3083	90	28.65	28.65	26.50	35.19	32.47	13.78	57.57	0.00
2015	343.69	5468	90	46.81	46.81	43.59	62.42	27.79	18.01	35.19	0.00
2016	432.03	7088	90	56.29	56.29	54.65	80.69	16.24	10.92	32.80	0.00
2017	340.25	5721	90	45.75	45.75	43.16	65.31	36.63	26.44	27.81	0.00
2018	273.96	4682	90	37.48	37.48	34.75	53.45	24.41	12.10	50.41	0.00
2019	38.97	759	90	4.94	4.94	4.94	8.66	48.28	4.61	90.44	0.00
2020	274.92	4869	90	44.41	44.41	34.78	55.43	44.02	34.93	20.66	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1972 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		3068			1249	
C. Inspection, maintenance or repair combined with refuelling				89		
D. Inspection, maintenance or repair without refuelling				1600		
E. Testing of plant systems or components				0	0	
G. Major backfitting, refurbishment or upgrading activities without refuelling				196		
J. Grid limitation, failure or grid unavailability			843			268
L. Human factor related					62	
P. Fire					3	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				205		
Z. Other				3	63	
Subtotal		3068	843	2093	1377	268
Total		**3911**			**3738**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1972 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		43
12. Reactor I&C Systems		104
13. Reactor Auxiliary Systems	367	125
14. Safety Systems		14
15. Reactor Cooling Systems	712	198
16. Steam generation systems	641	297
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		114
31. Turbine and auxiliaries	247	41
32. Feedwater and Main Steam System		73
33. Circulating Water System	84	34
34. Miscellaneous Systems		113
41. Main Generator Systems		4
42. Electrical Power Supply Systems	1016	192
Total	**3067**	**1353**

Highlights (2020)

Plant operated at average load of 71.06 with availability factor of 55.43% , gross capacity factor 40.62% in the year 2020

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2020 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

Reactor type and model	:	PHWR / CANDU 6
Thermal power	:	2180 MWth
Gross electrical power	:	706 MWe
Reference unit power (net)	:	650 MWe

Key Dates

Construction Date	:	1983-03-31
Grid Date	:	1996-07-11
Commercial Date	:	1996-12-02
Age at end of year	:	24 years

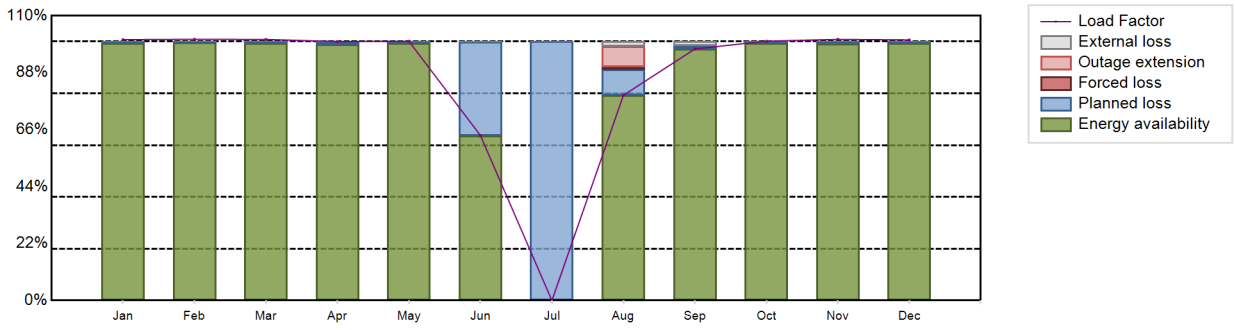
Design Characteristics

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]	:	NA
Part of the core refuelled [%]	:	NA
Average discharge burnup [MWd/t]	:	7100
Active core diameter [m]	:	6.123
Active core height/length [m]	:	5.94
Number of fissile fuel assemblies/bundles	:	4560
Fuel linear heat generation rate [kW/m]	:	42.9
Number of control rod assemblies	:	65
Number of external reactor coolant loops	:	2
Coolant type	:	D2O
Operating coolant pressure [MPa]	:	9.99
Reactor outlet temperature [°C]	:	310
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.1241
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]	:	4.551
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	:	2
Non-electrical applications	:	DH

Annual Production Results (2020)

Net Energy Production	:	4963.25 GW(e).h
Energy Availability Factor (EAF)	:	86.13 %
Unit Capability Factor (UCF)	:	86.46 %
Load Factor (LF)	:	86.93 %
Operating Factor (OF)	:	87.27 %
Equivalent non-electrical energy generated (NEG)	:	20.94 GW(e).h
Forced Loss Rate (FLR)	:	0.12 %
Unplanned Capability Loss Factor (UCL)	:	0.77 %
Planned Unavailability Factor (PUF)	:	12.77 %
Externally cause unavailability (XUF)	:	0.33 %
Total off-line time	:	1118 hours

Annual Summary



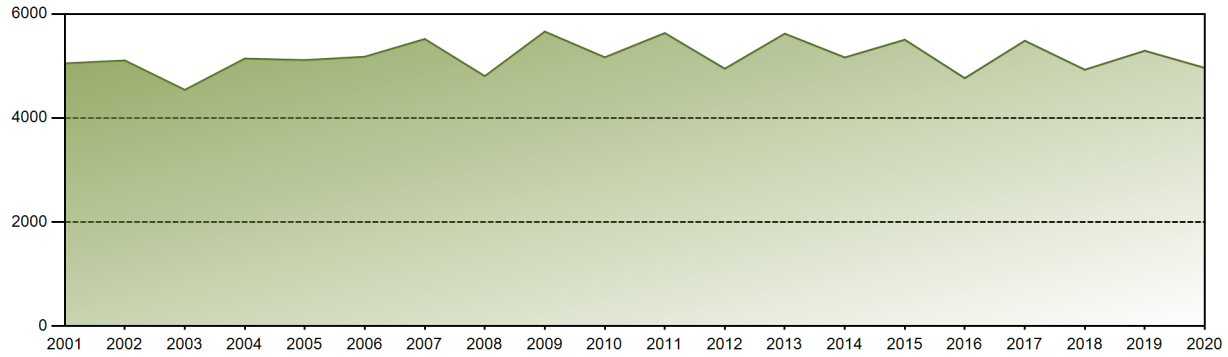
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	487.27	456.51	486.93	468.12	484.15	298.28	0.00	383.42	454.68	485.08	472.06	486.77	4963.25
EAF [%]	99.40	99.57	99.39	98.99	99.39	63.73	0.00	79.28	97.15	99.46	99.21	99.31	86.13
UCF [%]	99.40	99.57	99.39	99.23	99.39	63.96	0.00	81.05	98.90	99.46	99.21	99.31	86.46
LF [%]	100.76	100.91	100.82	100.03	100.11	63.73	0.00	79.28	97.15	100.17	100.87	100.66	86.93
OF [%]	100.00	100.00	100.00	100.00	100.00	64.86	0.00	83.74	100.00	100.00	100.00	100.00	87.27
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.12
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.11	0.00	0.00	0.00	0.00	0.77
PUF [%]	0.60	0.43	0.61	0.77	0.61	36.04	100.00	9.84	1.10	0.54	0.79	0.69	12.77
XUF [%]	0.00	0.00	0.00	0.24	0.00	0.23	0.00	1.76	1.75	0.00	0.00	0.00	0.33

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Historical Summary

Lifetime energy generation	:	124534.12 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.23 %
Cumulative Energy Availability Factor (EAF)	:	89.64 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.35 %
Cumulative Unit Capability Factor (UCF)	:	90.68 %	Cumulative Planned Unavailability Factor (PUF)	:	6.97 %
Cumulative Load Factor (LF)	:	89.95 %	Cumulative Externally cause unavailability (XUF)	:	1.05 %
Cumulative Operating Factor (OF)	:	91.05 %			

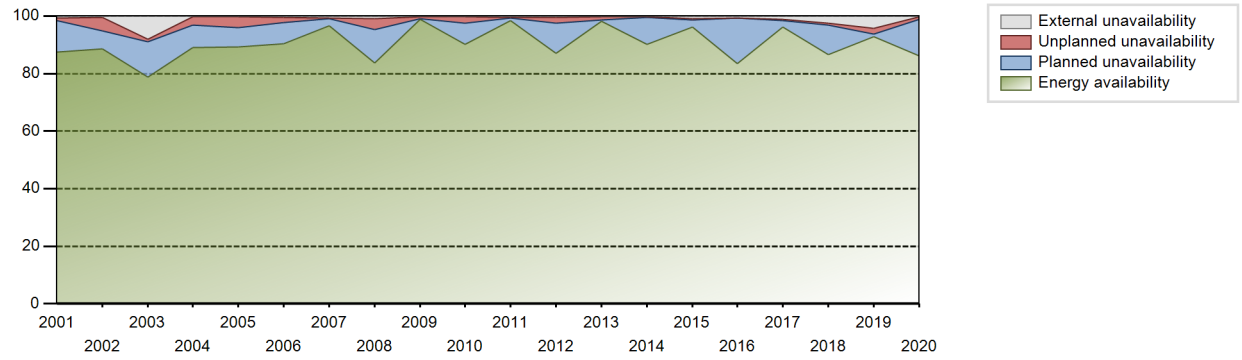
Electricity Production (net) [GWh]



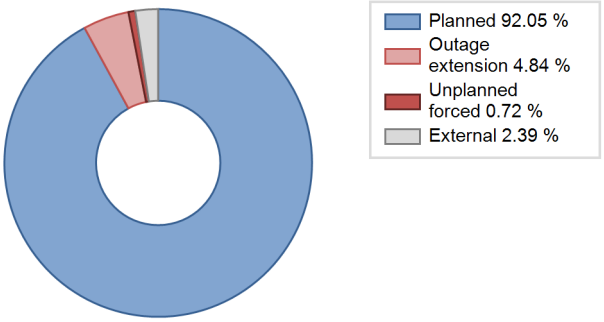
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1996	1186.44	2686	647	94.44	94.44	99.60	100.00	3.52	3.45	2.11	0.00
1997	4953.29	7753	646	86.74	87.32	87.53	88.50	9.94	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

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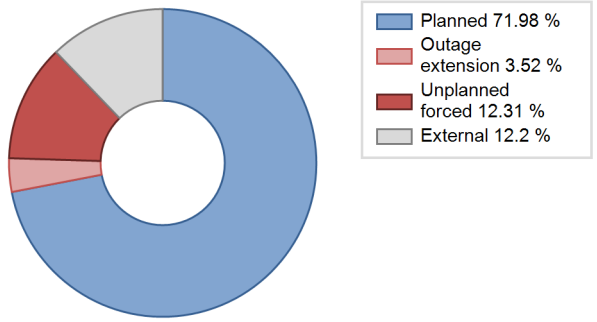
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			1996 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		7			155	
C. Inspection, maintenance or repair combined with refuelling				2		
D. Inspection, maintenance or repair without refuelling	1053			565		
E. Testing of plant systems or components		59			2	
J. Grid limitation, failure or grid unavailability						4
L. Human factor related					15	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						36
Z. Other					5	
Subtotal	1053	66		567	177	40
Total	**1119**			**784**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1996 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	59	2
12. Reactor I&C Systems		33
13. Reactor Auxiliary Systems		8
14. Safety Systems		4
15. Reactor Cooling Systems		7
16. Steam generation systems		7
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries		36
32. Feedwater and Main Steam System	7	20
33. Circulating Water System		38
34. Miscellaneous Systems		15
41. Main Generator Systems		19
42. Electrical Power Supply Systems		17
Total	**66**	**215**

Highlights (2020)

The unit was operated at full power in base load mode. The annual planed outage took place between June 20 -August 3 2020 followed by an unplanned extension until August, 5. During this year, Unit 1 had one unplanned outage: Turbine manually tripped due to low pressure in boilers.

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2020 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

Reactor type and model	:	PHWR / CANDU 6
Thermal power	:	2180 MWth
Gross electrical power	:	705 MWe
Reference unit power (net)	:	650 MWe

Key Dates

Construction Date	:	1983-07-01
Grid Date	:	2007-08-07
Commercial Date	:	2007-11-01
Age at end of year	:	13 years

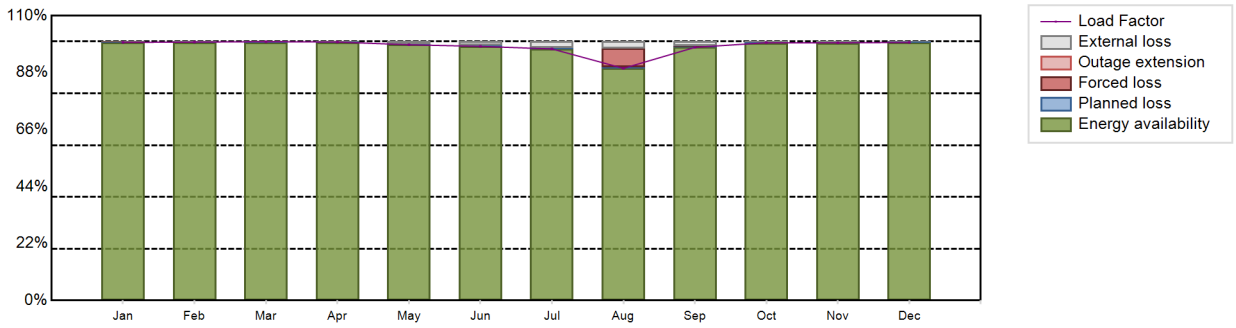
Design Characteristics

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]	:	NA
Part of the core refuelled [%]	:	NA
Average discharge burnup [MWd/t]	:	7100
Active core diameter [m]	:	6.123
Active core height/length [m]	:	5.94
Number of fissile fuel assemblies/bundles	:	4560
Fuel linear heat generation rate [kW/m]	:	42.9
Number of control rod assemblies	:	65
Number of external reactor coolant loops	:	2
Coolant type	:	D2O
Operating coolant pressure [MPa]	:	9.99
Reactor outlet temperature [°C]	:	310
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.1241
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]	:	4.551
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	:	2
Non-electrical applications	:	DH

Annual Production Results (2020)

Net Energy Production	:	5611.82 GW(e).h	Forced Loss Rate (FLR)	:	0.65 %
Energy Availability Factor (EAF)	:	98.21 %	Unplanned Capability Loss Factor (UCL)	:	0.65 %
Unit Capability Factor (UCF)	:	98.96 %	Planned Unavailability Factor (PUF)	:	0.39 %
Load Factor (LF)	:	98.29 %	Externally cause unavailability (XUF)	:	0.75 %
Operating Factor (OF)	:	99.46 %	Total off-line time	:	47 hours
Equivalent non-electrical energy generated (NEG)	:	16.21 GW(e).h			

Annual Summary



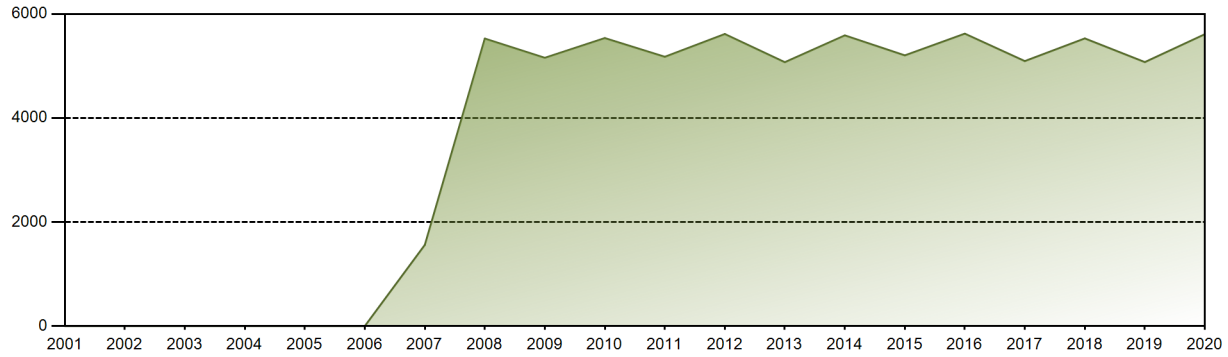
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	482.15	451.53	482.81	467.19	477.67	459.33	469.92	433.66	457.58	482.13	465.79	482.05	5611.82
EAF [%]	99.56	99.67	99.71	99.66	98.87	98.15	97.17	89.67	97.77	99.49	99.46	99.55	98.21
UCF [%]	99.56	99.67	99.71	99.66	99.63	99.45	99.49	92.18	99.50	99.63	99.60	99.55	98.96
LF [%]	99.70	99.81	99.97	99.83	98.77	98.15	97.17	89.67	97.77	99.56	99.53	99.68	98.29
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.68	100.00	100.00	100.00	100.00	99.46
FLR [%]	0.12	0.00	0.01	0.00	0.00	0.00	0.00	7.46	0.09	0.00	0.00	0.00	0.65
UCL [%]	0.12	0.00	0.01	0.00	0.00	0.00	0.00	7.43	0.09	0.00	0.00	0.00	0.65
PUF [%]	0.32	0.33	0.28	0.34	0.37	0.55	0.51	0.40	0.40	0.37	0.40	0.45	0.39
XUF [%]	0.00	0.00	0.00	0.00	0.76	1.30	2.32	2.51	1.73	0.15	0.15	0.00	0.75

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Historical Summary

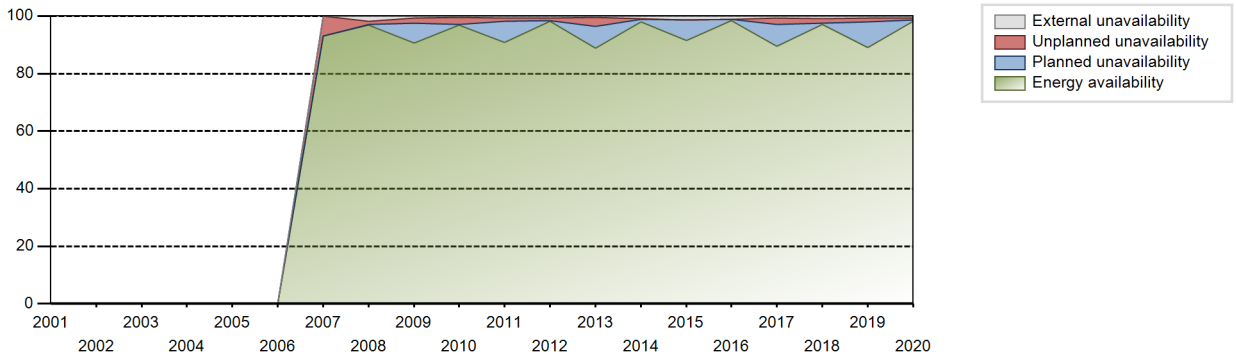
Lifetime energy generation	:	71380.3 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.32 %
Cumulative Energy Availability Factor (EAF)	:	94.13 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.37 %
Cumulative Unit Capability Factor (UCF)	:	94.98 %	Cumulative Planned Unavailability Factor (PUF)	:	3.66 %
Cumulative Load Factor (LF)	:	94.23 %	Cumulative Externally cause unavailability (XUF)	:	0.85 %
Cumulative Operating Factor (OF)	:	95.47 %			

Electricity Production (net) [GWh]



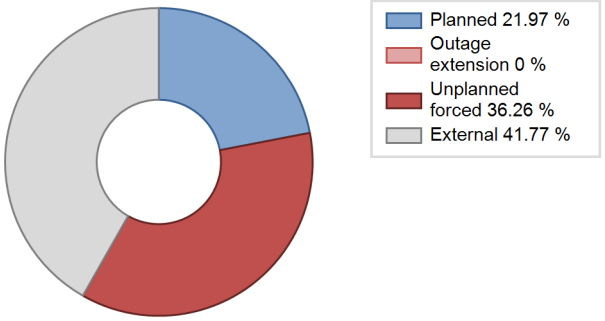
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2007	1560.20	2729	650	93.03	93.03	93.24	94.19	6.91	6.91	0.06	0.00
2008	5528.11	8669	650	96.85	98.63	96.82	98.69	1.24	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

Key Factors in Last 20 Years [%]

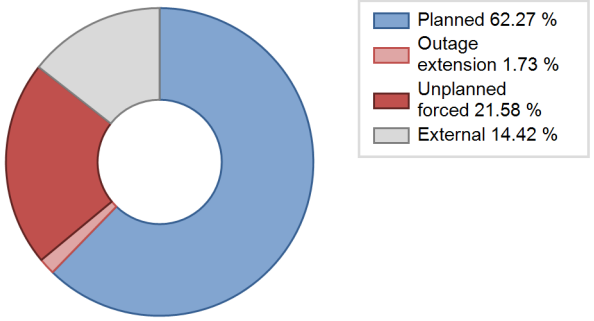


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2007 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		47			90	
D. Inspection, maintenance or repair without refuelling				290		
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.)						5
Subtotal		47		290	100	5
Total		**47**			**395**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2007 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		9
12. Reactor I&C Systems		17
15. Reactor Cooling Systems		9
16. Steam generation systems		3
21. Fuel Handling and Storage Facilities		14
31. Turbine and auxiliaries	47	12
32. Feedwater and Main Steam System		7
41. Main Generator Systems		16
42. Electrical Power Supply Systems		18
Total	**47**	**105**

Highlights (2020)

No annual outage was planned for this year, the unit was operated at full power in base load mode, with the following exception: Turbine trip on August, 29 for 46.6 hours.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia)

Reactor Unit Details

Reactor type and model	:	PWR / KLT-40S 'Floating'
Thermal power	:	150 MWth
Gross electrical power	:	35 MWe
Reference unit power (net)	:	32 MWe

Key Dates

Construction Date	:	2007-04-15
Grid Date	:	2019-12-19
Commercial Date	:	2020-05-22
Age at end of year	:	1 years

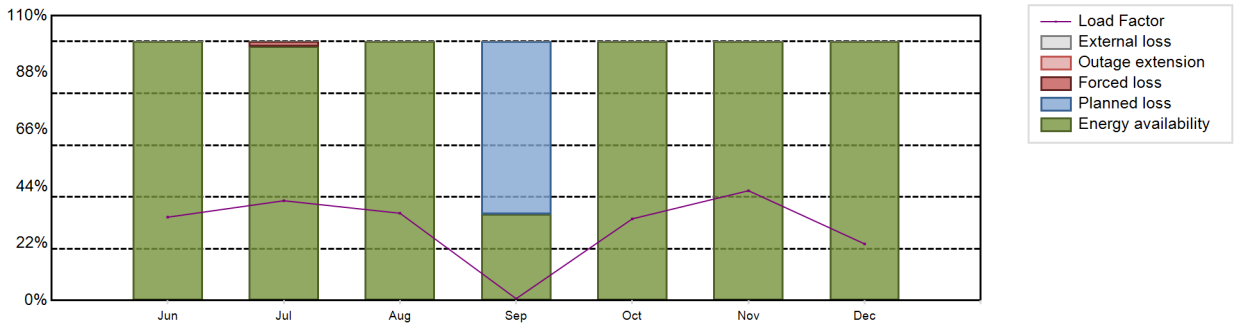
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	Other
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	14.1
Refuelling frequency [month]	:	29
Part of the core refuelled [%]	:	100
Average discharge burnup [MWd/t]	:	68700
Active core diameter [m]	:	1.220
Active core height/length [m]	:	1.2
Number of fissile fuel assemblies/bundles	:	121
Fuel linear heat generation rate [kW/m]	:	14
Number of control rod assemblies	:	11
Number of external reactor coolant loops	:	4
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	12.7
Reactor outlet temperature [°C]	:	316
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.4
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	NA
HP cylinder inlet steam pressure [MPa]	:	3.43
Output voltage [kV]	:	10.5
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	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	64.94 GW(e).h	Forced Loss Rate (FLR)	:	0.3 %
Energy Availability Factor (EAF)	:	90.38 %	Unplanned Capability Loss Factor (UCL)	:	0.27 %
Unit Capability Factor (UCF)	:	90.38 %	Planned Unavailability Factor (PUF)	:	9.34 %
Load Factor (LF)	:	28.76 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	71.63 %	Total off-line time	:	3646 hours

Annual Summary



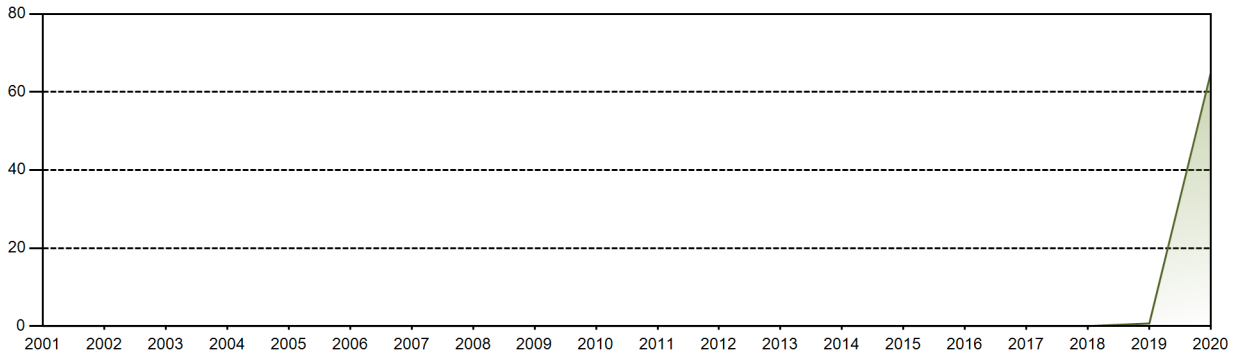
	May	Jan	Feb	Mar	Apr	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h						7.42	9.18	8.03	0.17	7.51	9.77	5.20	47.27
EAF [%]						100.00	98.12	100.00	33.36	100.00	100.00	100.00	90.38
UCF [%]						100.00	98.12	100.00	33.36	100.00	100.00	100.00	90.38
LF [%]						32.18	38.54	33.71	0.72	31.55	42.41	21.86	28.76
OF [%]						100.00	99.19	83.60	2.50	70.97	98.61	46.10	71.63
FLR [%]						0.00	1.88	0.00	0.00	0.00	0.00	0.00	0.30
UCL [%]						0.00	1.88	0.00	0.00	0.00	0.00	0.00	0.27
PUF [%]						0.00	0.00	0.00	66.64	0.00	0.00	0.00	9.34
XUF [%]						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Historical Summary

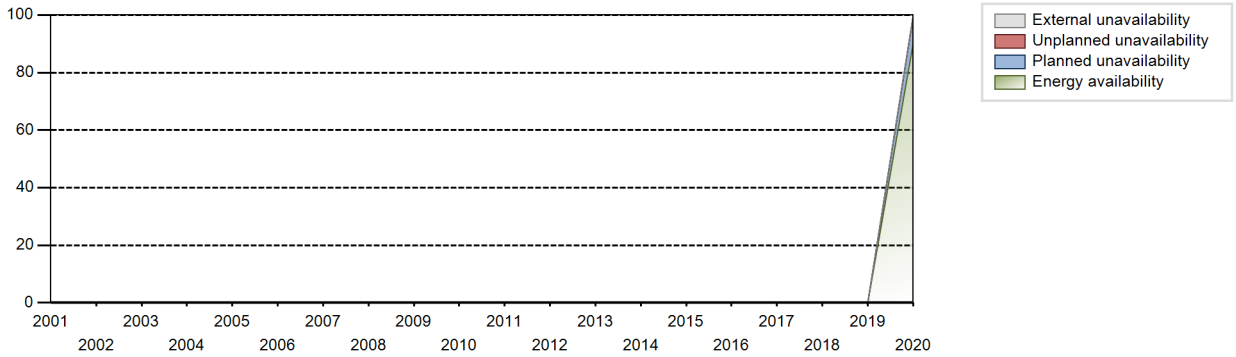
Lifetime energy generation	:	65.62 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.3 %
Cumulative Energy Availability Factor (EAF)	:	90.38 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.27 %
Cumulative Unit Capability Factor (UCF)	:	90.38 %	Cumulative Planned Unavailability Factor (PUF)	:	9.34 %
Cumulative Load Factor (LF)	:	28.76 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	71.63 %			

Electricity Production (net) [GWh]

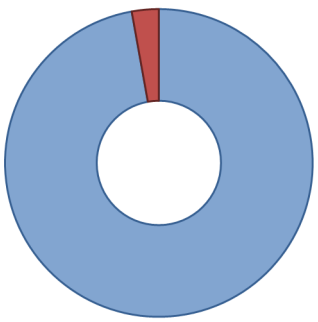


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2020	64.94	5138	32	90.38	90.38	28.76	71.63	0.30	0.27	9.34	0.00

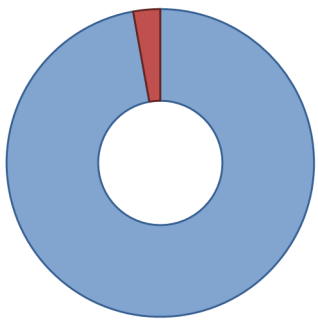
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2020 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
D. Inspection, maintenance or repair without refuelling	480			823		
L. Human factor related		12			21	
Subtotal	480	12		823	21	
Total	**492**			**844**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2020 to 2020
	Hours Lost	Average hours lost per reactor-year
31. Turbine and auxiliaries	12	12
Total	**12**	**12**

Highlights (2020)

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 2020.09.10 to 2020.09.03. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	KALUGA (JSC "Kaluga turbine plant" 32, Glagoleva Street, Kaluga, 248021, Russia)

Reactor Unit Details

Reactor type and model	:	PWR / KLT-40S 'Floating'
Thermal power	:	150 MWth
Gross electrical power	:	35 MWe
Reference unit power (net)	:	32 MWe

Key Dates

Construction Date	:	2007-04-15
Grid Date	:	2019-12-19
Commercial Date	:	2020-05-22
Age at end of year	:	1 years

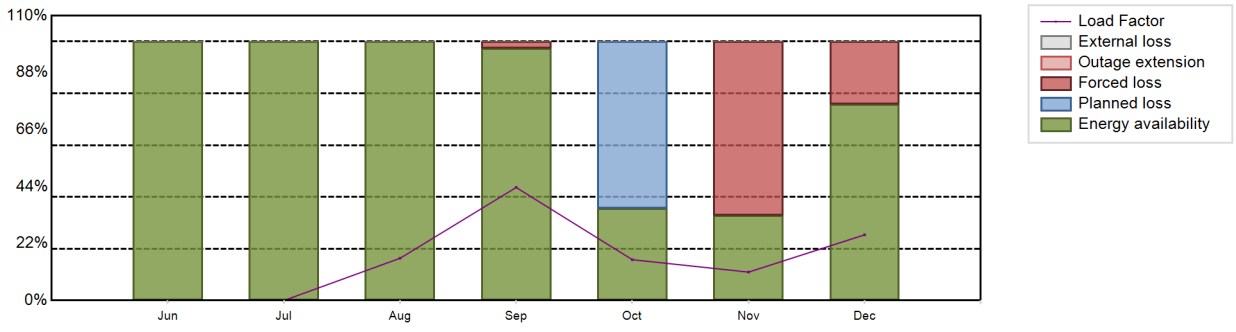
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	Other
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	14.1
Refuelling frequency [month]	:	29
Part of the core refuelled [%]	:	100
Average discharge burnup [MWd/t]	:	68700
Active core diameter [m]	:	1.220
Active core height/length [m]	:	1.2
Number of fissile fuel assemblies/bundles	:	121
Fuel linear heat generation rate [kW/m]	:	14
Number of control rod assemblies	:	11
Number of external reactor coolant loops	:	4
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	12.7
Reactor outlet temperature [°C]	:	316
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.4
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	NA
HP cylinder inlet steam pressure [MPa]	:	3.43
Output voltage [kV]	:	10.5
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	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	51.44 GW(e).h	Forced Loss Rate (FLR)	:	14.66 %
Energy Availability Factor (EAF)	:	77.36 %	Unplanned Capability Loss Factor (UCL)	:	13.29 %
Unit Capability Factor (UCF)	:	77.36 %	Planned Unavailability Factor (PUF)	:	9.35 %
Load Factor (LF)	:	15.99 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	38.32 %	Total off-line time	:	4842 hours

Annual Summary



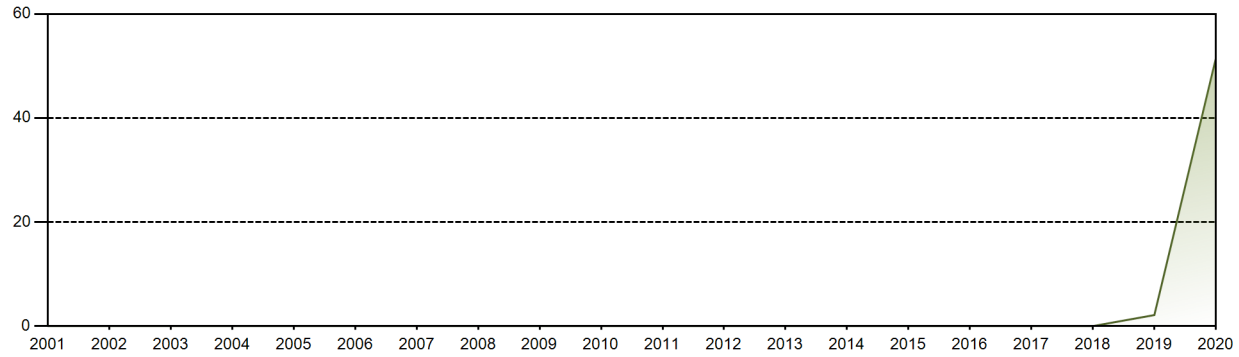
	May	Jan	Feb	Mar	Apr	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h						0.00	0.00	3.88	10.06	3.76	2.53	6.04	26.27
EAF [%]						100.00	100.00	100.00	97.36	35.47	32.80	75.81	77.36
UCF [%]						100.00	100.00	100.00	97.36	35.47	32.80	75.81	77.36
LF [%]						0.00	0.00	16.31	43.67	15.78	10.98	25.39	15.99
OF [%]						0.00	0.00	49.46	97.36	32.53	32.78	56.59	38.32
FLR [%]						0.00	0.00	0.00	2.64	0.00	67.20	24.19	14.66
UCL [%]						0.00	0.00	0.00	2.64	0.00	67.20	24.19	13.29
PUF [%]						0.00	0.00	0.00	0.00	64.53	0.00	0.00	9.35
XUF [%]						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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Historical Summary

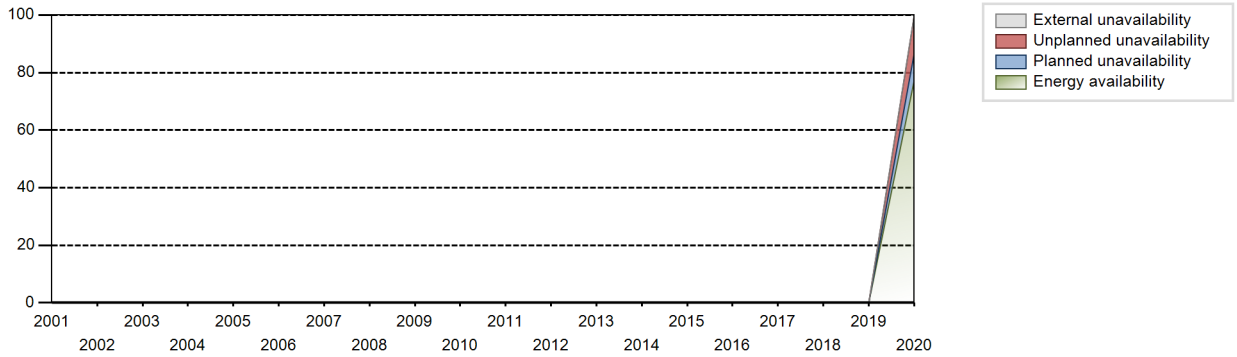
Lifetime energy generation	:	53.56 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.66 %
Cumulative Energy Availability Factor (EAF)	:	77.36 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.29 %
Cumulative Unit Capability Factor (UCF)	:	77.36 %	Cumulative Planned Unavailability Factor (PUF)	:	9.35 %
Cumulative Load Factor (LF)	:	15.99 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	38.32 %			

Electricity Production (net) [GWh]

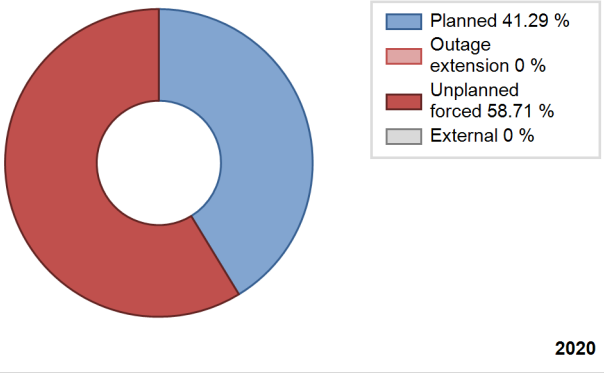


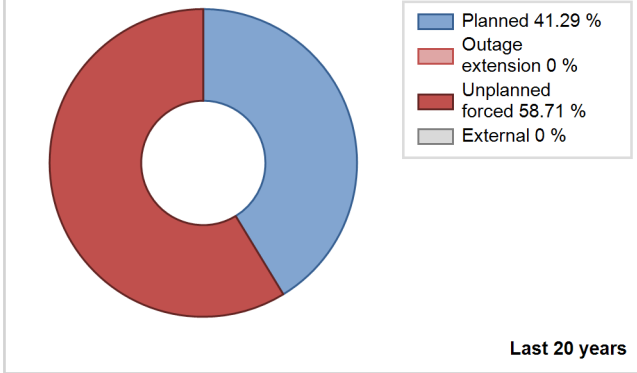
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2020	51.44	3942	32	77.36	77.36	15.99	38.32	14.66	13.29	9.35	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2020 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		696			1193	
D. Inspection, maintenance or repair without refuelling	600			1029		
L. Human factor related		19			33	
Subtotal	600	715		1029	1226	
Total	**1315**			**2255**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2020 to 2020
	Hours Lost	Average hours lost per reactor-year
16. Steam generation systems	696	696
Total	**696**	**696**

Highlights (2020)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. . The unit was in the routine maintenance from 2020.10.01 to 2020.10.20. 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.

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2020 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 (JSC 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	:	35 years

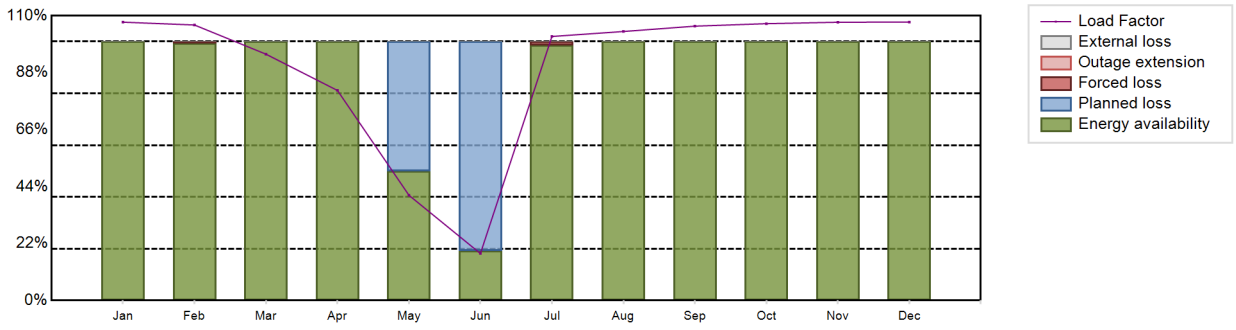
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	7533.32 GW(e).h
Energy Availability Factor (EAF)	:	88.96 %
Unit Capability Factor (UCF)	:	88.96 %
Load Factor (LF)	:	90.28 %
Operating Factor (OF)	:	89.28 %
Equivalent non-electrical energy generated (NEG)	:	6.56 GW(e).h
Forced Loss Rate (FLR)	:	0.18 %
Unplanned Capability Loss Factor (UCL)	:	0.16 %
Planned Unavailability Factor (PUF)	:	10.87 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	942 hours

Annual Summary



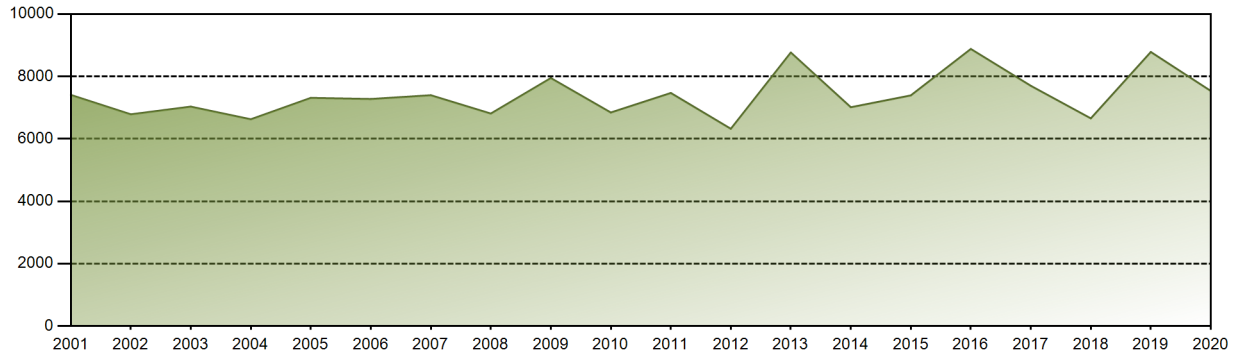
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	759.83	703.58	672.48	554.95	287.39	124.22	720.74	734.42	724.76	755.71	735.10	760.14	7533.33
EAF [%]	100.00	99.45	100.00	100.00	49.87	19.13	98.61	100.00	100.00	100.00	100.00	100.00	88.96
UCF [%]	100.00	99.45	100.00	100.00	49.87	19.13	98.61	100.00	100.00	100.00	100.00	100.00	88.96
LF [%]	107.50	106.41	95.14	81.13	40.66	18.16	101.97	103.91	105.96	106.92	107.47	107.55	90.28
OF [%]	100.00	100.00	100.00	100.00	49.87	20.97	100.00	100.00	100.00	100.00	100.00	100.00	89.28
FLR [%]	0.00	0.55	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.18
UCL [%]	0.00	0.55	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.16
PUF [%]	0.00	0.00	0.00	0.00	50.13	80.87	0.00	0.00	0.00	0.00	0.00	0.00	10.87
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

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Historical Summary

Lifetime energy generation	:	213728.73 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.62 %
Cumulative Energy Availability Factor (EAF)	:	74.21 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.47 %
Cumulative Unit Capability Factor (UCF)	:	75.98 %	Cumulative Planned Unavailability Factor (PUF)	:	17.54 %
Cumulative Load Factor (LF)	:	73.57 %	Cumulative Externally cause unavailability (XUF)	:	1.77 %
Cumulative Operating Factor (OF)	:	76.33 %			

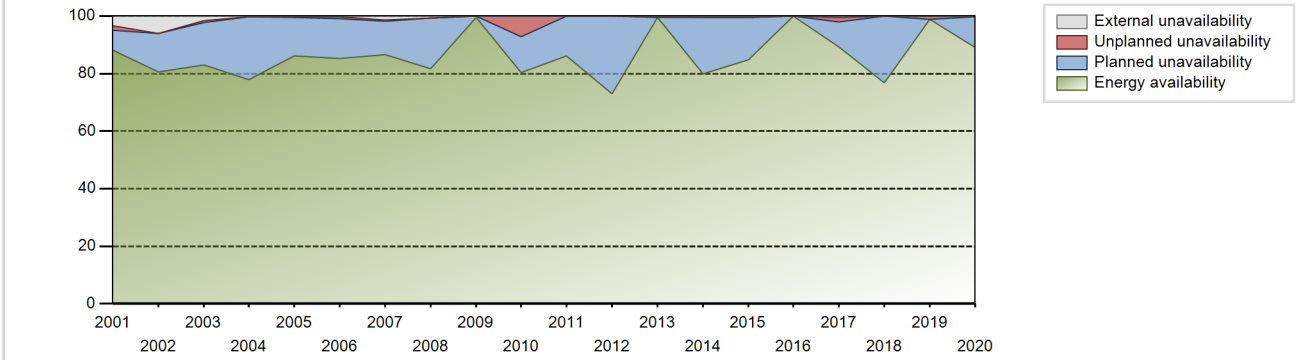
Electricity Production (net) [GWh]



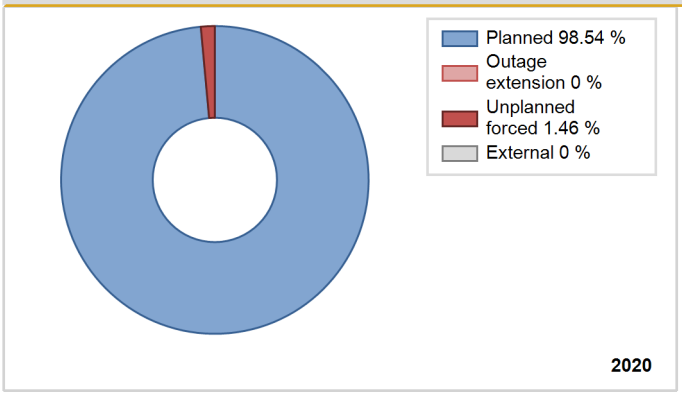
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	4868.03	6082	950	64.85	64.85	64.46	69.51	17.62	13.87	21.28	0.00
1987	4703.68	5302	1000	57.40	57.40	53.70	60.53	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

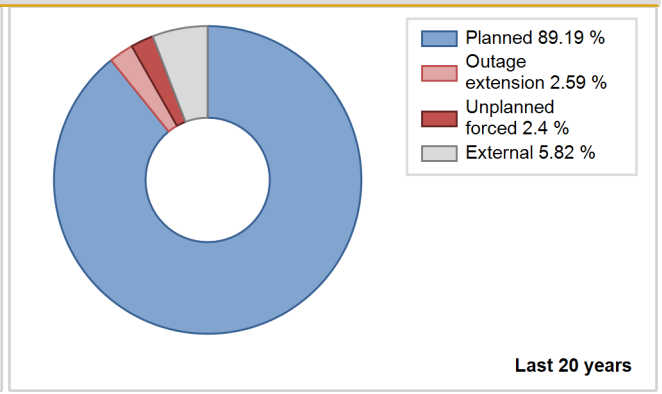
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1986 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					313	
C. Inspection, maintenance or repair combined with refuelling	1010			1243	11	
D. Inspection, maintenance or repair without refuelling				265		
E. Testing of plant systems or components				1	1	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						139
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
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						71
Z. Other					23	
Subtotal	1010			1509	356	211
Total	**1010**			**2076**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	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		11
16. Steam generation systems		97
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		45
32. Feedwater and Main Steam System		11
33. Circulating Water System		4
34. Miscellaneous Systems		26
35. All other I&C Systems		8
41. Main Generator Systems		86
42. Electrical Power Supply Systems		20
Total		**315**

Highlights (2020)

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-April, June-December. Additional electricity generation amounted to 375537 MWh. The unit was in the intermediate outage from 2020.05.16 to 2020.06.27. 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.

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2020 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 (JSC 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	:	1981-08-01
Grid Date	:	1987-10-08
Commercial Date	:	1988-01-18
Age at end of year	:	33 years

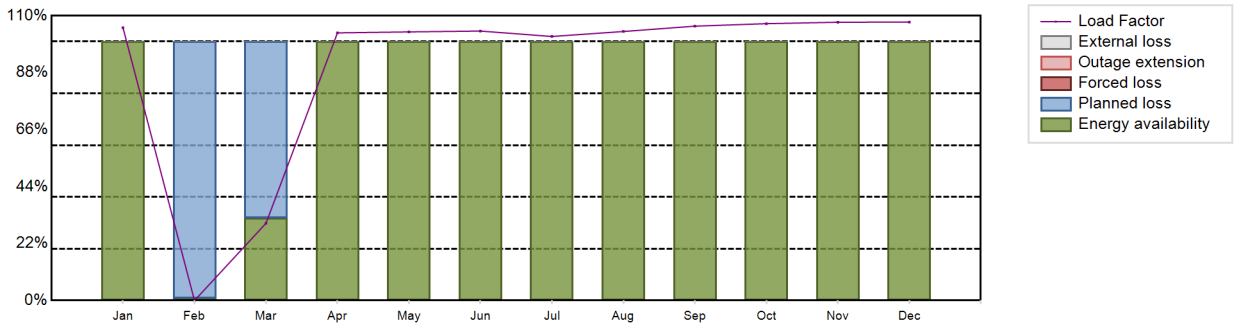
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	7538.45 GW(e).h
Energy Availability Factor (EAF)	:	86.37 %
Unit Capability Factor (UCF)	:	86.37 %
Load Factor (LF)	:	90.34 %
Operating Factor (OF)	:	86.41 %
Equivalent non-electrical energy generated (NEG)	:	4.39 GW(e).h
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	13.63 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1194 hours

Annual Summary



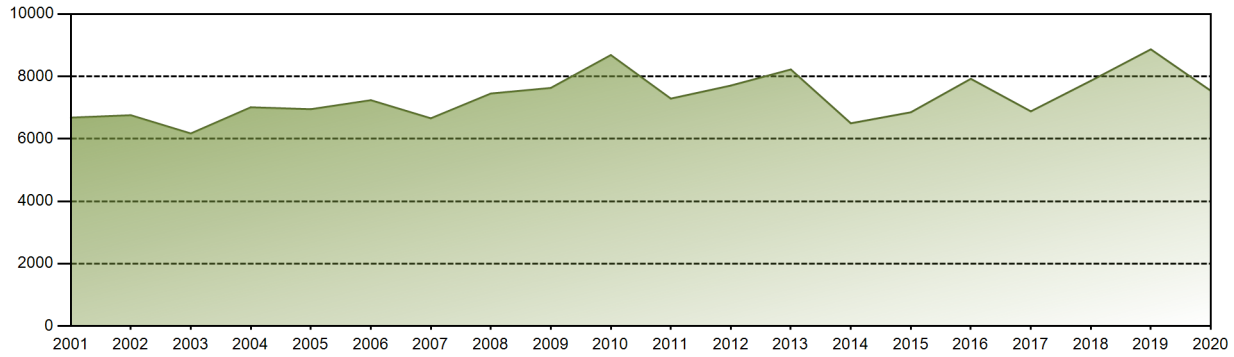
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	744.49	0.00	210.78	707.13	733.30	711.87	720.74	734.42	724.76	755.71	735.10	760.14	7538.45
EAF [%]	100.00	0.91	31.80	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.37
UCF [%]	100.00	0.91	31.80	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.37
LF [%]	105.33	0.00	29.82	103.38	103.75	104.07	101.97	103.91	105.96	106.92	107.47	107.55	90.34
OF [%]	100.00	1.58	31.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.41
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	99.09	68.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.63
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

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Historical Summary

Lifetime energy generation	:	205164 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.33 %
Cumulative Energy Availability Factor (EAF)	:	73.56 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.01 %
Cumulative Unit Capability Factor (UCF)	:	75.95 %	Cumulative Planned Unavailability Factor (PUF)	:	18.04 %
Cumulative Load Factor (LF)	:	74.29 %	Cumulative Externally cause unavailability (XUF)	:	2.39 %
Cumulative Operating Factor (OF)	:	77.82 %			

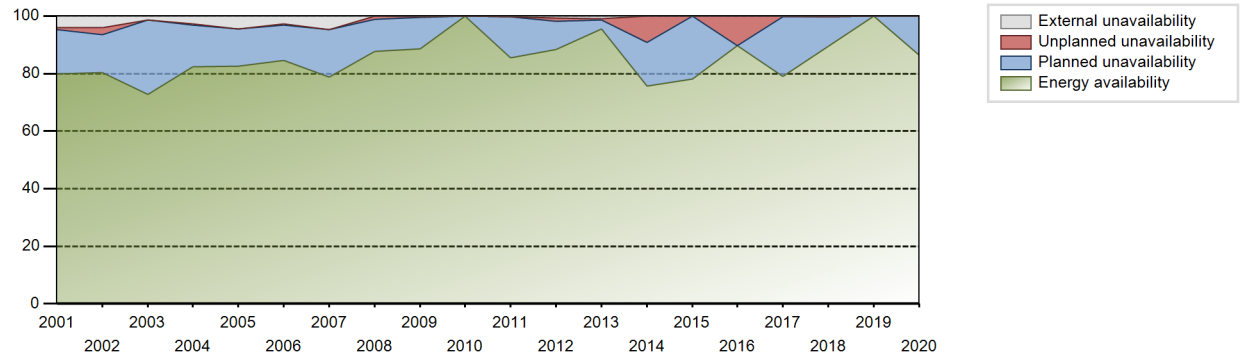
Electricity Production (net) [GWh]



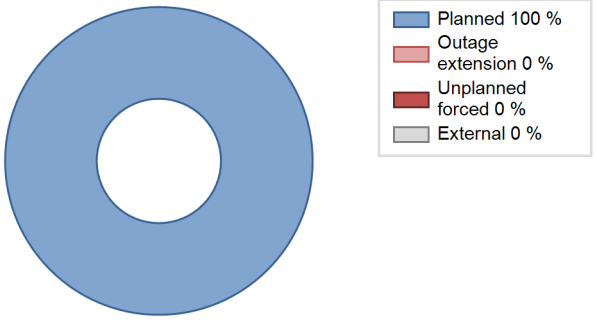
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	5978.43	6928	950	75.49	75.49	70.63	77.66	6.59	5.33	19.18	0.00
1989	6703.63	7626	950	84.75	84.77	80.55	87.05	9.33	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

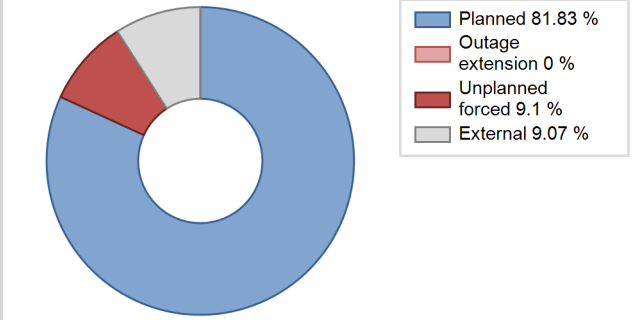
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					347	
C. Inspection, maintenance or repair combined with refuelling	1193			1399	83	
D. Inspection, maintenance or repair without refuelling				91		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						6
L. Human factor related					3	
Z. Other					13	
Subtotal	1193			1490	446	6
Total	**1193**			**1942**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		7
15. Reactor Cooling Systems		6
16. Steam generation systems		243
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		1
32. Feedwater and Main Steam System		17
35. All other I&C Systems		3
41. Main Generator Systems		69
42. Electrical Power Supply Systems		1
Total		**349**

Highlights (2020)

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-Desember. Additional electricity generation amounted to 369536 MWh. The unit was in the overhaul outage from 2020.02.01 to 2020.03.22. 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.

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2020 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 (JSC 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	:	3000 MWth
Gross electrical power	:	1000 MWe
Reference unit power (net)	:	950 MWe

Key Dates

Construction Date	:	1982-11-01
Grid Date	:	1988-12-25
Commercial Date	:	1989-04-08
Age at end of year	:	32 years

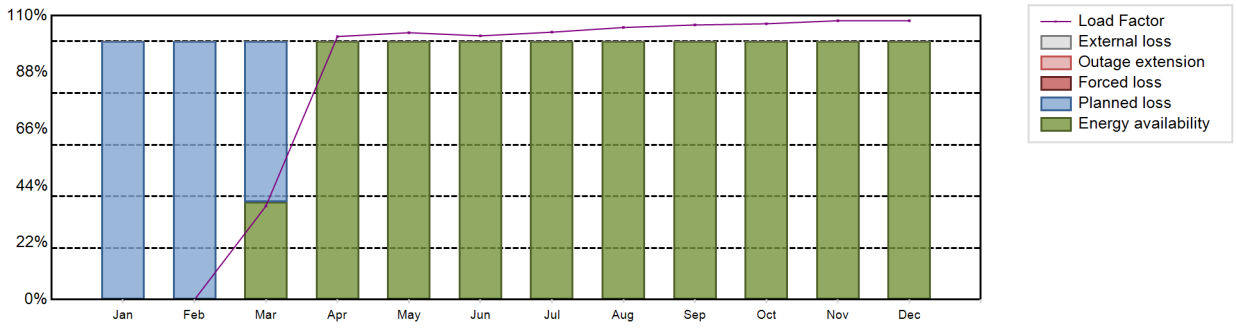
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	6845.49 GW(e).h
Energy Availability Factor (EAF)	:	78.34 %
Unit Capability Factor (UCF)	:	78.34 %
Load Factor (LF)	:	82.03 %
Operating Factor (OF)	:	78.32 %
Equivalent non-electrical energy generated (NEG)	:	2.26 GW(e).h
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	21.66 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1904 hours

Annual Summary



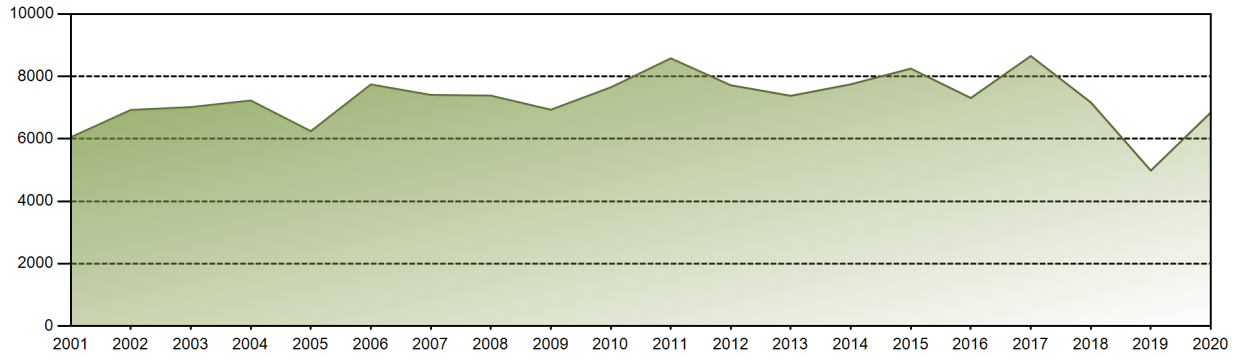
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	256.41	696.99	730.79	698.78	732.20	744.99	727.63	755.20	738.89	763.60	6845.49
EAF [%]	0.00	0.00	37.77	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	78.34
UCF [%]	0.00	0.00	37.77	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	78.34
LF [%]	0.00	0.00	36.28	101.90	103.39	102.16	103.59	105.40	106.38	106.85	108.03	108.04	82.03
OF [%]	0.00	0.00	37.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	78.32
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	62.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.66
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

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Historical Summary

Lifetime energy generation	:	203588.44 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.02 %
Cumulative Energy Availability Factor (EAF)	:	76.17 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.47 %
Cumulative Unit Capability Factor (UCF)	:	79.11 %	Cumulative Planned Unavailability Factor (PUF)	:	18.42 %
Cumulative Load Factor (LF)	:	76.55 %	Cumulative Externally cause unavailability (XUF)	:	2.95 %
Cumulative Operating Factor (OF)	:	80.4 %			

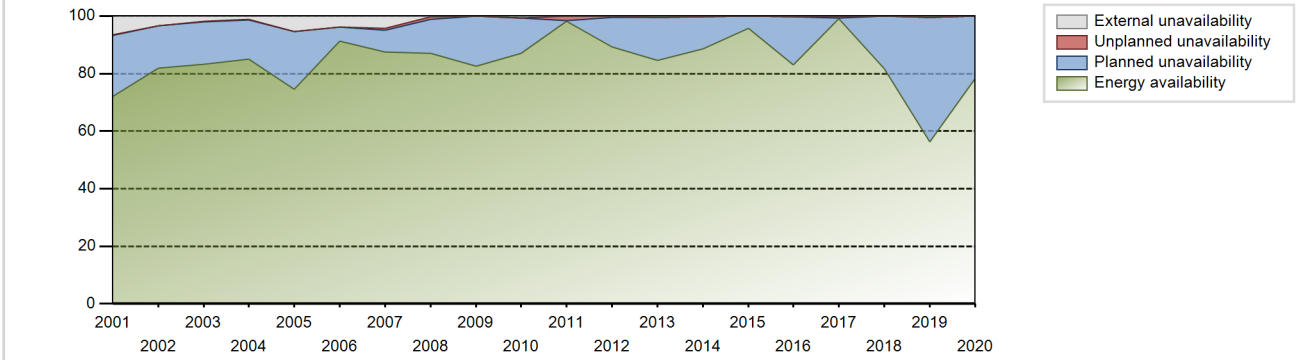
Electricity Production (net) [GWh]



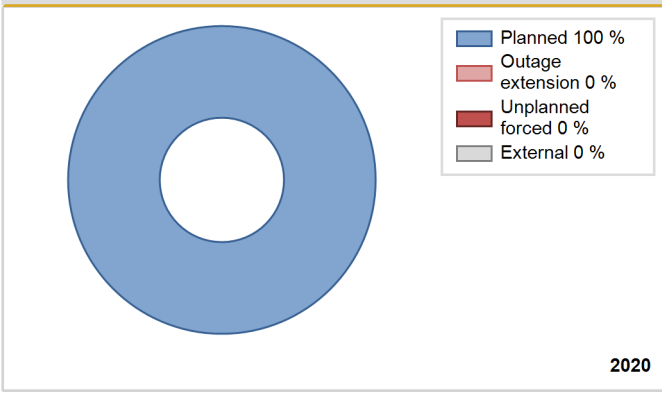
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	6621.41	7792	950	88.36	88.36	87.44	91.12	6.11	5.75	5.90	0.00
1990	5718.71	6696	950	67.84	68.04	68.72	76.44	13.53	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

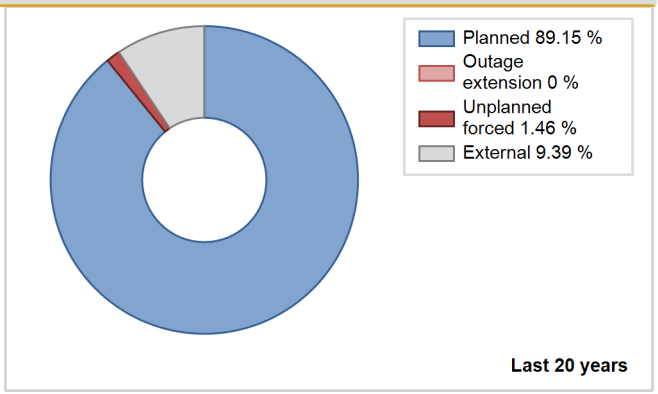
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					74	
C. Inspection, maintenance or repair combined with refuelling	1903			1395	21	
D. Inspection, maintenance or repair without refuelling				169		
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)						46
L. Human factor related					5	
Z. Other					2	
Subtotal	1903			1564	103	47
Total	**1903**			**1714**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		24
13. Reactor Auxiliary Systems		0
15. Reactor Cooling Systems		5
16. Steam generation systems		1
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		9
32. Feedwater and Main Steam System		5
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		12
Total		**77**

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Highlights (2020)

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 March-December. Additional electricity generation amounted to 355916 MWh. The unit was in the intermediate outage from 2020.01.01 to 2020.03.20. 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.

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2020 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 (JSC 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	:	1984-04-01
Grid Date	:	1993-04-11
Commercial Date	:	1993-12-22
Age at end of year	:	27 years

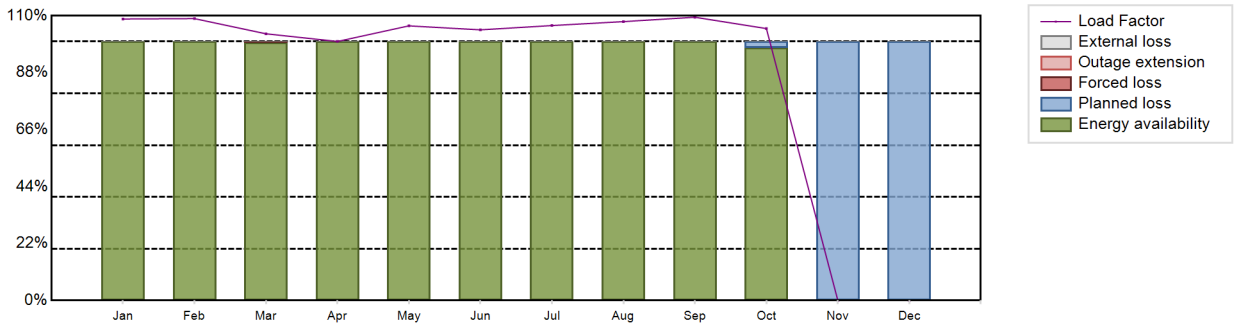
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	7368.35 GW(e).h	Forced Loss Rate (FLR)	:	0.03 %
Energy Availability Factor (EAF)	:	83.11 %	Unplanned Capability Loss Factor (UCL)	:	0.02 %
Unit Capability Factor (UCF)	:	83.11 %	Planned Unavailability Factor (PUF)	:	16.87 %
Load Factor (LF)	:	88.3 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	83.19 %	Total off-line time	:	1477 hours
Equivalent non-electrical energy generated (NEG)	:	4.1 GW(e).h			

Annual Summary



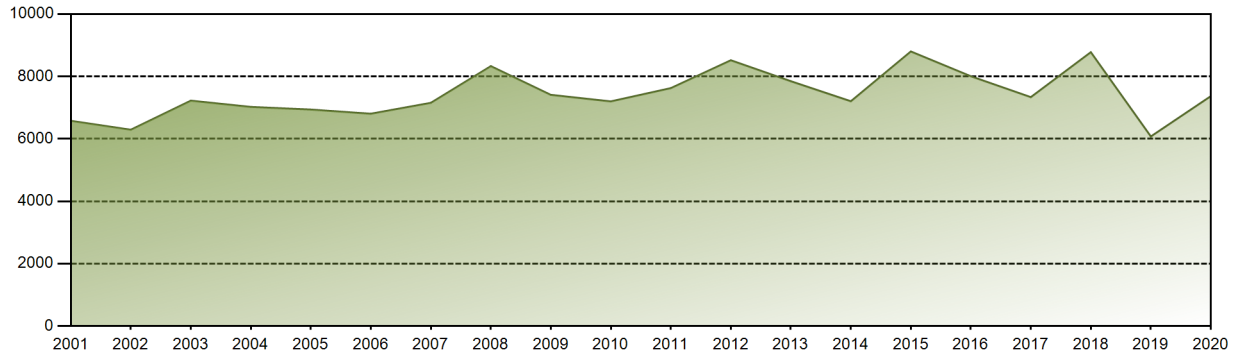
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	768.46	719.90	728.12	684.35	749.77	715.03	750.64	761.36	748.34	742.39	0.00	0.00	7368.35
EAF [%]	100.00	100.00	99.71	100.00	100.00	100.00	100.00	100.00	100.00	97.63	0.00	0.00	83.11
UCF [%]	100.00	100.00	99.71	100.00	100.00	100.00	100.00	100.00	100.00	97.63	0.00	0.00	83.11
LF [%]	108.72	108.88	103.02	100.05	106.08	104.54	106.20	107.72	109.41	105.04	0.00	0.00	88.30
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.25	0.00	0.00	83.19
FLR [%]	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03
UCL [%]	0.00	0.00	0.29	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	0.00	0.00	0.00	0.00	0.00	2.37	100.00	100.00	16.87
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

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Historical Summary

Lifetime energy generation	:	188323.96 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.41 %
Cumulative Energy Availability Factor (EAF)	:	80.5 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.2 %
Cumulative Unit Capability Factor (UCF)	:	83.71 %	Cumulative Planned Unavailability Factor (PUF)	:	15.09 %
Cumulative Load Factor (LF)	:	82.12 %	Cumulative Externally cause unavailability (XUF)	:	3.21 %
Cumulative Operating Factor (OF)	:	84.95 %			

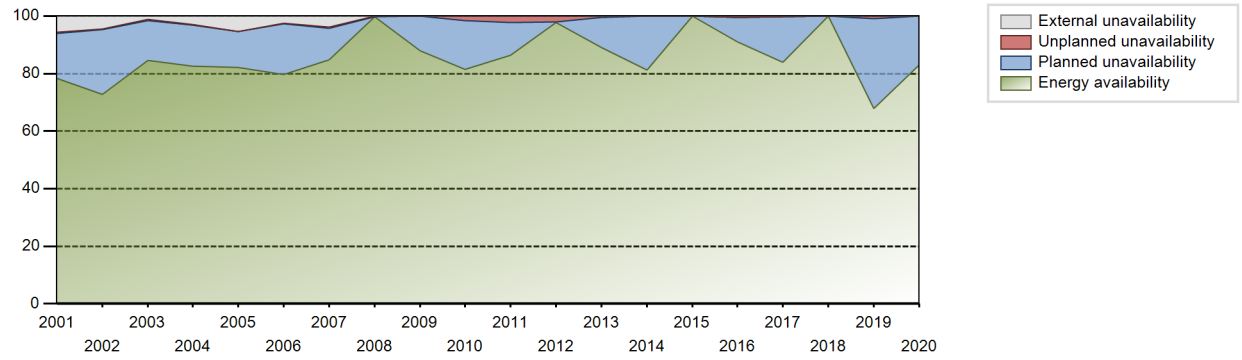
Electricity Production (net) [GWh]



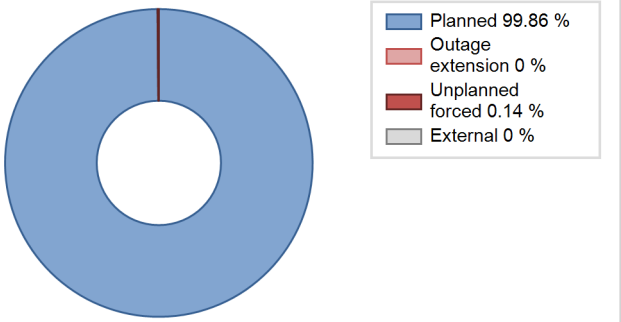
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	3676.28	5206	950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	3828.53	4604	950	48.45	69.54	46.00	52.56	1.58	1.12	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

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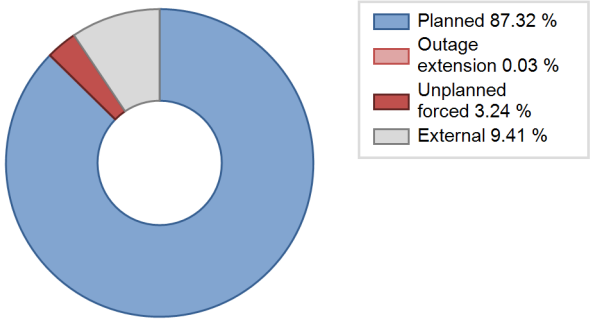
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1993 to 2020 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	1477			1199		
D. Inspection, maintenance or repair without refuelling				17		
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						13
L. Human factor related					0	
Z. Other						62
Subtotal	1477			1216	28	75
Total	**1477**			**1319**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1993 to 2020 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		10
35. All other I&C Systems		1
41. Main Generator Systems		2
42. Electrical Power Supply Systems		4
Total		**28**

Highlights (2020)

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-October. Additional electricity generation amounted to 468553 MWh. The unit was in the overhaul outage from 2020.10.31 to 2021.01.01. 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.

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2020 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 (JSC 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	:	40 years

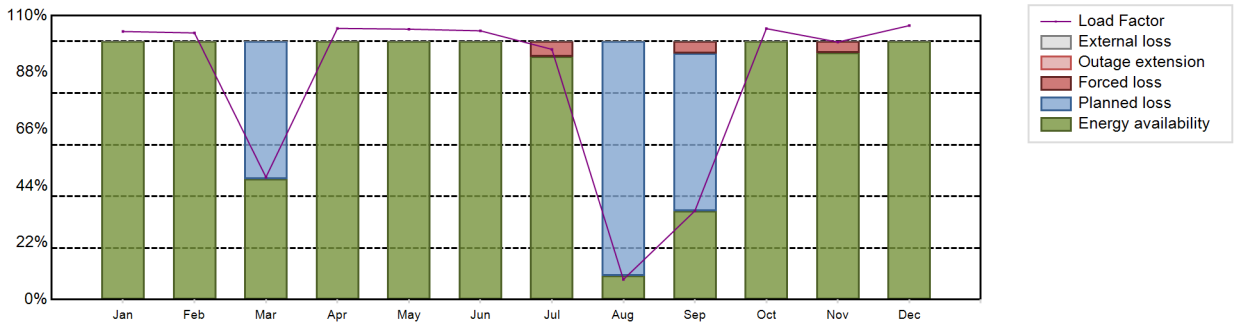
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	8.8
Reactor vessel centreline orientation	:	-	Reactor outlet temperature [°C]	:	550
Fuel material	:	UO2	Number of SG	:	3
Refuelling type	:	ON-line	Containment type	:	-
Moderator material	:	-	Containment design pressure [MPa]	:	-
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	5	Number of turbine-generators per unit/reactor	:	3
Part of the core refuelled [%]	:	30	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	100000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	2.05	HP cylinder inlet steam pressure [MPa]	:	13
Active core height/length [m]	:	1.03	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	369	Primary means of condenser cooling	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	38	Number of main condensate pumps	:	-
Number of control rod assemblies	:	19	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	:	Na	**Non-electrical applications**	:	DH / PH

Annual Production Results (2020)

Net Energy Production	:	4169.76 GW(e).h	Forced Loss Rate (FLR)	:	1.47 %
Energy Availability Factor (EAF)	:	81.6 %	Unplanned Capability Loss Factor (UCL)	:	1.22 %
Unit Capability Factor (UCF)	:	81.6 %	Planned Unavailability Factor (PUF)	:	17.19 %
Load Factor (LF)	:	84.77 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	83.54 %	Total off-line time	:	1446 hours
Equivalent non-electrical energy generated (NEG)	:	86.46 GW(e).h			

Annual Summary



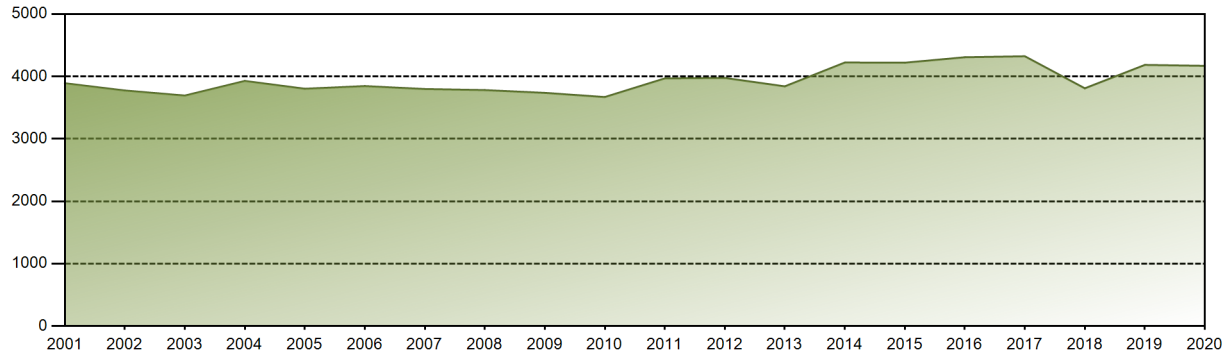
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	432.72	402.60	197.62	423.62	436.42	419.83	403.88	32.57	138.63	437.37	402.25	442.25	4169.76
EAF [%]	100.00	100.00	46.86	100.00	100.00	100.00	94.27	9.26	34.44	100.00	95.63	100.00	81.60
UCF [%]	100.00	100.00	46.86	100.00	100.00	100.00	94.27	9.26	34.44	100.00	95.63	100.00	81.60
LF [%]	103.86	103.29	47.43	105.06	104.75	104.12	96.94	7.82	34.38	104.97	99.76	106.15	84.77
OF [%]	100.00	100.00	51.48	100.00	100.00	100.00	100.00	10.62	41.67	100.00	100.00	100.00	83.54
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	5.73	0.00	11.70	0.00	4.37	0.00	1.47
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	5.73	0.00	4.57	0.00	4.37	0.00	1.22
PUF [%]	0.00	0.00	53.14	0.00	0.00	0.00	0.00	90.74	60.99	0.00	0.00	0.00	17.19
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

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Historical Summary

Lifetime energy generation	:	149131.03 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.68 %
Cumulative Energy Availability Factor (EAF)	:	75.73 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.99 %
Cumulative Unit Capability Factor (UCF)	:	76.26 %	Cumulative Planned Unavailability Factor (PUF)	:	20.75 %
Cumulative Load Factor (LF)	:	76.16 %	Cumulative Externally cause unavailability (XUF)	:	0.53 %
Cumulative Operating Factor (OF)	:	78.77 %			

Electricity Production (net) [GWh]

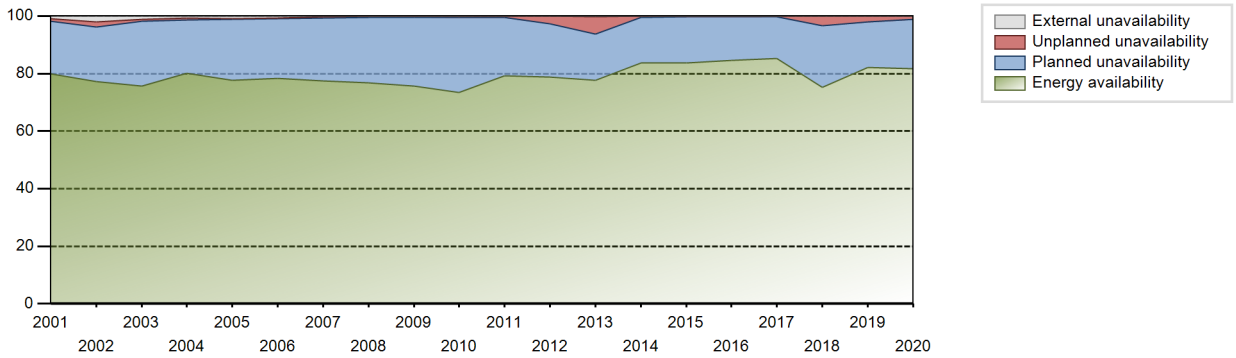


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	Data not provided										
1982	2771.00	5555	560	59.25	59.25	56.49	63.41	11.50	7.70	33.05	0.00
1983	3545.21	6737	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

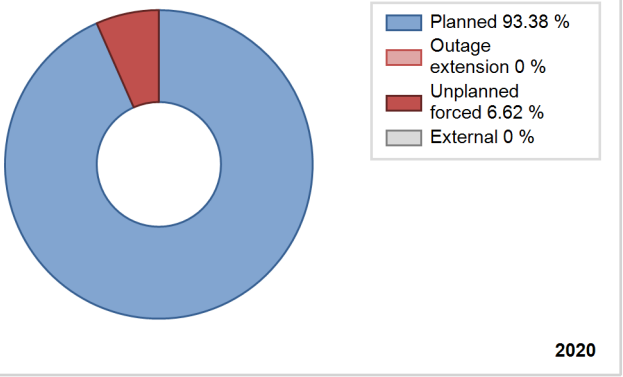
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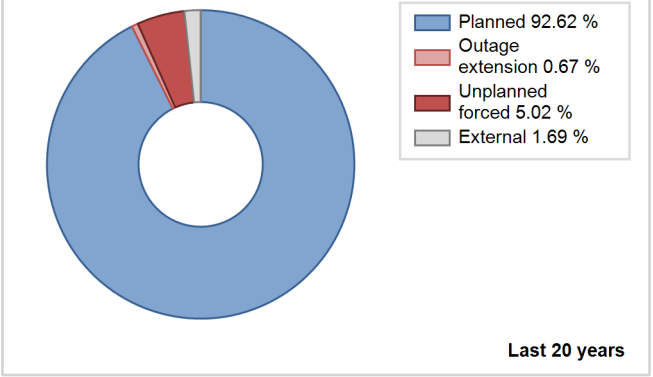
2018	3809.52	6911	560	75.28	75.28	77.66	78.89	3.23	3.38	21.34	0.00
2019	4184.26	7453	560	82.22	82.22	85.30	85.08	1.95	2.15	15.63	0.00
2020	4169.76	7338	560	81.60	81.60	84.77	83.54	1.47	1.22	17.19	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		71			121	
C. Inspection, maintenance or repair combined with refuelling	1443			1269		
D. Inspection, maintenance or repair without refuelling				430	6	
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	1443	71		1699	129	3
Total		**1514**			**1831**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1981 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems	71	2
13. Reactor Auxiliary Systems		12
15. Reactor Cooling Systems		29
21. Fuel Handling and Storage Facilities		68
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	**71**	**123**

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Highlights (2020)

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-December. Additional electricity generation amounted to 151462.267 MWh. The unit was in the intermediate outage from 2020.03.02 to 2020.03.17 and the routine maintenance outage from 2020.08.04 to 2020.09.18 . 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	AEM (JSC 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	:	5 years

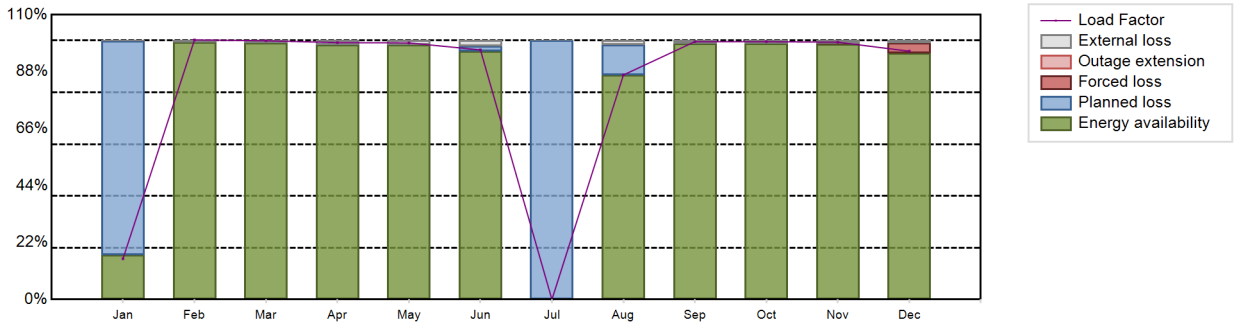
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	1.65
Reactor vessel centreline orientation	:	-	Reactor outlet temperature [°C]	:	547
Fuel material	:	UO2/PuO2	Number of SG	:	3
Refuelling type	:	OFF-line	Containment type	:	-
Moderator material	:	-	Containment design pressure [MPa]	:	-
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	6	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	-	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	-	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	2.56	HP cylinder inlet steam pressure [MPa]	:	13
Active core height/length [m]	:	0.88	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	565	Primary means of condenser cooling	:	-
Fuel linear heat generation rate [kW/m]	:	38	Number of main condensate pumps	:	-
Number of control rod assemblies	:	16	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	:	NA	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	5934.14 GW(e).h	Forced Loss Rate (FLR)	:	0.45 %
Energy Availability Factor (EAF)	:	81.92 %	Unplanned Capability Loss Factor (UCL)	:	0.38 %
Unit Capability Factor (UCF)	:	82.98 %	Planned Unavailability Factor (PUF)	:	16.64 %
Load Factor (LF)	:	82.39 %	Externally cause unavailability (XUF)	:	1.06 %
Operating Factor (OF)	:	83.94 %	Total off-line time	:	1411 hours

Annual Summary



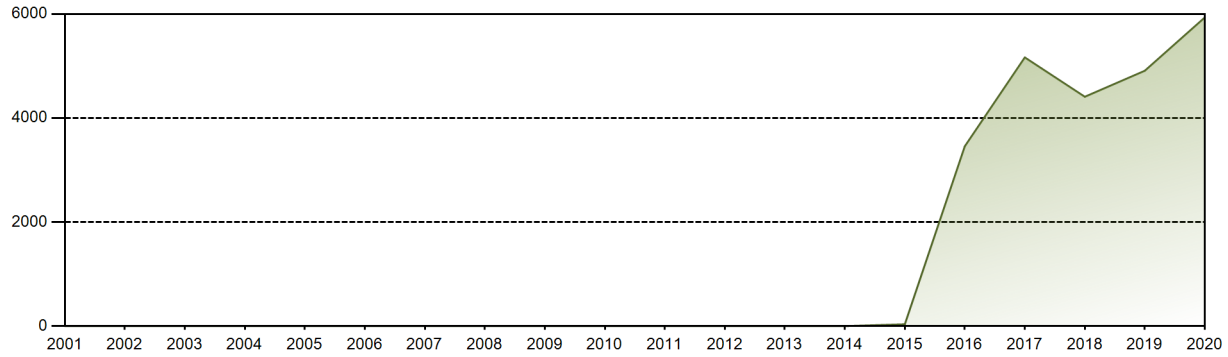
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	96.17	572.25	609.66	585.82	604.68	569.23	0.00	529.08	587.91	607.59	586.70	585.05	5934.14
EAF [%]	17.17	99.41	99.08	98.35	98.25	95.78	0.01	86.63	98.99	98.99	98.52	95.07	81.92
UCF [%]	17.28	100.00	100.00	100.00	100.00	98.02	0.01	88.17	100.00	100.00	99.55	96.00	82.98
LF [%]	15.76	100.27	99.93	99.22	99.12	96.41	0.00	86.72	99.58	99.59	99.37	95.90	82.39
OF [%]	20.30	100.00	100.00	100.00	100.00	100.00	0.13	89.92	100.00	100.00	100.00	100.00	83.94
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	4.00	0.45
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	4.00	0.38
PUF [%]	82.72	0.00	0.00	0.00	0.00	1.98	99.99	11.83	0.00	0.00	0.00	0.00	16.64
XUF [%]	0.11	0.59	0.92	1.65	1.75	2.25	0.00	1.54	1.01	1.01	1.03	0.93	1.06

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Historical Summary

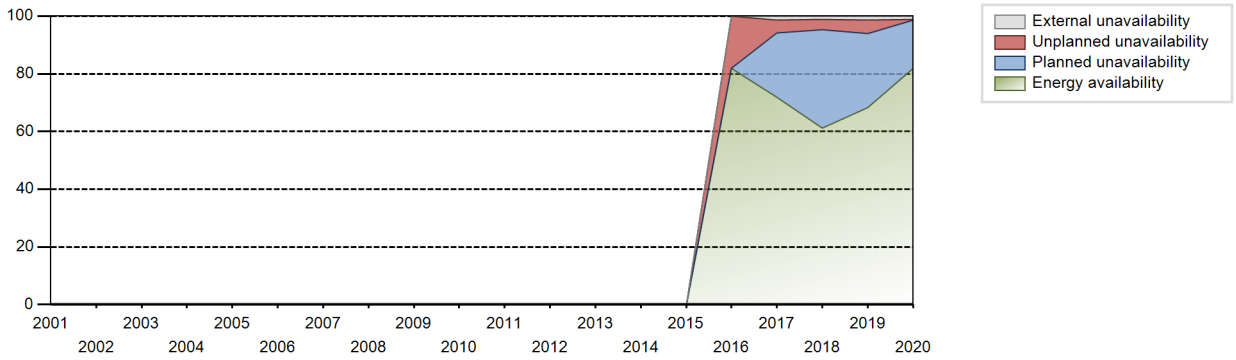
Lifetime energy generation	:	23909.64 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.41 %
Cumulative Energy Availability Factor (EAF)	:	71.26 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.88 %
Cumulative Unit Capability Factor (UCF)	:	72.41 %	Cumulative Planned Unavailability Factor (PUF)	:	23.71 %
Cumulative Load Factor (LF)	:	71.45 %	Cumulative Externally cause unavailability (XUF)	:	1.15 %
Cumulative Operating Factor (OF)	:	74.5 %			

Electricity Production (net) [GWh]

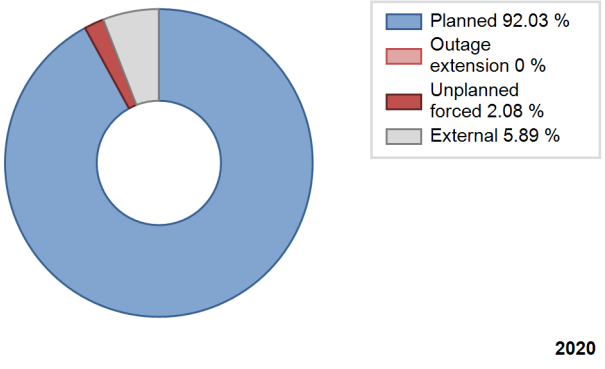


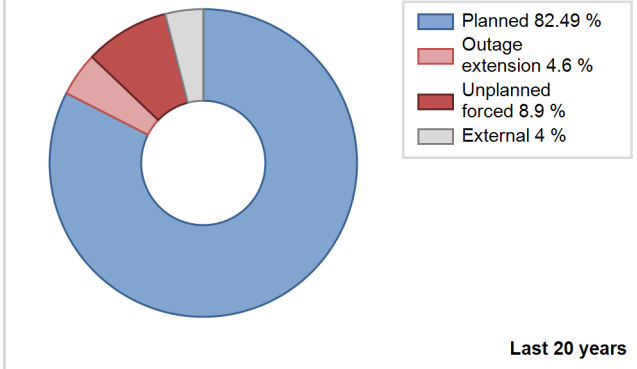
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	3456.96	5453	820	81.92	81.92	81.96	96.45	18.08	18.08	0.00	0.00
2017	5165.75	6551	820	71.81	73.11	71.91	74.78	1.71	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					202	
C. Inspection, maintenance or repair combined with refuelling	1411			1947		
D. Inspection, maintenance or repair without refuelling				101		
Subtotal	1411			2048	202	
Total	**1411**			**2250**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		38
14. Safety Systems		15
31. Turbine and auxiliaries		59
32. Feedwater and Main Steam System		10
41. Main Generator Systems		46
Total		**168**

Highlights (2020)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. The unit was in the overhoul outage from 2020.01.01 to 2020.01.25 and routine maintenance outage from 2020.07.01 to 2020.08.06. 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.

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2020 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 (JSC 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	:	46 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

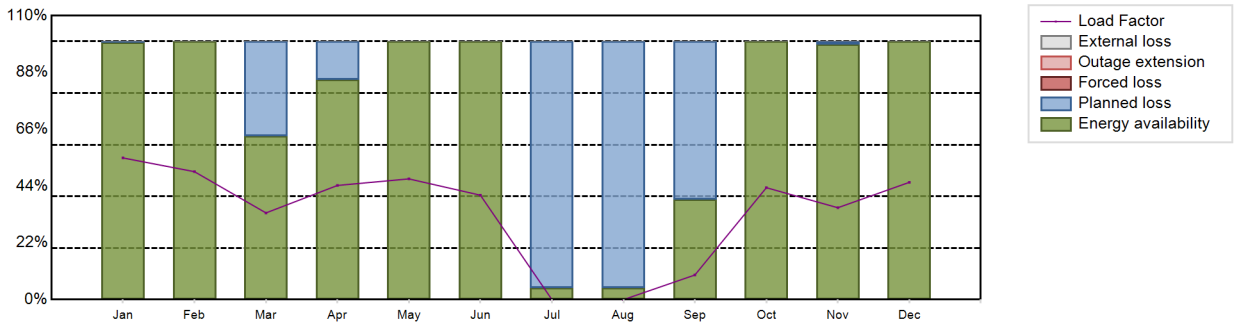
Operating coolant pressure [MPa]	:	6
Reactor outlet temperature [°C]	:	280
Number of SG	:	NA
Containment type	:	NA
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	32.42 GW(e).h
Energy Availability Factor (EAF)	:	74.4 %
Unit Capability Factor (UCF)	:	74.4 %
Load Factor (LF)	:	33.55 %
Operating Factor (OF)	:	73.19 %
Equivalent non-electrical energy generated (NEG)	:	13.54 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	25.6 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	2355 hours

Annual Summary



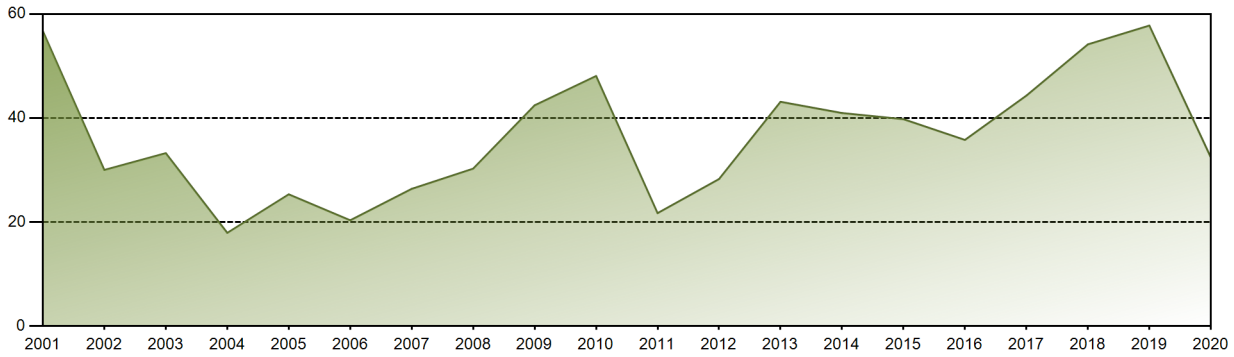
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	4.49	3.79	2.75	3.50	3.83	3.20	0.00	0.00	0.76	3.55	2.82	3.72	32.42
EAF [%]	99.69	100.00	63.48	85.24	100.00	100.00	4.64	4.55	38.81	100.00	98.85	100.00	74.40
UCF [%]	99.69	100.00	63.48	85.24	100.00	100.00	4.64	4.55	38.81	100.00	98.85	100.00	74.40
LF [%]	54.89	49.57	33.59	44.23	46.77	40.45	0.04	0.00	9.56	43.37	35.61	45.44	33.55
OF [%]	99.73	100.00	61.69	84.58	100.00	100.00	0.13	0.00	35.97	100.00	98.75	100.00	73.19
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 [%]	0.31	0.00	36.52	14.76	0.00	0.00	95.36	95.45	61.19	0.00	1.15	0.00	25.60
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

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Historical Summary

Lifetime energy generation	:	2246.46 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.85 %
Cumulative Energy Availability Factor (EAF)	:	72.68 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.54 %
Cumulative Unit Capability Factor (UCF)	:	81.55 %	Cumulative Planned Unavailability Factor (PUF)	:	16.92 %
Cumulative Load Factor (LF)	:	52.28 %	Cumulative Externally cause unavailability (XUF)	:	8.87 %
Cumulative Operating Factor (OF)	:	79.38 %			

Electricity Production (net) [GWh]

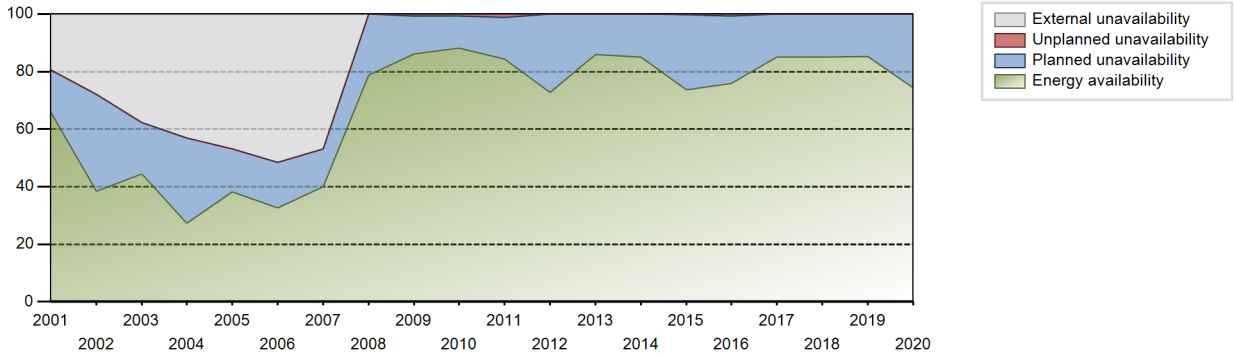


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	63.76	7365	10	88.97	94.67	78.14	90.14	1.31	1.26	4.07	5.70
1976	66.10	7901	10	83.67	89.44	75.25	89.95	1.10	0.99	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

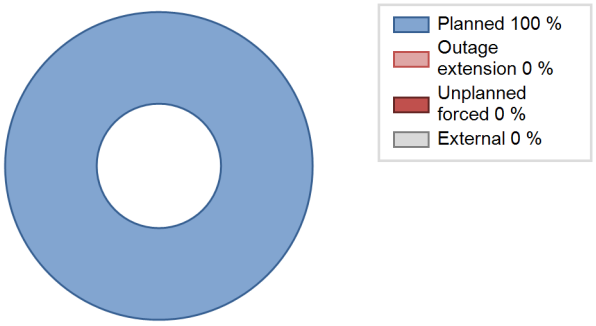
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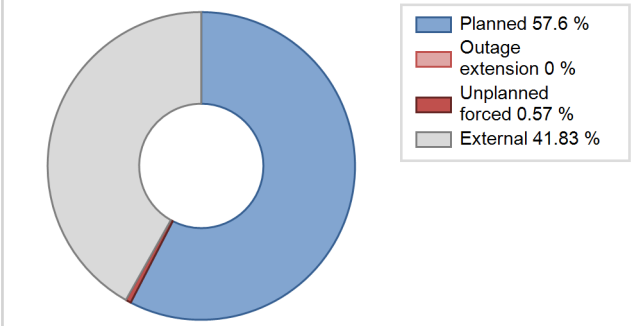
2012	28.27	5461	11	72.73	72.73	29.26	62.17	0.05	0.04	27.24	0.00
2013	43.12	6904	11	85.84	85.84	44.75	78.81	0.00	0.00	14.16	0.00
2014	40.96	6457	11	84.92	84.92	42.51	73.71	0.00	0.00	15.08	0.00
2015	39.78	6331	11	73.73	73.73	41.28	72.27	0.44	0.32	25.95	0.00
2016	35.79	6506	11	75.88	75.88	37.04	74.07	0.86	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					107	
B. Refuelling without maintenance	396			9		
C. Inspection, maintenance or repair combined with refuelling	1949			1423	65	
D. Inspection, maintenance or repair without refuelling				104		
E. Testing of plant systems or components	11			7		
J. Grid limitation, failure or grid unavailability						13
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						109
L. Human factor related					5	
Z. Other				5		
Subtotal	2356			1548	177	122
Total	**2356**			**1847**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		55
12. Reactor I&C Systems		10
14. Safety Systems		0
15. Reactor Cooling Systems		6
16. Steam generation systems		4
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		7
33. Circulating Water System		0
34. Miscellaneous Systems		3
41. Main Generator Systems		6
Total		**108**

Highlights (2020)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. The unit was in the routine maintenance outage from 2020.03.20 to 2020.04.05 and in the in the overhoul outage from 2020.07.01 to 2020.09.20. 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.

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2020 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 (JSC 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	:	45 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

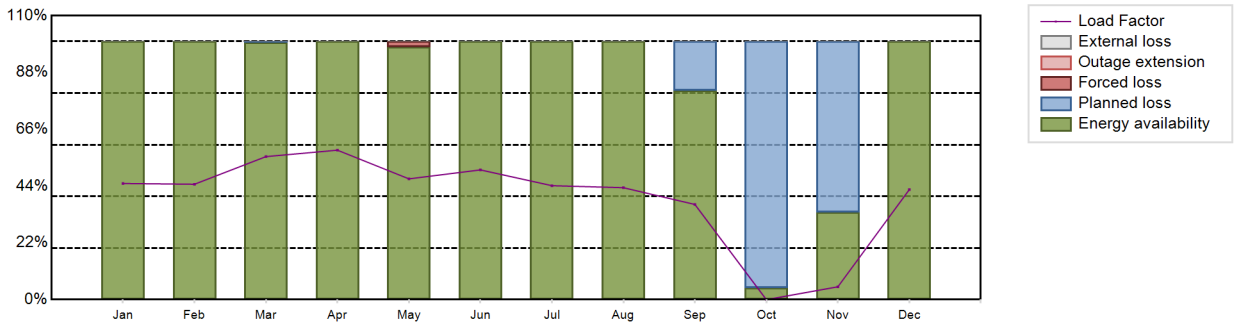
Operating coolant pressure [MPa]	:	6
Reactor outlet temperature [°C]	:	280
Number of SG	:	NA
Containment type	:	NA
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	38 GW(e).h
Energy Availability Factor (EAF)	:	84.73 %
Unit Capability Factor (UCF)	:	84.73 %
Load Factor (LF)	:	39.33 %
Operating Factor (OF)	:	84.02 %
Equivalent non-electrical energy generated (NEG)	:	24.02 GW(e).h

Forced Loss Rate (FLR)	:	0.21 %
Unplanned Capability Loss Factor (UCL)	:	0.18 %
Planned Unavailability Factor (PUF)	:	15.09 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1404 hours

Annual Summary



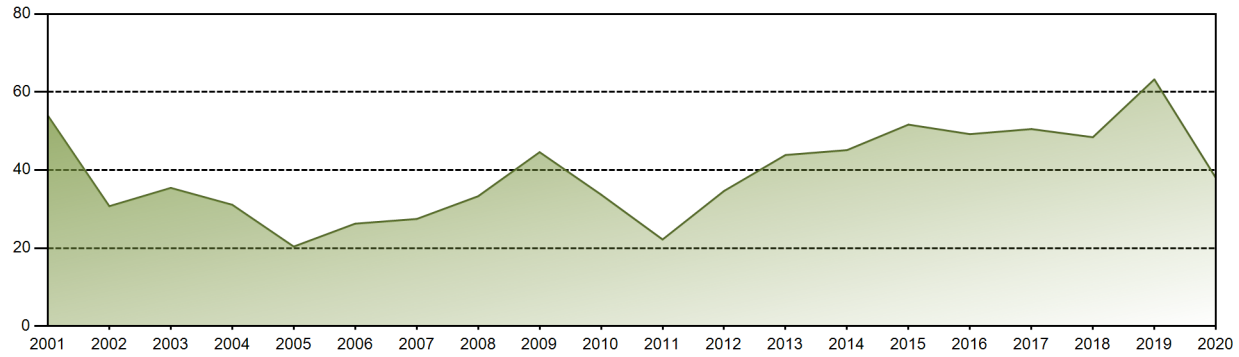
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	3.68	3.42	4.53	4.58	3.83	3.98	3.61	3.55	2.92	0.00	0.39	3.49	38.00
EAF [%]	100.00	100.00	99.65	100.00	97.90	100.00	100.00	100.00	81.00	4.55	33.94	100.00	84.73
UCF [%]	100.00	100.00	99.65	100.00	97.90	100.00	100.00	100.00	81.00	4.55	33.94	100.00	84.73
LF [%]	44.99	44.70	55.40	57.89	46.79	50.25	44.15	43.37	36.87	0.00	4.97	42.64	39.33
OF [%]	100.00	100.00	99.60	100.00	97.85	100.00	100.00	100.00	80.14	0.00	30.83	100.00	84.02
FLR [%]	0.00	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
UCL [%]	0.00	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18
PUF [%]	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	19.00	95.45	66.06	0.00	15.09
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

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Historical Summary

Lifetime energy generation	:	2293.18 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.64 %
Cumulative Energy Availability Factor (EAF)	:	73.05 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.53 %
Cumulative Unit Capability Factor (UCF)	:	81.97 %	Cumulative Planned Unavailability Factor (PUF)	:	17.5 %
Cumulative Load Factor (LF)	:	54.49 %	Cumulative Externally cause unavailability (XUF)	:	8.93 %
Cumulative Operating Factor (OF)	:	80.29 %			

Electricity Production (net) [GWh]

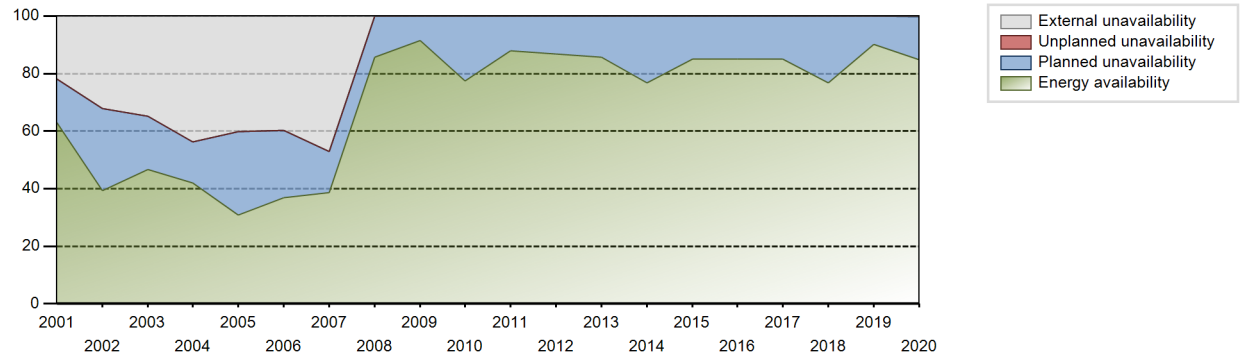


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	51.20	6655	10	83.33	90.55	62.19	77.39	2.85	2.65	6.80	7.21
1977	46.50	7533	10	78.21	92.83	53.08	85.99	0.39	0.36	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

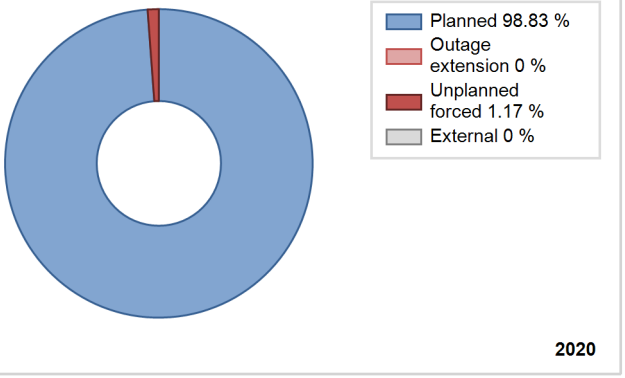
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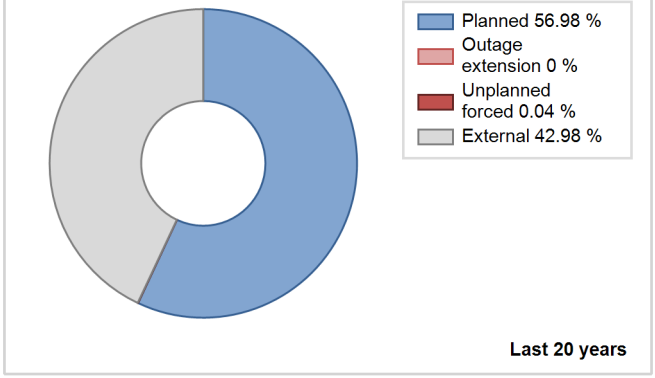
2013	43.85	7436	11	85.64	85.64	45.51	84.89	0.00	0.00	14.36	0.00
2014	45.10	6615	11	76.67	76.67	46.80	75.51	0.00	0.00	23.33	0.00
2015	51.64	7337	11	85.10	85.10	53.60	83.76	0.00	0.00	14.90	0.00
2016	49.20	7410	11	85.10	85.10	50.92	84.36	0.00	0.00	14.90	0.00
2017	50.50	7377	11	84.93	84.93	52.41	84.21	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1976 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		17			46	
C. Inspection, maintenance or repair combined with refuelling	1386			1308		
D. Inspection, maintenance or repair without refuelling				253		
E. Testing of plant systems or components	3			7		
J. Grid limitation, failure or grid unavailability						35
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						98
Z. Other				11	1	
Subtotal	1389	17		1579	47	133
Total	**1406**			**1759**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1976 to 2020 Average hours lost per reactor-year
13. Reactor Auxiliary Systems		1
15. Reactor Cooling Systems		13
31. Turbine and auxiliaries	17	11
32. Feedwater and Main Steam System		7
33. Circulating Water System		0
34. Miscellaneous Systems		13
Total	**17**	**45**

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Highlights (2020)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. The unit was in the intermediate outage from 2020.09.25 to 2020.11.21. 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.

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2020 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 (JSC 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	:	44 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

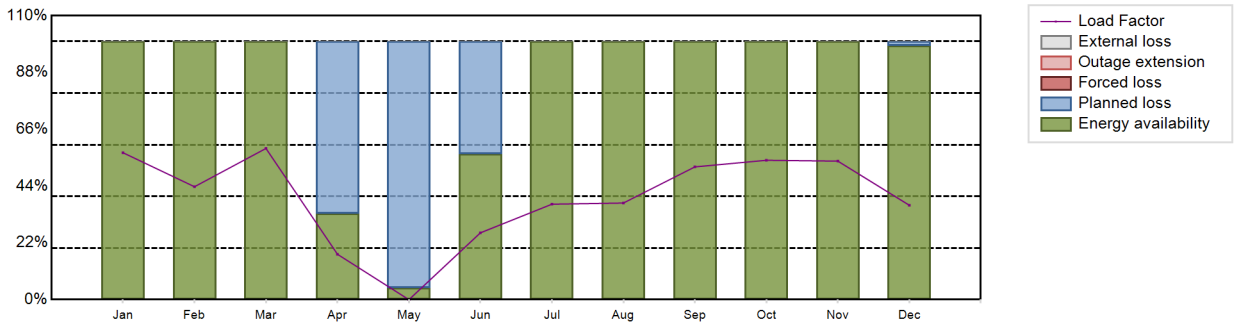
Operating coolant pressure [MPa]	:	6
Reactor outlet temperature [°C]	:	280
Number of SG	:	NA
Containment type	:	NA
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	38.06 GW(e).h
Energy Availability Factor (EAF)	:	82.72 %
Unit Capability Factor (UCF)	:	82.72 %
Load Factor (LF)	:	39.39 %
Operating Factor (OF)	:	81.9 %
Equivalent non-electrical energy generated (NEG)	:	23.01 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	17.28 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1590 hours

Annual Summary



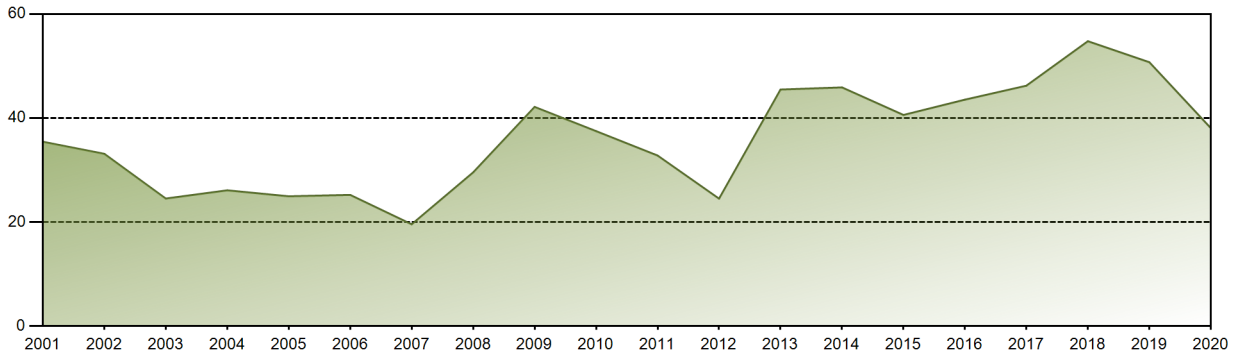
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	4.66	3.35	4.79	1.39	0.00	2.05	3.03	3.06	4.07	4.42	4.25	2.99	38.06
EAF [%]	100.00	100.00	100.00	33.37	4.55	56.31	100.00	100.00	100.00	100.00	100.00	98.25	82.72
UCF [%]	100.00	100.00	100.00	33.37	4.55	56.31	100.00	100.00	100.00	100.00	100.00	98.25	82.72
LF [%]	56.92	43.74	58.57	17.59	0.00	25.88	36.97	37.43	51.41	53.98	53.65	36.56	39.39
OF [%]	100.00	100.00	100.00	30.14	0.00	54.31	100.00	100.00	100.00	100.00	100.00	98.12	81.90
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	66.63	95.45	43.69	0.00	0.00	0.00	0.00	0.00	1.75	17.28
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

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Historical Summary

Lifetime energy generation	:	2132.37 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.66 %
Cumulative Energy Availability Factor (EAF)	:	71.59 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.53 %
Cumulative Unit Capability Factor (UCF)	:	80.12 %	Cumulative Planned Unavailability Factor (PUF)	:	19.35 %
Cumulative Load Factor (LF)	:	52.73 %	Cumulative Externally cause unavailability (XUF)	:	8.53 %
Cumulative Operating Factor (OF)	:	77.97 %			

Electricity Production (net) [GWh]

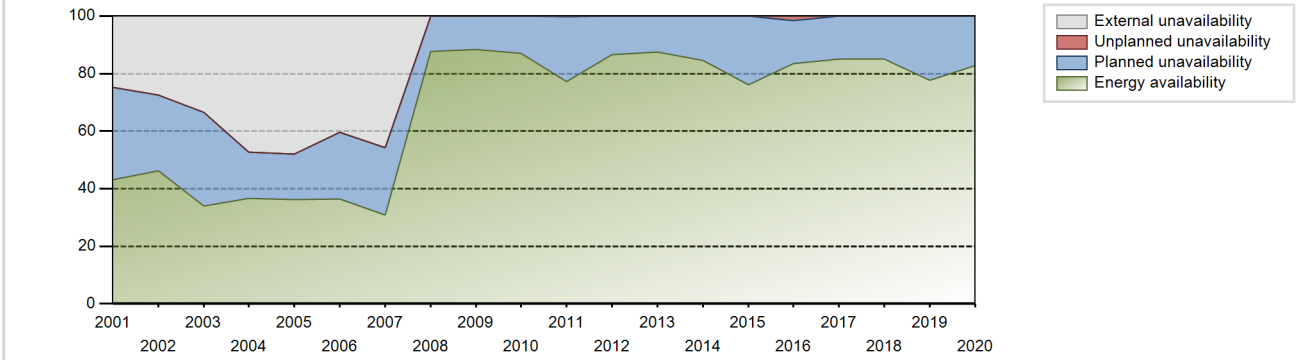


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	52.65	7392	10	82.89	93.56	60.10	84.38	0.28	0.27	6.17	10.67
1978	58.30	7827	10	91.06	91.06	66.55	89.35	0.01	0.01	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

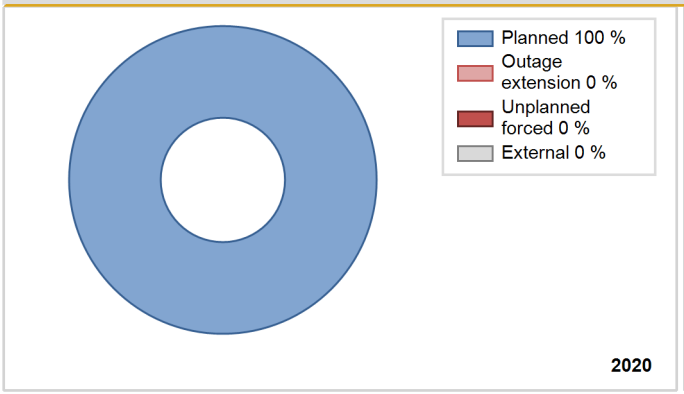
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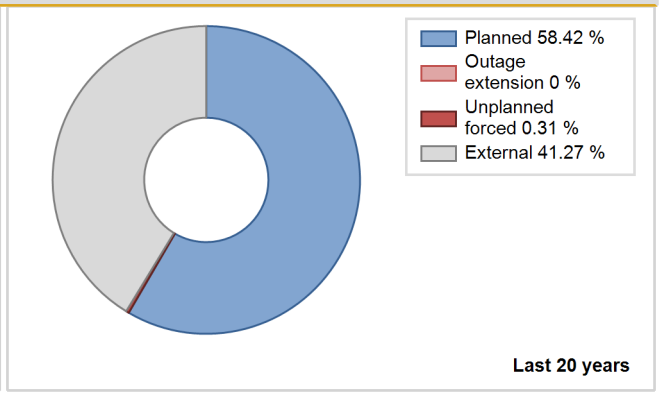
2014	45.89	7187	11	84.56	84.56	47.63	82.04	0.00	0.00	15.44	0.00
2015	40.59	6307	11	76.02	76.02	42.12	72.00	0.00	0.00	23.98	0.00
2016	43.53	7163	11	83.57	83.57	45.05	81.55	1.87	1.59	14.84	0.00
2017	46.22	7395	11	85.13	85.13	47.97	84.42	0.00	0.00	14.87	0.00
2018	54.77	7392	11	85.09	85.09	56.84	84.38	0.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020			1977 to 2020		
		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	1576			1448		
D.	Inspection, maintenance or repair without refuelling				319		
E.	Testing of plant systems or components	14			7		
J.	Grid limitation, failure or grid unavailability						44
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						106
L.	Human factor related					0	
Z.	Other					1	
Subtotal		1590			1774	51	150
Total		**1590**			**1975**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	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		13
Total		**49**

Highlights (2020)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. The unit was in the intermediate outage from 2020.04.10 to 2020.06.14. 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.

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2020 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 (JSC 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	:	36 years

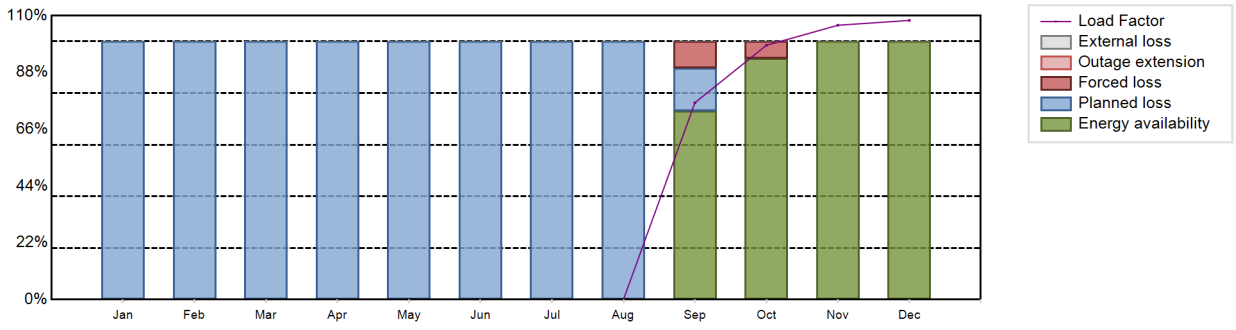
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	2709.37 GW(e).h
Energy Availability Factor (EAF)	:	30.56 %
Unit Capability Factor (UCF)	:	30.56 %
Load Factor (LF)	:	32.47 %
Operating Factor (OF)	:	30.77 %
Equivalent non-electrical energy generated (NEG)	:	5.54 GW(e).h
Forced Loss Rate (FLR)	:	4.41 %
Unplanned Capability Loss Factor (UCL)	:	1.41 %
Planned Unavailability Factor (PUF)	:	68.03 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	6081 hours

Annual Summary



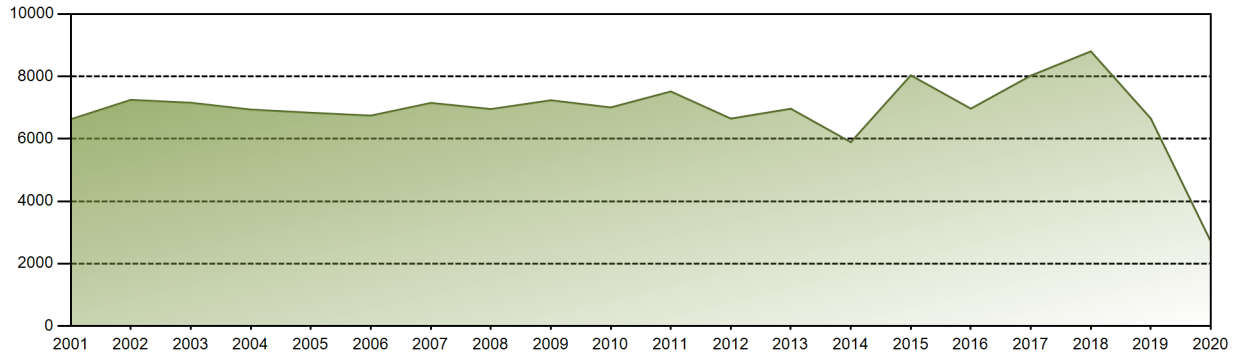
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	521.73	696.33	726.89	764.42	2709.37
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73.01	93.41	100.00	100.00	30.56
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	73.01	93.41	100.00	100.00	30.56
LF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	76.28	98.52	106.27	108.15	32.47
OF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.28	93.68	100.00	100.00	30.77
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.44	6.59	0.00	0.00	4.41
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.37	6.59	0.00	0.00	1.41
PUF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	16.62	0.00	0.00	0.00	68.03
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

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Historical Summary

Lifetime energy generation	:	227893.23 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.73 %
Cumulative Energy Availability Factor (EAF)	:	74.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.76 %
Cumulative Unit Capability Factor (UCF)	:	74.77 %	Cumulative Planned Unavailability Factor (PUF)	:	19.48 %
Cumulative Load Factor (LF)	:	75.94 %	Cumulative Externally cause unavailability (XUF)	:	0.68 %
Cumulative Operating Factor (OF)	:	76.85 %			

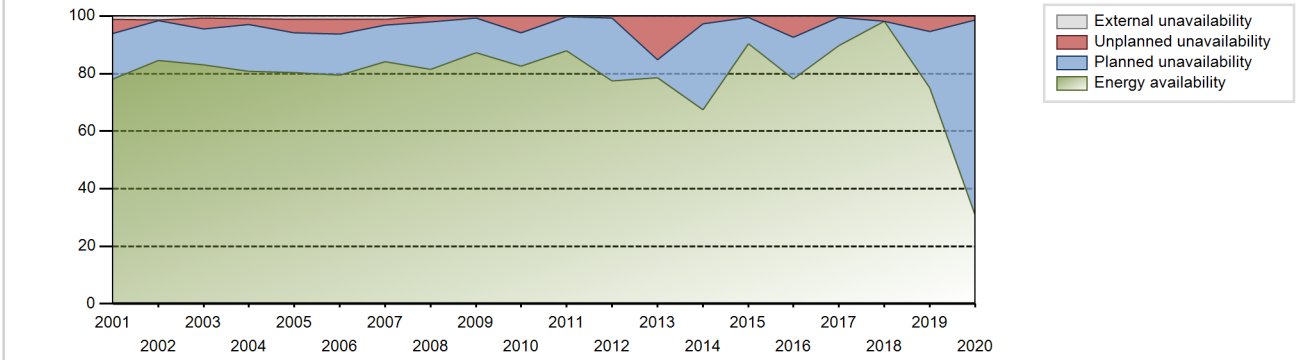
Electricity Production (net) [GWh]



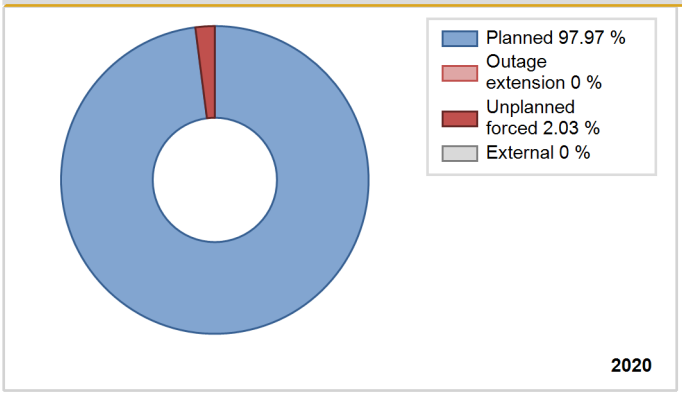
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	4487.64	5824	950	58.28	58.28	57.38	60.38	10.99	7.20	34.52	0.00
1986	5297.73	5946	950	62.85	62.85	63.66	67.88	28.18	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

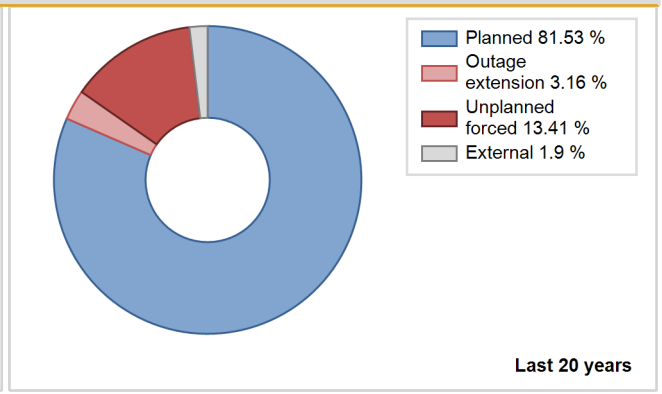
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		47			280	
C. Inspection, maintenance or repair combined with refuelling	5962			1563	30	
D. Inspection, maintenance or repair without refuelling				107	1	
E. Testing of plant systems or components					1	
J. Grid limitation, failure or grid unavailability						3
L. Human factor related		72			7	
Z. Other					36	
Subtotal	5962	119		1670	355	3
Total	**6081**			**2028**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		35
12. Reactor I&C Systems		14
15. Reactor Cooling Systems		6
16. Steam generation systems		38
17. Safety I&C Systems (excluding reactor I&C)		6
31. Turbine and auxiliaries		25
32. Feedwater and Main Steam System		21
34. Miscellaneous Systems		3
35. All other I&C Systems	47	7
41. Main Generator Systems		127
42. Electrical Power Supply Systems		7
Total	**47**	**289**

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Highlights (2020)

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 September-Desember. Additional electricity generation amounted to 173244 MWh. The unit was in the overhaul outage from 2019.11.22 to 2020.09.05. 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.

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2020 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 (JSC 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	:	34 years

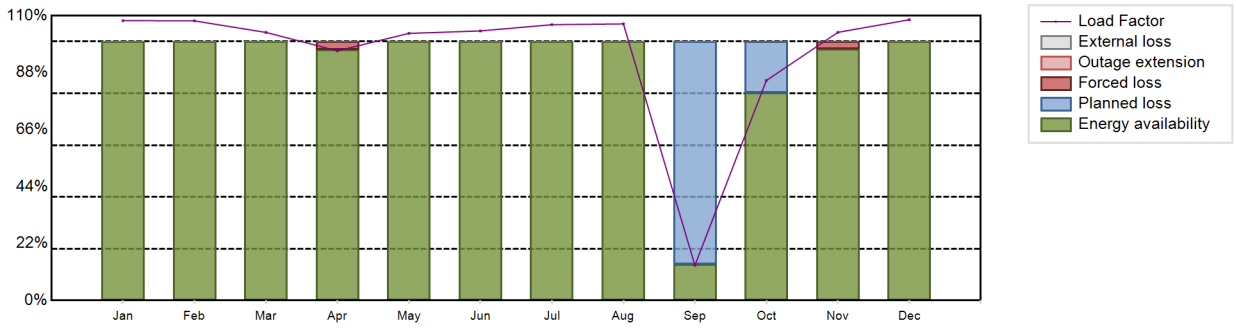
Design Characteristics

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	:	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 (2020)

Net Energy Production	:	7987.58 GW(e).h
Energy Availability Factor (EAF)	:	90.8 %
Unit Capability Factor (UCF)	:	90.8 %
Load Factor (LF)	:	95.72 %
Operating Factor (OF)	:	91.43 %
Equivalent non-electrical energy generated (NEG)	:	72.92 GW(e).h
Forced Loss Rate (FLR)	:	0.52 %
Unplanned Capability Loss Factor (UCL)	:	0.48 %
Planned Unavailability Factor (PUF)	:	8.73 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	753 hours

Annual Summary



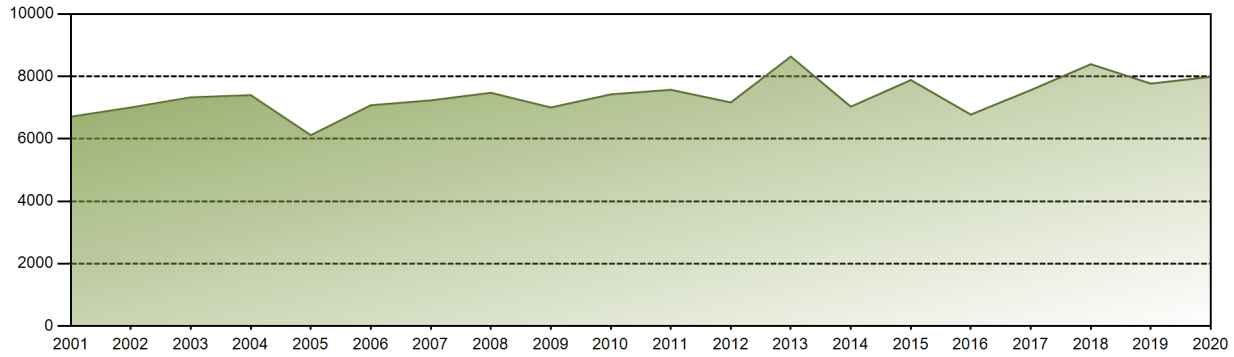
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	764.04	714.10	731.86	659.61	729.28	712.18	752.92	755.13	92.94	600.62	708.46	766.44	7987.59
EAF [%]	100.00	100.00	100.00	96.99	100.00	100.00	100.00	100.00	14.01	80.20	97.20	100.00	90.80
UCF [%]	100.00	100.00	100.00	96.99	100.00	100.00	100.00	100.00	14.01	80.20	97.20	100.00	90.80
LF [%]	108.10	108.00	103.55	96.43	103.18	104.12	106.53	106.84	13.59	84.98	103.58	108.44	95.72
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	15.42	80.65	100.00	100.00	91.43
FLR [%]	0.00	0.00	0.00	3.01	0.00	0.00	0.00	0.00	0.00	0.00	2.80	0.00	0.52
UCL [%]	0.00	0.00	0.00	3.01	0.00	0.00	0.00	0.00	0.00	0.00	2.80	0.00	0.48
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	85.99	19.80	0.00	0.00	8.73
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

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Historical Summary

Lifetime energy generation	:	225521.58 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.03 %
Cumulative Energy Availability Factor (EAF)	:	77.14 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.22 %
Cumulative Unit Capability Factor (UCF)	:	79.1 %	Cumulative Planned Unavailability Factor (PUF)	:	15.68 %
Cumulative Load Factor (LF)	:	79.77 %	Cumulative Externally cause unavailability (XUF)	:	1.95 %
Cumulative Operating Factor (OF)	:	82.64 %			

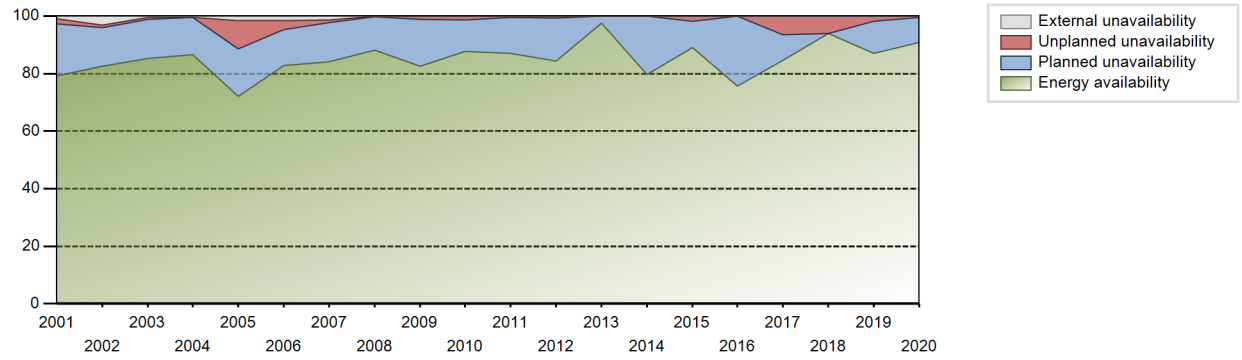
Electricity Production (net) [GWh]



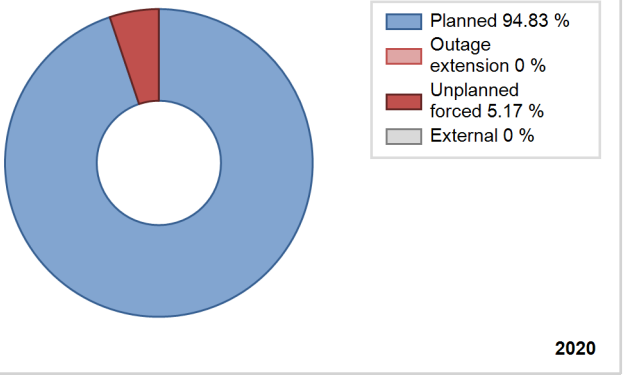
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	6494.00	7605	1000	86.27	86.27	79.18	87.96	9.13	8.67	5.07	0.00
1988	5829.43	6446	950	71.67	71.67	69.86	73.38	9.64	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

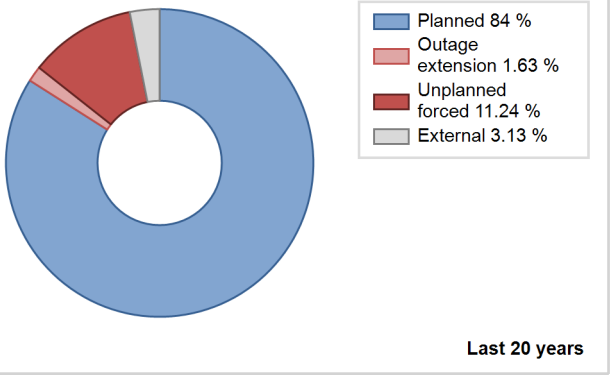
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					182	
C. Inspection, maintenance or repair combined with refuelling	753			1234	6	
D. Inspection, maintenance or repair without refuelling	21			69		
J. Grid limitation, failure or grid unavailability						3
L. Human factor related					16	
Z. Other					3	
Subtotal	774			1303	207	3
Total	**774**			**1513**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		6
12. Reactor I&C Systems		19
15. Reactor Cooling Systems		30
16. Steam generation systems		4
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		30
32. Feedwater and Main Steam System		7
34. Miscellaneous Systems		8
35. All other I&C Systems		6
41. Main Generator Systems		73
42. Electrical Power Supply Systems		4
Total		**189**

Highlights (2020)

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-Desember. Additional electricity generation amounted to 510875,3 MWh. The unit was in the overhaul outage from 2020.09.05 to 2020.10.07. 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.

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2020 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 (JSC 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	:	1985-10-01
Grid Date	:	2004-12-16
Commercial Date	:	2005-11-08
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]	:	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

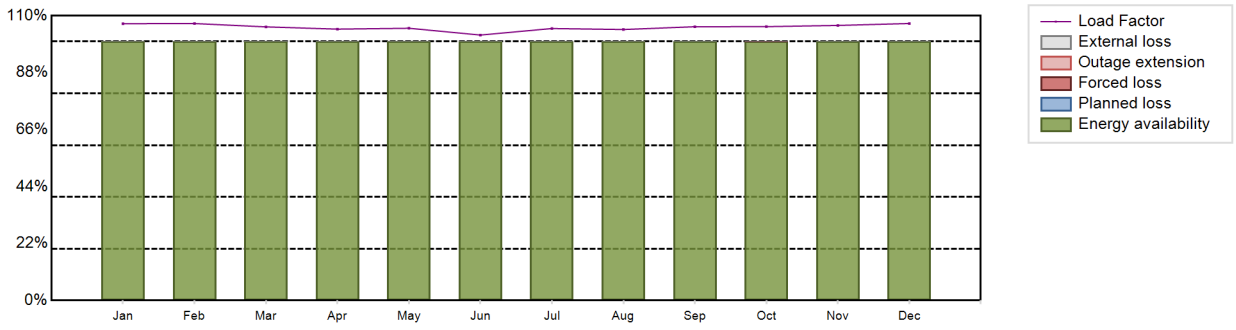
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Confinement
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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 (2020)

Net Energy Production	:	8807.69 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	105.55 %
Operating Factor (OF)	:	100 %
Equivalent non-electrical energy generated (NEG)	:	26.56 GW(e).h

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	:	0 hours

Annual Summary



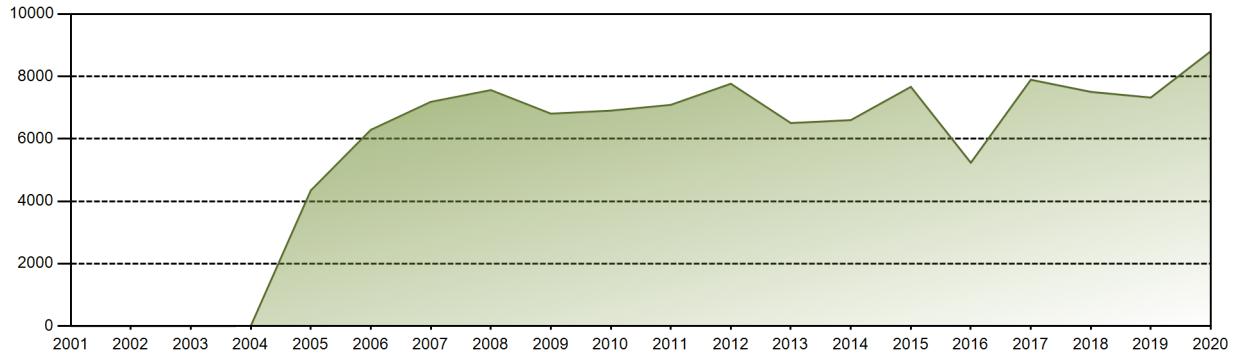
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	755.78	707.27	746.96	717.00	743.28	701.30	742.47	739.76	723.33	747.67	726.73	756.14	8807.69
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	100.00	100.00	100.00
LF [%]	106.93	106.97	105.68	104.82	105.16	102.53	105.05	104.66	105.75	105.78	106.25	106.98	105.55
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	0.01	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	0.01	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

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Historical Summary

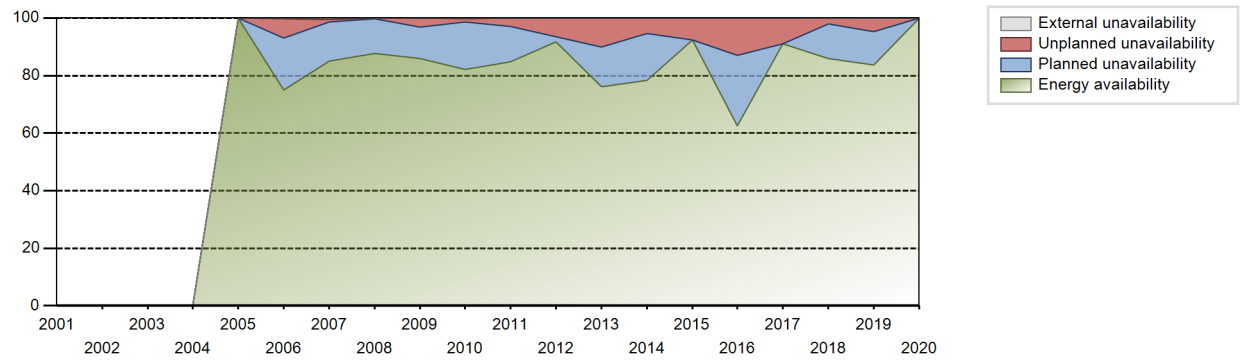
Lifetime energy generation	:	111471.88 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.93 %
Cumulative Energy Availability Factor (EAF)	:	84.32 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.82 %
Cumulative Unit Capability Factor (UCF)	:	84.41 %	Cumulative Planned Unavailability Factor (PUF)	:	10.78 %
Cumulative Load Factor (LF)	:	85.92 %	Cumulative Externally cause unavailability (XUF)	:	0.09 %
Cumulative Operating Factor (OF)	:	84.86 %			

Electricity Production (net) [GWh]



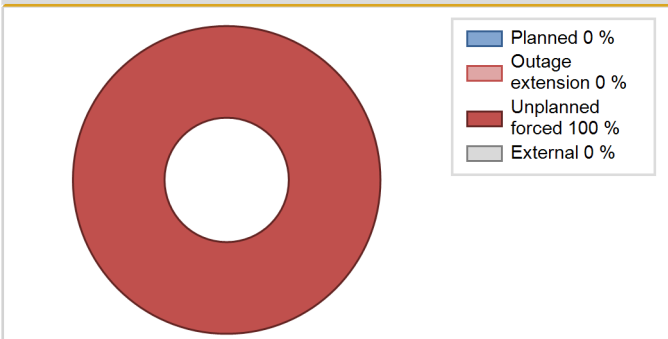
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2005	4345.70	5686	950	100.00	100.00	100.84	100.00	0.00	0.00	0.00	0.00
2006	6287.23	6692	950	74.90	75.20	75.55	76.39	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

Key Factors in Last 20 Years [%]

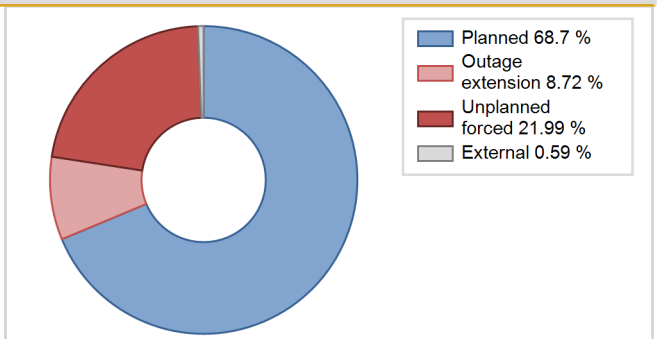


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2005 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					359	
C. Inspection, maintenance or repair combined with refuelling				929	12	
D. Inspection, maintenance or repair without refuelling				19		
E. Testing of plant systems or components				0	2	
H. Nuclear regulatory requirements					5	
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					2	
Z. Other					13	
Subtotal				948	393	2
Total		**0**			**1343**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2005 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		11
15. Reactor Cooling Systems		5
16. Steam generation systems		4
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		59
32. Feedwater and Main Steam System		12
33. Circulating Water System		1
35. All other I&C Systems		2
41. Main Generator Systems		171
42. Electrical Power Supply Systems		97
Total		**376**

Highlights (2020)

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-Desember. Additional electricity generation amounted to 498955.5 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.

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2020 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 (JSC 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	:	9 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

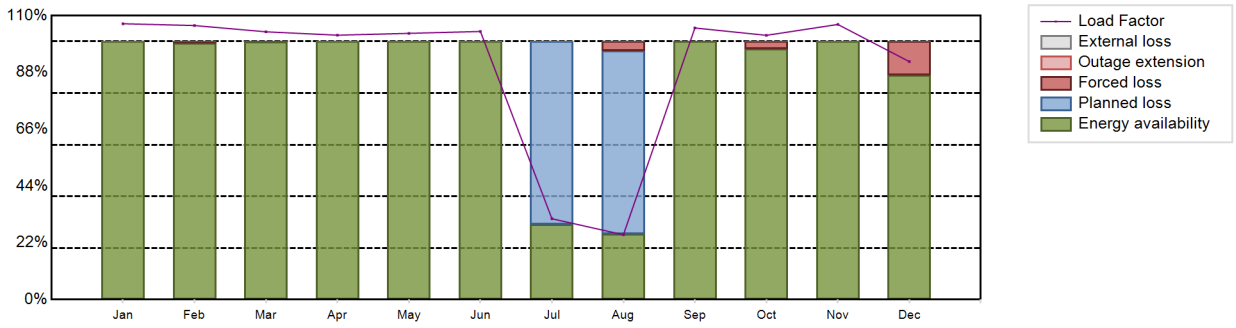
Operating coolant pressure [MPa]	:	1.05
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	7553.71 GW(e).h
Energy Availability Factor (EAF)	:	86.28 %
Unit Capability Factor (UCF)	:	86.28 %
Load Factor (LF)	:	90.52 %
Operating Factor (OF)	:	86.95 %
Equivalent non-electrical energy generated (NEG)	:	23.52 GW(e).h

Forced Loss Rate (FLR)	:	1.93 %
Unplanned Capability Loss Factor (UCL)	:	1.69 %
Planned Unavailability Factor (PUF)	:	12.02 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1146 hours

Annual Summary



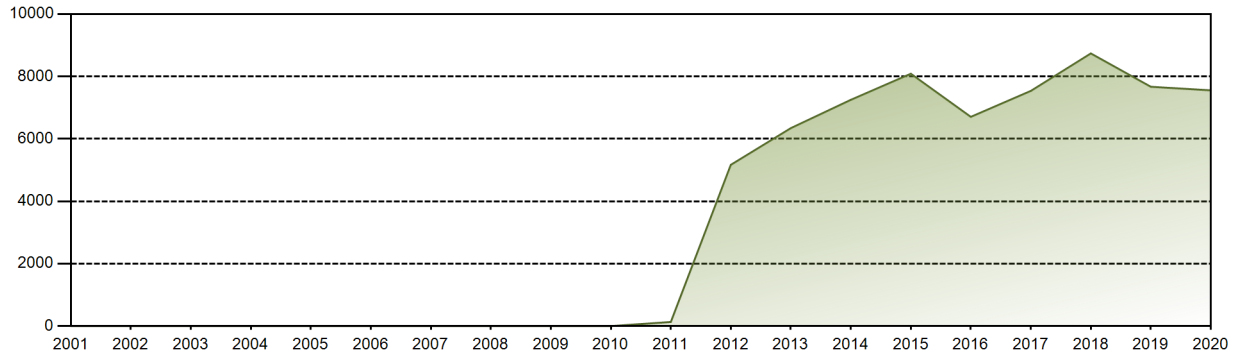
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	755.35	701.95	733.23	700.61	728.96	710.47	221.53	177.63	719.69	723.59	729.07	651.63	7553.71
EAF [%]	100.00	99.47	99.94	100.00	100.00	100.00	29.05	25.45	100.00	97.14	100.00	86.99	86.28
UCF [%]	100.00	99.47	99.94	100.00	100.00	100.00	29.05	25.45	100.00	97.14	100.00	86.99	86.28
LF [%]	106.87	106.16	103.74	102.43	103.14	103.87	31.34	25.13	105.22	102.37	106.59	92.19	90.52
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	32.39	26.21	100.00	100.00	100.00	87.37	86.95
FLR [%]	0.00	0.53	0.06	0.00	0.00	0.00	0.00	12.34	0.00	2.86	0.00	13.01	1.93
UCL [%]	0.00	0.53	0.06	0.00	0.00	0.00	0.00	3.58	0.00	2.86	0.00	13.01	1.69
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	70.95	70.97	0.00	0.00	0.00	0.00	12.02
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

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Historical Summary

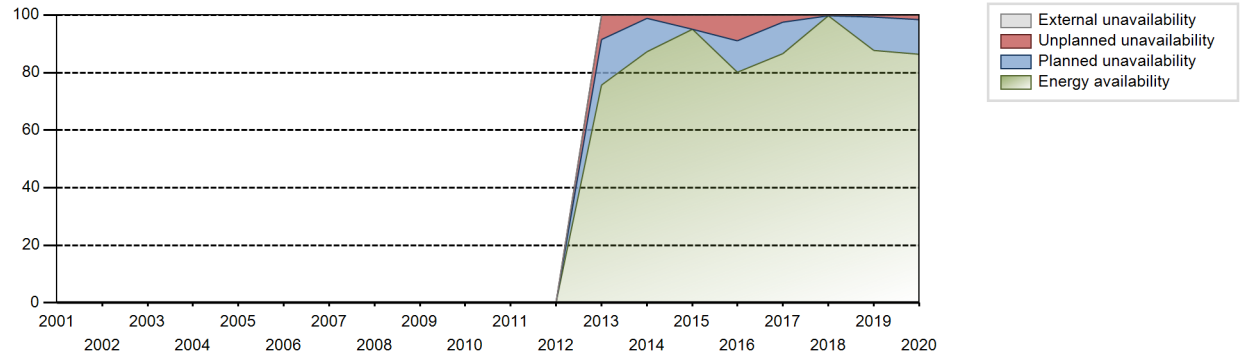
Lifetime energy generation	:	65215.28 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.29 %
Cumulative Energy Availability Factor (EAF)	:	87.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.55 %
Cumulative Unit Capability Factor (UCF)	:	87.29 %	Cumulative Planned Unavailability Factor (PUF)	:	9.16 %
Cumulative Load Factor (LF)	:	89.88 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	87.82 %			

Electricity Production (net) [GWh]

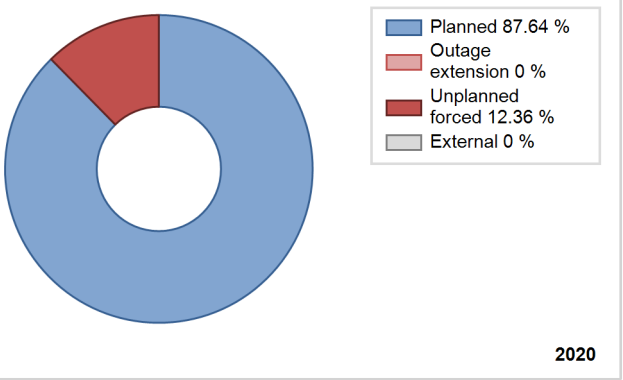


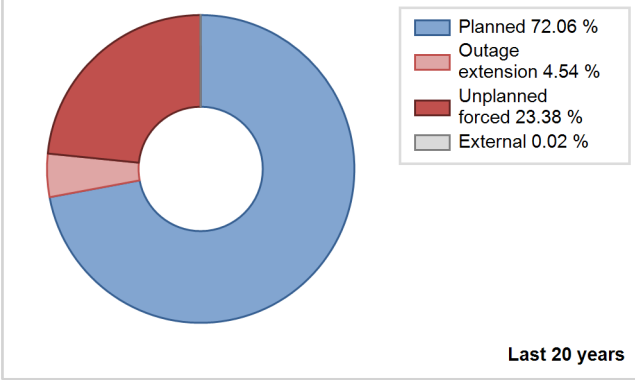
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2012	5166.49	6858	950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2013	6342.91	6662	950	75.72	75.73	76.22	76.05	6.89	8.42	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2012 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		118			254	
C. Inspection, maintenance or repair combined with refuelling	1007			786		
D. Inspection, maintenance or repair without refuelling				17		
L. Human factor related					9	
Subtotal	1007	118		803	263	
Total	**1125**			**1066**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2012 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		8
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		84
32. Feedwater and Main Steam System	94	10
33. Circulating Water System	25	3
35. All other I&C Systems		2
41. Main Generator Systems		79
42. Electrical Power Supply Systems		44
Total	**119**	**233**

Highlights (2020)

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-Desember. Additional electricity generation amounted to 439698 MWh. The unit was in the overhaul outage from 2020.07.11 to 2020.08.22. 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.

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2020 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 (JSC 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	:	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]	:	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

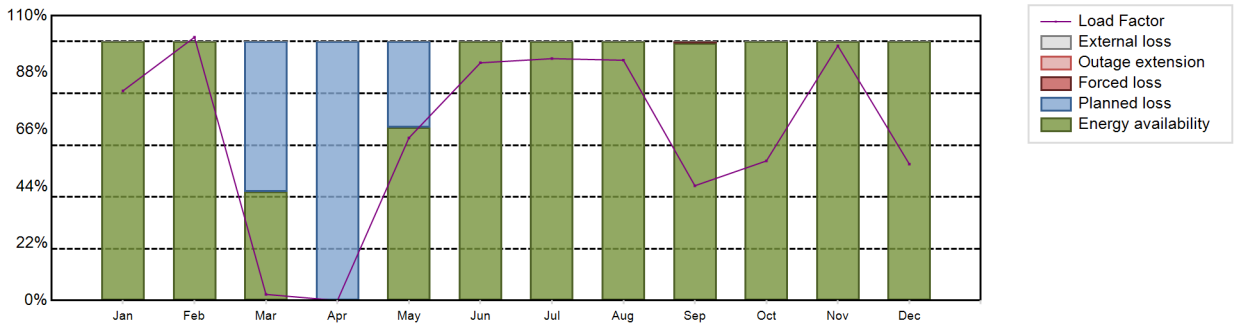
Operating coolant pressure [MPa]	:	12.5
Reactor outlet temperature [°C]	:	300
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP 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 (2020)

Net Energy Production	:	2327.08 GW(e).h
Energy Availability Factor (EAF)	:	84.03 %
Unit Capability Factor (UCF)	:	84.03 %
Load Factor (LF)	:	64.46 %
Operating Factor (OF)	:	81.89 %
Equivalent non-electrical energy generated (NEG)	:	1.76 GW(e).h

Forced Loss Rate (FLR)	:	0.07 %
Unplanned Capability Loss Factor (UCL)	:	0.05 %
Planned Unavailability Factor (PUF)	:	15.92 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1591 hours

Annual Summary



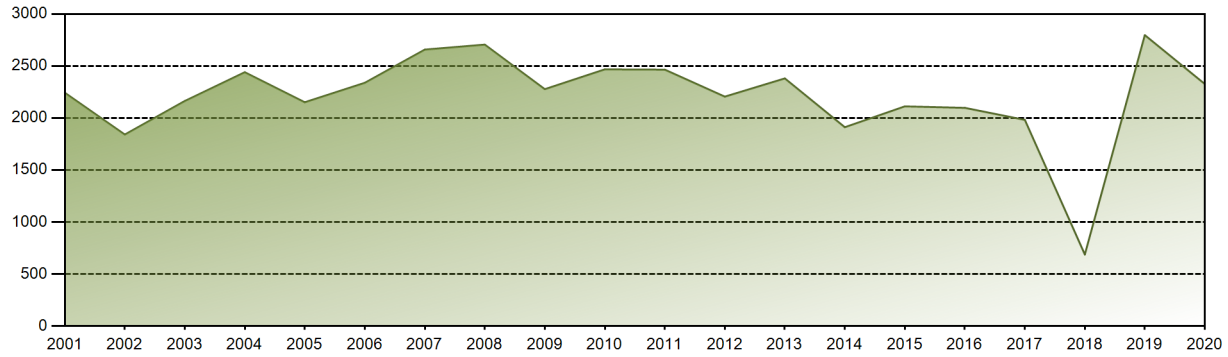
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	247.63	290.87	7.24	0.00	192.08	271.65	285.65	283.77	131.19	164.87	291.02	161.11	2327.08
EAF [%]	100.00	100.00	41.94	0.01	66.92	100.00	100.00	100.00	99.33	100.00	100.00	100.00	84.03
UCF [%]	100.00	100.00	41.94	0.01	66.92	100.00	100.00	100.00	99.33	100.00	100.00	100.00	84.03
LF [%]	80.98	101.68	2.37	0.00	62.81	91.80	93.42	92.80	44.33	53.92	98.35	52.69	64.46
OF [%]	100.00	100.00	8.20	0.00	76.08	100.00	100.00	100.00	98.61	100.00	100.00	100.00	81.89
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.07
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.05
PUF [%]	0.00	0.00	58.06	99.99	33.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.92
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

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Historical Summary

Lifetime energy generation	:	109279.94 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.7 %
Cumulative Energy Availability Factor (EAF)	:	71.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.19 %
Cumulative Unit Capability Factor (UCF)	:	77.16 %	Cumulative Planned Unavailability Factor (PUF)	:	20.64 %
Cumulative Load Factor (LF)	:	64 %	Cumulative Externally cause unavailability (XUF)	:	5.24 %
Cumulative Operating Factor (OF)	:	79.25 %			

Electricity Production (net) [GWh]

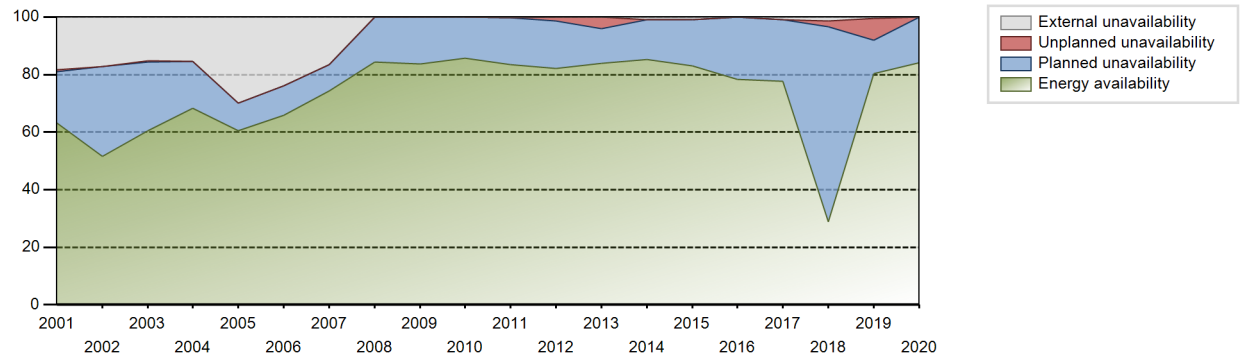


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	918.20	4180	411	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	1990.06	8463	411	79.22	79.22	55.27	96.61	0.90	0.72	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

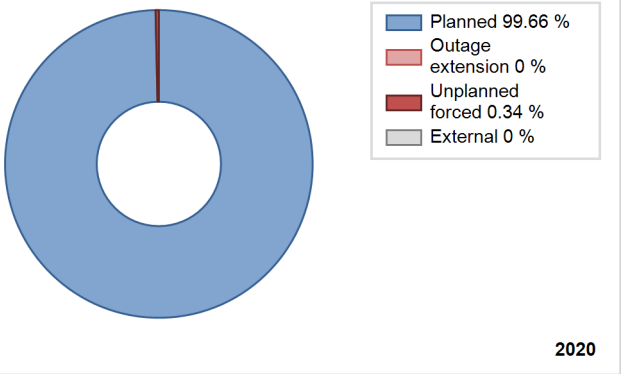
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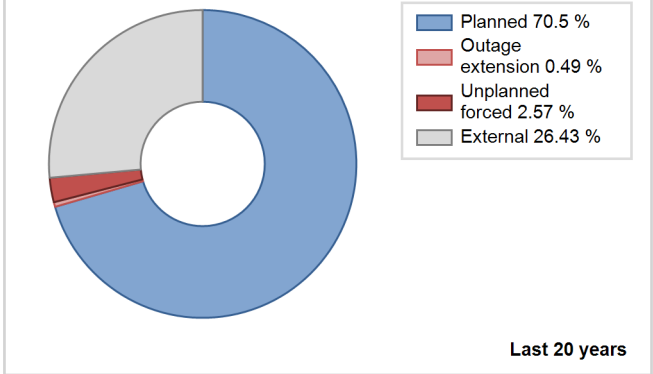
2010	2467.97	7912	411	85.79	85.82	68.55	90.32	0.00	0.00	14.18	0.03
2011	2465.32	7870	411	83.47	83.62	68.48	89.85	0.00	0.00	16.38	0.15
2012	2205.74	7021	411	82.24	82.24	61.10	79.93	1.67	1.39	16.37	0.00
2013	2380.88	7811	411	83.98	83.98	66.13	89.17	4.60	4.05	11.97	0.00
2014	1911.66	7536	411	85.18	86.19	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		10			49	
C.	Inspection, maintenance or repair combined with refuelling	1330			1492	3	
D.	Inspection, maintenance or repair without refuelling				76		
F.	Major backfitting, refurbishment or upgrading activities with refuelling				56		
J.	Grid limitation, failure or grid unavailability						40
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			251			118
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)						5
Z.	Other					8	
Subtotal		1330	10	251	1624	61	165
Total		**1591**			**1850**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		4
15. Reactor Cooling Systems		12
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	10	1
42. Electrical Power Supply Systems		3
Total	**10**	**49**

Highlights (2020)

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, May-July, October-Desember. Additional electricity generation amounted to 23553 MWh. The unit was in the overhaul outage from 2020.03.14 to 2020.05.08. 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.

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2020 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 (JSC 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	:	46 years

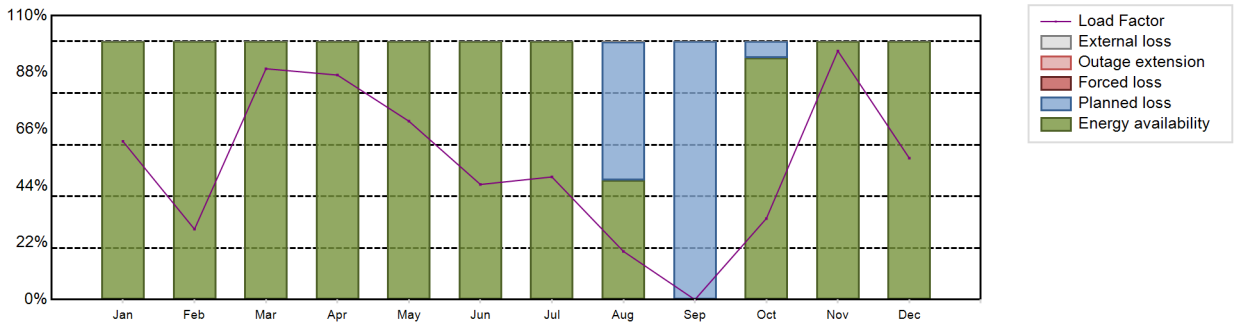
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	-
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 (2020)

Net Energy Production	:	1890.68 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	86.71 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	86.71 %	Planned Unavailability Factor (PUF)	:	13.29 %
Load Factor (LF)	:	52.37 %	Externally cause unavailability (XUF)	:	0.01 %
Operating Factor (OF)	:	81.83 %	Total off-line time	:	1596 hours
Equivalent non-electrical energy generated (NEG)	:	1.03 GW(e).h			

Annual Summary



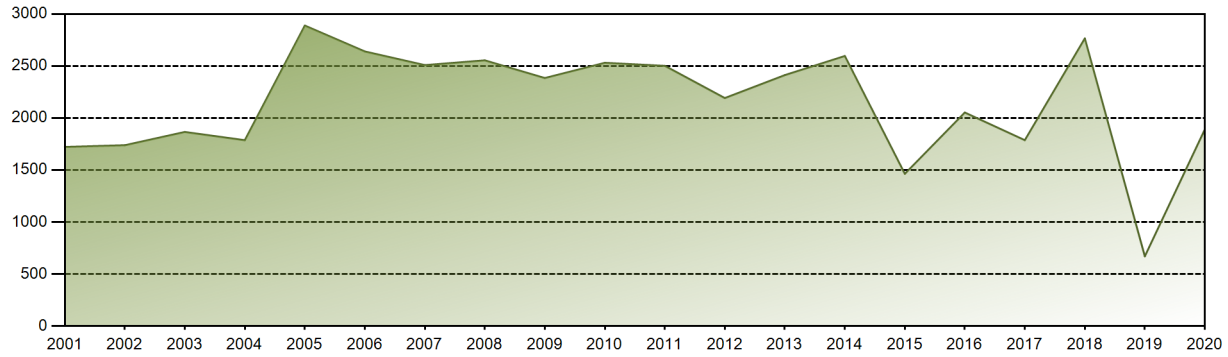
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	187.41	78.04	273.45	257.41	211.32	132.01	145.30	57.19	0.00	96.10	285.00	167.45	1890.68
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	46.27	0.01	93.55	100.00	100.00	86.71
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	46.36	0.01	93.55	100.00	100.00	86.71
LF [%]	61.29	27.28	89.43	86.99	69.11	44.61	47.52	18.70	0.00	31.43	96.31	54.76	52.37
OF [%]	100.00	68.82	100.00	100.00	100.00	100.00	100.00	46.37	0.00	65.05	100.00	100.00	81.83
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	0.00	0.00	0.00	0.00	0.00	0.00	53.64	99.99	6.45	0.00	0.00	13.29
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.01

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Historical Summary

Lifetime energy generation	:	106181.31 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.72 %
Cumulative Energy Availability Factor (EAF)	:	72.77 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.16 %
Cumulative Unit Capability Factor (UCF)	:	77.34 %	Cumulative Planned Unavailability Factor (PUF)	:	20.5 %
Cumulative Load Factor (LF)	:	64.18 %	Cumulative Externally cause unavailability (XUF)	:	4.56 %
Cumulative Operating Factor (OF)	:	76.76 %			

Electricity Production (net) [GWh]

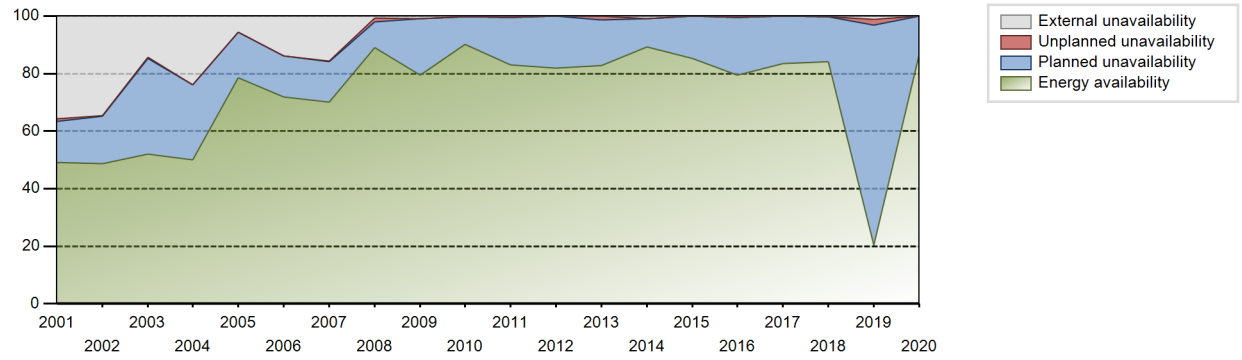


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	1383.07	6449	411	88.23	88.23	37.48	73.97	3.66	3.35	8.41	0.00
1976	1943.15	7083	411	70.82	70.82	53.82	80.64	0.74	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

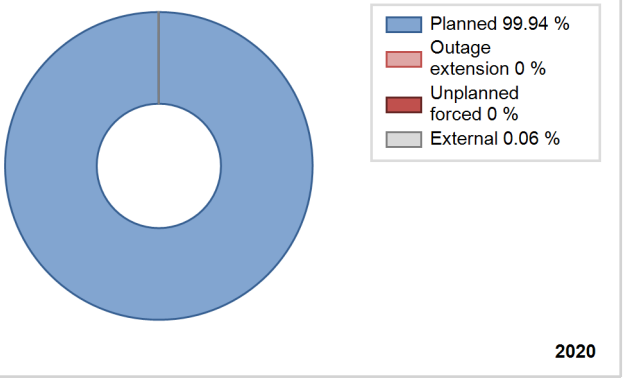
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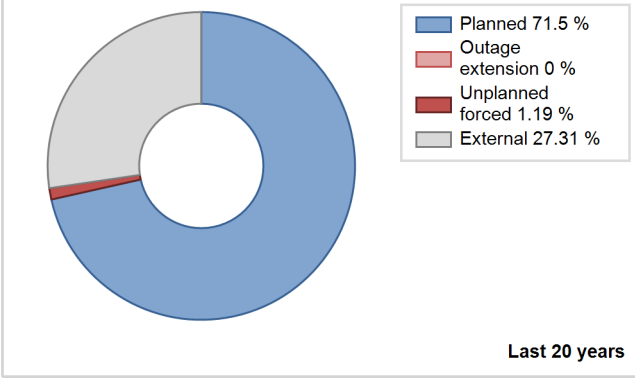
2012	2192.07	7775	411	81.85	81.85	60.72	88.51	0.00	0.00	18.14	0.00
2013	2412.70	7233	411	82.80	82.80	67.01	82.57	1.51	1.27	15.93	0.00
2014	2596.45	7823	411	89.32	90.15	72.11	89.29	0.03	0.03	9.82	0.83
2015	1463.78	5450	411	85.32	85.32	40.66	62.21	0.00	0.00	14.68	0.00
2016	2053.14	6416	411	79.35	79.79	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					68	
C.	Inspection, maintenance or repair combined with refuelling	1215			1481		
D.	Inspection, maintenance or repair without refuelling				54		
E.	Testing of plant systems or components				7		
F.	Major backfitting, refurbishment or upgrading activities with refuelling				107		
H.	Nuclear regulatory requirements					4	
J.	Grid limitation, failure or grid unavailability						29
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			217			244
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		1215		217	1649	73	275
Total		**1432**			**1997**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		39
12. Reactor I&C Systems		1
13. Reactor Auxiliary Systems		2
14. Safety Systems		2
15. Reactor Cooling Systems		16
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		1
35. All other I&C Systems		1
41. Main Generator Systems		0
42. Electrical Power Supply Systems		1
Total		**68**

Highlights (2020)

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, March, May, November. Additional electricity generation amounted to 8667 MWh. The unit was in the intermediate outage from 2020.08.15 to 2020.10.01. 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.

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2020 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 (JSC 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	:	39 years

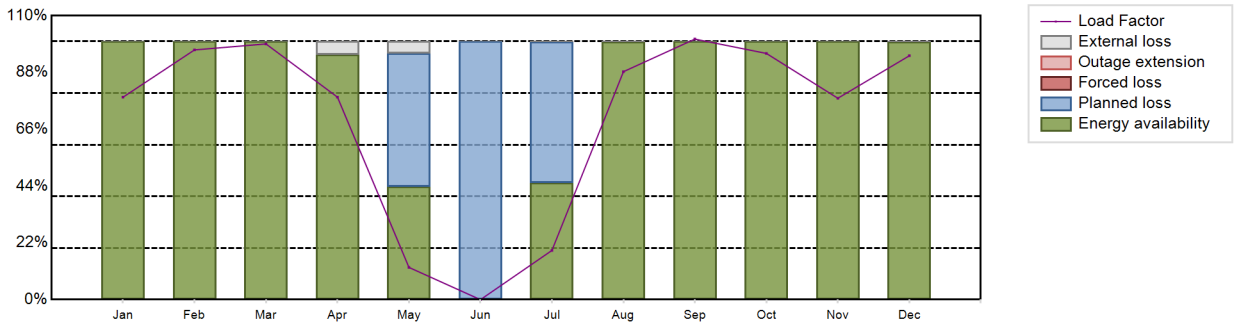
Design Characteristics

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 (2020)

Net Energy Production	:	2527.89 GW(e).h
Energy Availability Factor (EAF)	:	81.99 %
Unit Capability Factor (UCF)	:	82.81 %
Load Factor (LF)	:	70.02 %
Operating Factor (OF)	:	81.01 %
Equivalent non-electrical energy generated (NEG)	:	2.06 GW(e).h
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	17.19 %
Externally cause unavailability (XUF)	:	0.82 %
Total off-line time	:	1668 hours

Annual Summary



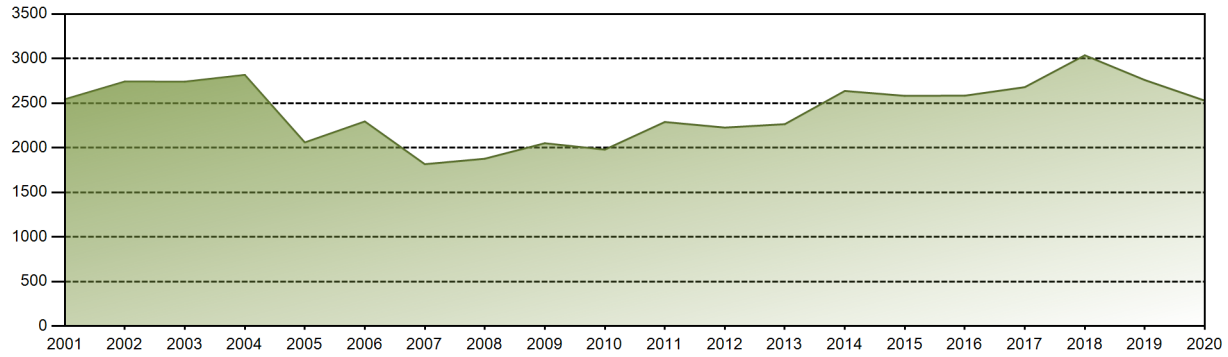
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	239.78	276.68	302.87	232.13	38.21	0.00	58.30	269.96	298.64	291.63	230.84	288.87	2527.89
EAF [%]	100.00	100.00	100.00	94.87	43.81	0.01	45.33	99.97	100.00	100.00	100.00	99.93	81.99
UCF [%]	100.00	100.00	100.00	100.00	48.39	0.01	45.37	100.00	100.00	100.00	100.00	100.00	82.81
LF [%]	78.42	96.72	99.05	78.44	12.50	0.00	19.06	88.29	100.92	95.37	78.01	94.47	70.02
OF [%]	100.00	100.00	100.00	100.00	27.02	0.00	45.56	100.00	100.00	100.00	100.00	100.00	81.01
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	54.63	0.00	0.00	0.00	0.00	0.00	17.19
XUF [%]	0.00	0.00	0.00	5.13	4.58	0.00	0.04	0.03	0.00	0.00	0.00	0.07	0.82

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Historical Summary

Lifetime energy generation	:	98492.71 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.38 %
Cumulative Energy Availability Factor (EAF)	:	76.41 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.02 %
Cumulative Unit Capability Factor (UCF)	:	82.36 %	Cumulative Planned Unavailability Factor (PUF)	:	15.62 %
Cumulative Load Factor (LF)	:	70.02 %	Cumulative Externally cause unavailability (XUF)	:	5.95 %
Cumulative Operating Factor (OF)	:	82.3 %			

Electricity Production (net) [GWh]

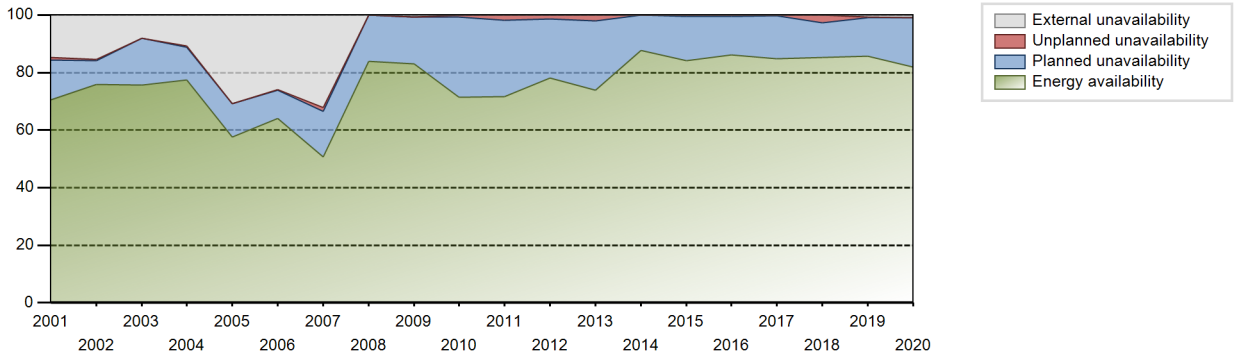


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1982	1891.17	7252	411	99.35	99.38	98.74	100.00	0.08	0.08	0.54	0.03
1983	2459.86	6818	411	71.98	71.99	68.32	77.83	3.90	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

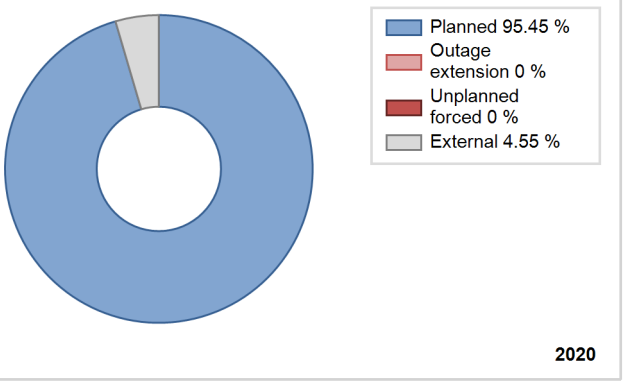
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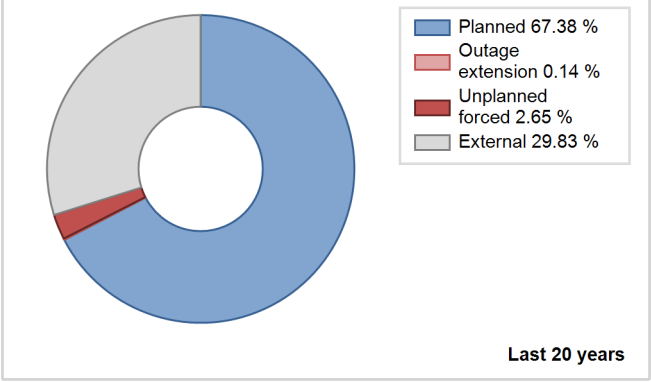
2019	2759.12	7606	411	85.71	86.49	76.63	86.83	0.04	0.04	13.47	0.78
2020	2527.89	7116	411	81.99	82.81	70.02	81.01	0.00	0.00	17.19	0.82

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1982 to 2020 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	1509			1256		
D. Inspection, maintenance or repair without refuelling				64		
E. Testing of plant systems or components				10	1	
J. Grid limitation, failure or grid unavailability						51
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			159			107
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	1509		159	1330	73	159
Total	**1668**			**1562**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1982 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		5
12. Reactor I&C Systems		23
15. Reactor Cooling Systems		11
16. Steam generation systems		8
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		4
32. Feedwater and Main Steam System		8
34. Miscellaneous Systems		0
41. Main Generator Systems		1
42. Electrical Power Supply Systems		7
Total		**67**

Highlights (2020)

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-April, August-December. Additional electricity generation amounted to 36430 MWh. The unit was in the intermediate outage from 2020.05.16 to 2020.07.17. 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.

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2020 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 (JSC 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	:	36 years

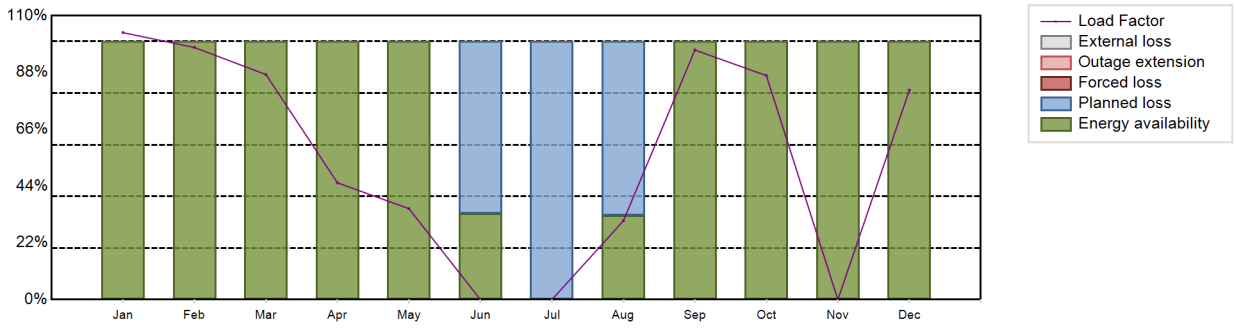
Design Characteristics

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]	:	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 (2020)

Net Energy Production	:	1996.91 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	80.37 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	80.37 %	Planned Unavailability Factor (PUF)	:	19.63 %
Load Factor (LF)	:	55.31 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	68.21 %	Total off-line time	:	2792 hours
Equivalent non-electrical energy generated (NEG)	:	0.43 GW(e).h			

Annual Summary



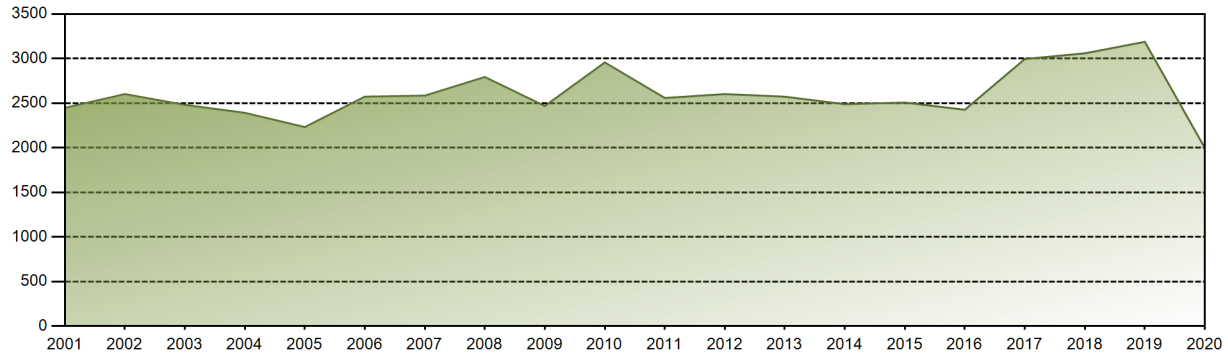
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	316.21	279.35	266.65	133.90	107.80	0.00	0.00	93.42	286.09	265.42	0.00	248.07	1996.91
EAF [%]	100.00	100.00	100.00	100.00	100.00	33.34	0.01	32.71	100.00	100.00	100.00	100.00	80.37
UCF [%]	100.00	100.00	100.00	100.00	100.00	33.34	0.01	32.71	100.00	100.00	100.00	100.00	80.37
LF [%]	103.41	97.65	87.20	45.25	35.25	0.00	0.00	30.55	96.68	86.80	0.00	81.13	55.31
OF [%]	100.00	100.00	100.00	100.00	76.61	0.00	0.00	55.11	100.00	100.00	1.39	85.22	68.21
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 [%]	0.00	0.00	0.00	0.00	0.00	66.66	99.99	67.29	0.00	0.00	0.00	0.00	19.63
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

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Historical Summary

Lifetime energy generation	:	93758.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.65 %
Cumulative Energy Availability Factor (EAF)	:	76.49 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.24 %
Cumulative Unit Capability Factor (UCF)	:	82.32 %	Cumulative Planned Unavailability Factor (PUF)	:	15.44 %
Cumulative Load Factor (LF)	:	72.14 %	Cumulative Externally cause unavailability (XUF)	:	5.83 %
Cumulative Operating Factor (OF)	:	82.69 %			

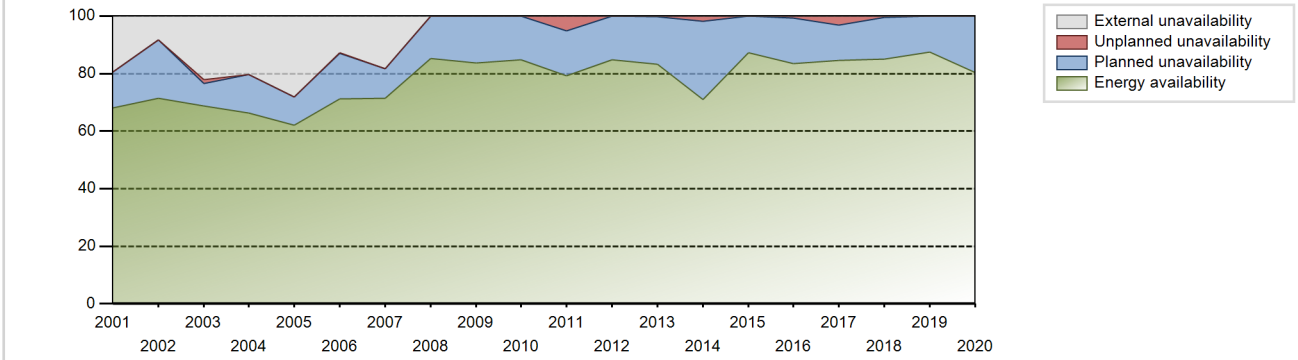
Electricity Production (net) [GWh]



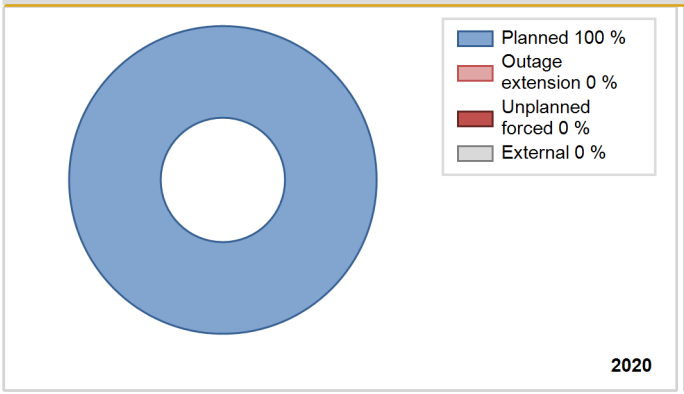
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	249.38	1605	411	100.00	100.00	55.09	98.12	0.00	0.00	0.00	0.00
1985	2585.77	7751	411	78.18	78.19	71.82	88.48	3.31	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

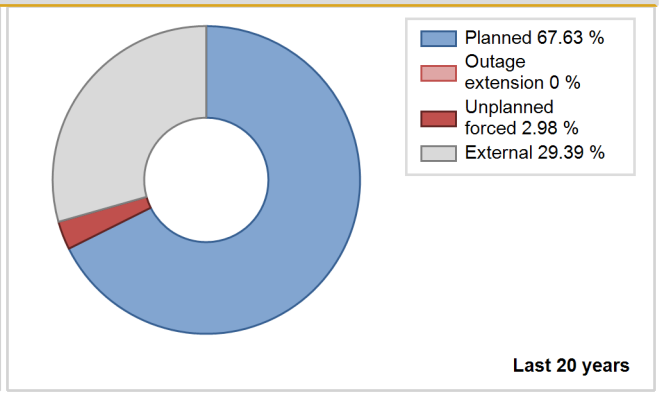
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					54	
C. Inspection, maintenance or repair combined with refuelling	1558			1149	16	
D. Inspection, maintenance or repair without refuelling				72		
E. Testing of plant systems or components				5		
J. Grid limitation, failure or grid unavailability						42
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			1100			167
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	1558		1100	1226	73	209
Total	**2658**			**1508**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		13
14. Safety Systems		6
15. Reactor Cooling Systems		4
16. Steam generation systems		10
17. Safety I&C Systems (excluding reactor I&C)		1
32. Feedwater and Main Steam System		6
41. Main Generator Systems		2
42. Electrical Power Supply Systems		14
Total		**58**

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Highlights (2020)

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-March, August-October, December. Additional electricity generation amounted to 31747 MWh. The unit was in the intermediate outage from 2020.06.11 to 2020.08.14. 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.

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2020 Operating Experience

RU-17 KURSK-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 (JSC 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	:	1972-06-01
Grid Date	:	1976-12-19
Commercial Date	:	1977-10-12
Age at end of year	:	44 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	:	1693
Fuel linear heat generation rate [kW/m]	:	11.2
Number of control rod assemblies	:	138
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

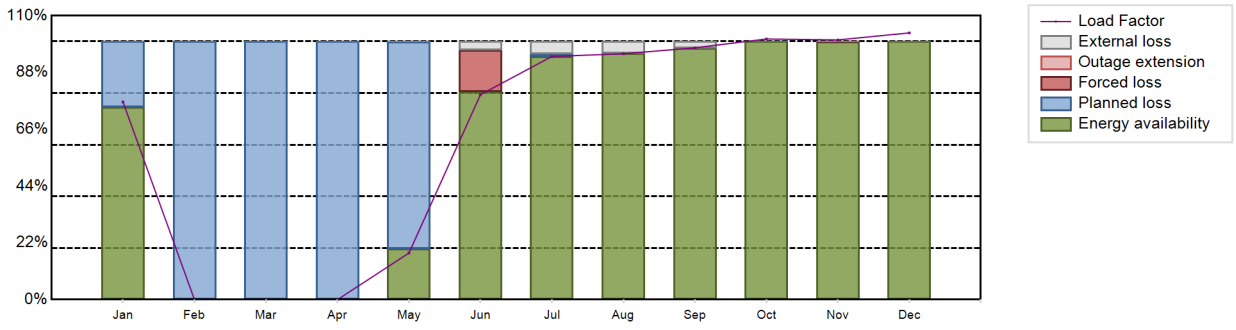
Operating coolant pressure [MPa]	:	7
Reactor outlet temperature [°C]	:	284
Number of SG	:	NA
Containment type	:	NA
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5208.97 GW(e).h
Energy Availability Factor (EAF)	:	63.74 %
Unit Capability Factor (UCF)	:	65.06 %
Load Factor (LF)	:	64.11 %
Operating Factor (OF)	:	65.81 %
Equivalent non-electrical energy generated (NEG)	:	60.66 GW(e).h

Forced Loss Rate (FLR)	:	2 %
Unplanned Capability Loss Factor (UCL)	:	1.33 %
Planned Unavailability Factor (PUF)	:	33.61 %
Externally cause unavailability (XUF)	:	1.32 %
Total off-line time	:	3003 hours

Annual Summary



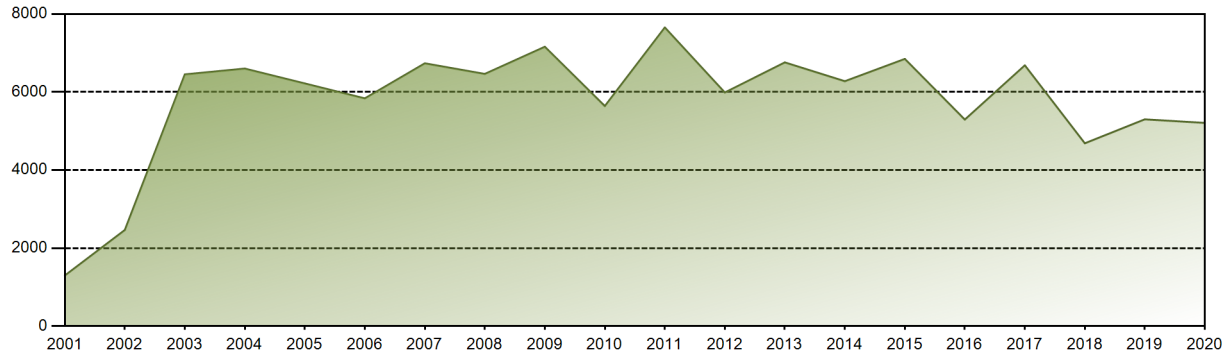
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	527.03	0.00	0.00	0.00	124.25	528.72	648.22	655.42	649.60	694.74	669.96	711.02	5208.97
EAF [%]	74.61	0.00	0.00	0.00	19.58	80.43	94.25	95.30	97.33	100.00	99.96	100.00	63.74
UCF [%]	74.61	0.00	0.00	0.00	19.71	83.79	99.13	100.00	100.00	100.00	99.99	100.00	65.06
LF [%]	76.58	0.00	0.00	0.00	18.05	79.39	94.19	95.24	97.54	100.95	100.60	103.32	64.11
OF [%]	77.82	0.00	0.00	0.00	22.58	85.83	100.00	100.00	100.00	100.00	100.00	100.00	65.81
FLR [%]	0.00	0.00	0.00	0.00	0.00	16.21	0.00	0.00	0.00	0.00	0.01	0.00	2.00
UCL [%]	0.00	0.00	0.00	0.00	0.00	16.21	0.00	0.00	0.00	0.00	0.01	0.00	1.33
PUF [%]	25.39	100.00	100.00	100.00	80.29	0.00	0.87	0.00	0.00	0.00	0.00	0.00	33.61
XUF [%]	0.00	0.00	0.00	0.00	0.13	3.36	4.88	4.70	2.67	0.00	0.03	0.00	1.32

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Historical Summary

Lifetime energy generation	:	225409 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.41 %
Cumulative Energy Availability Factor (EAF)	:	63.84 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.51 %
Cumulative Unit Capability Factor (UCF)	:	65.53 %	Cumulative Planned Unavailability Factor (PUF)	:	29.96 %
Cumulative Load Factor (LF)	:	63.83 %	Cumulative Externally cause unavailability (XUF)	:	1.69 %
Cumulative Operating Factor (OF)	:	72.09 %			

Electricity Production (net) [GWh]

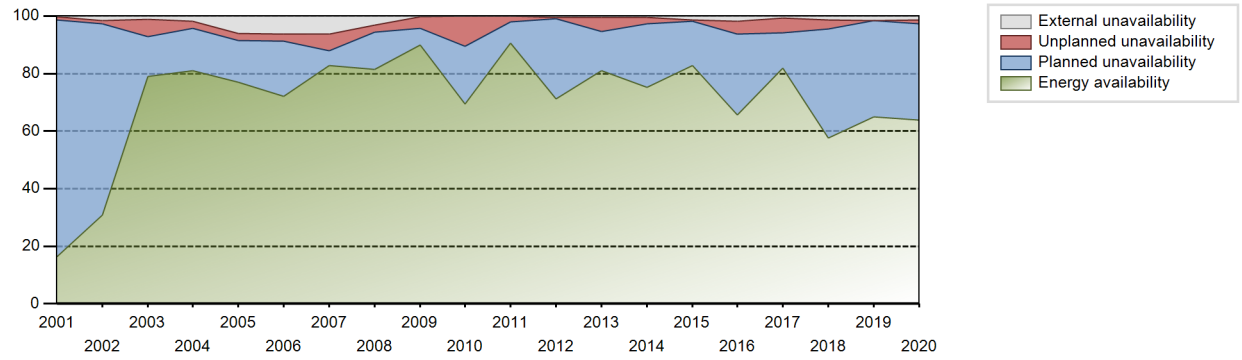


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	3644.87	6899	925	79.11	79.11	71.43	85.91	9.31	8.12	12.77	0.00
1978	5058.11	7573	925	63.00	63.00	62.42	86.45	17.07	12.96	24.04	0.00
1979	5930.25	7528	925	73.09	73.93	73.19	85.94	14.94	12.98	13.08	0.84
1980	6477.67	7669	925	79.69	79.92	79.72	87.31	7.39	6.38	13.70	0.23
1981	6132.76	7885	925	76.36	76.36	75.69	90.01	12.25	10.66	12.98	0.00
1982	7010.42	7788	925	85.71	85.71	86.52	88.90	2.73	2.40	11.89	0.00
1983	6720.27	7456	925	82.16	82.20	82.94	85.11	1.94	1.63	16.17	0.04
1984	6659.97	7369	925	81.37	81.37	81.97	83.89	2.66	2.22	16.41	0.00
1985	6346.78	7186	925	76.81	76.86	78.33	82.03	3.99	3.19	19.95	0.05
1986	5675.79	6598	925	69.22	69.22	70.05	75.32	14.73	11.96	18.83	0.00
1987	7022.68	7407	1000	82.56	82.56	80.17	84.55	2.48	2.10	15.34	0.00
1988	6637.98	7350	925	81.75	81.75	81.70	83.67	1.04	0.86	17.39	0.00
1989	5745.43	6582	925	68.25	68.29	70.91	75.14	8.37	6.24	25.48	0.03
1990	5090.51	6817	925	65.69	65.69	62.82	77.82	17.24	13.68	20.63	0.00
1991	4163.08	7038	925	52.50	53.46	51.38	80.34	1.96	1.07	45.47	0.96
1992	3669.24	6103	925	46.25	46.25	45.16	69.49	4.44	2.15	51.60	0.00
1993	4809.41	8145	925	61.81	91.61	59.35	92.98	1.35	1.25	7.13	29.80
1994	1560.59	2686	925	19.76	20.64	19.26	30.66	60.69	31.88	47.48	0.88
1995	0.00	0	925	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1996	0.00	0	925	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1997	27.76	61	925	0.54	0.54	0.34	0.70	39.09	0.35	99.11	0.00
1998	4508.63	7845	925	57.36	59.33	55.64	89.55	5.73	3.61	37.07	1.96
1999	4557.04	7464	925	57.64	58.74	56.24	85.21	0.91	0.54	40.72	1.11
2000	3449.69	5531	925	43.56	44.33	42.46	62.97	6.37	3.02	52.65	0.77
2001	1296.07	2042	925	16.39	16.62	15.99	23.31	6.51	1.16	82.22	0.23
2002	2462.70	3439	925	30.83	32.51	30.39	39.26	2.91	0.97	66.52	1.68
2003	6452.71	7262	925	78.90	80.17	79.63	82.90	6.86	5.91	13.93	1.27
2004	6601.33	7363	925	81.11	83.00	81.25	83.82	2.85	2.43	14.57	1.89
2005	6219.96	7651	925	76.99	82.99	76.75	87.33	2.72	2.53	14.48	5.99
2006	5837.69	7089	925	72.19	78.44	72.04	80.92	3.17	2.56	18.99	6.25
2007	6736.18	7670	925	82.77	89.05	83.13	87.56	6.05	5.74	5.21	6.29
2008	6464.58	7596	925	81.36	84.43	79.56	86.48	2.89	2.51	13.06	3.08
2009	7161.20	8068	925	89.95	90.26	88.38	92.10	4.16	3.92	5.82	0.31
2010	5640.73	5991	925	69.52	69.65	69.61	68.39	12.86	10.28	20.06	0.13
2011	7654.80	8620	925	90.66	90.80	94.48	98.41	1.96	1.82	7.38	0.15
2012	5988.71	6392	925	71.19	71.72	73.71	72.77	0.64	0.46	27.82	0.53
2013	6759.55	7217	925	80.99	81.37	83.42	82.39	5.16	4.96	13.67	0.38

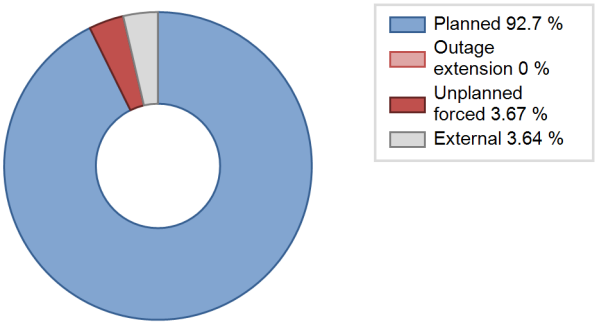
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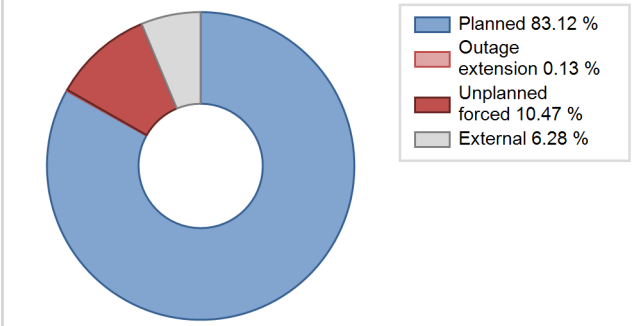
2014	6277.53	6846	925	75.22	75.72	77.46	78.14	2.80	2.18	22.10	0.49
2015	6849.24	7482	925	82.74	84.12	84.53	85.41	0.45	0.38	15.50	1.37
2016	5293.85	6143	925	65.56	67.46	65.15	69.93	6.10	4.38	28.16	1.90
2017	6684.29	7504	925	81.87	82.54	82.49	85.66	5.99	5.26	12.20	0.68
2018	4685.45	5302	925	57.65	58.92	57.82	60.53	5.30	3.29	37.78	1.27
2019	5300.40	5889	925	64.96	66.51	65.41	67.23	0.00	0.00	33.49	1.55
2020	5208.97	5781	925	63.74	65.06	64.11	65.81	2.00	1.33	33.61	1.32

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		101			122	
C.	Inspection, maintenance or repair combined with refuelling	2906			911		
D.	Inspection, maintenance or repair without refuelling				1264		
E.	Testing of plant systems or components				4		
F.	Major backfitting, refurbishment or upgrading activities with refuelling				120		
H.	Nuclear regulatory requirements					9	
J.	Grid limitation, failure or grid unavailability						9
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L.	Human factor related					5	
Z.	Other					4	
Subtotal		2906	101		2299	140	9
Total		**3007**			**2448**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		5
12. Reactor I&C Systems	101	35
13. Reactor Auxiliary Systems		3
15. Reactor Cooling Systems		20
16. Steam generation systems		6
17. Safety I&C Systems (excluding reactor I&C)		3
21. Fuel Handling and Storage Facilities		3
31. Turbine and auxiliaries		12
32. Feedwater and Main Steam System		13
34. Miscellaneous Systems		16
35. All other I&C Systems		1
41. Main Generator Systems		2
42. Electrical Power Supply Systems		4
Total	**101**	**123**

Highlights (2020)

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 49767.775 MWh. The unit was in the intermediate outage from 2020.01.24 to 2020.05.24. 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.

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2020 Operating Experience

RU-22 KURSK-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 (JSC 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	:	1973-01-01
Grid Date	:	1979-01-28
Commercial Date	:	1979-08-17
Age at end of year	:	41 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	:	1693
Fuel linear heat generation rate [kW/m]	:	11.2
Number of control rod assemblies	:	150
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

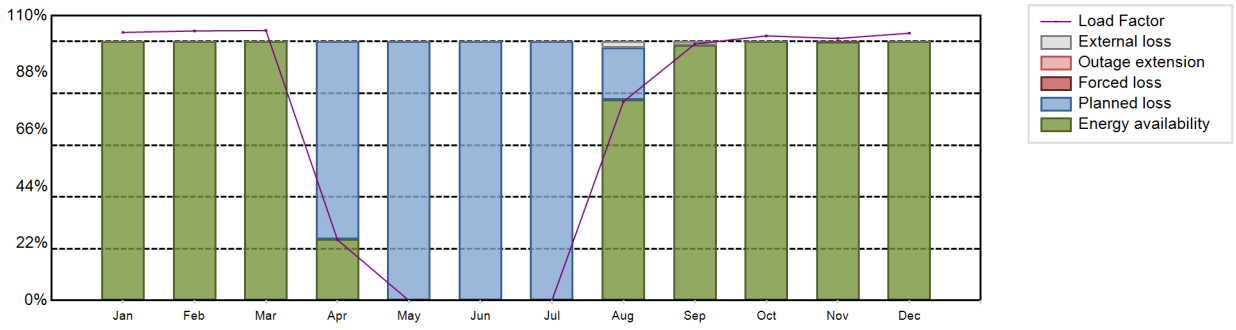
Operating coolant pressure [MPa]	:	7
Reactor outlet temperature [°C]	:	284
Number of SG	:	NA
Containment type	:	NA
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5532.83 GW(e).h
Energy Availability Factor (EAF)	:	66.59 %
Unit Capability Factor (UCF)	:	66.89 %
Load Factor (LF)	:	68.09 %
Operating Factor (OF)	:	67.68 %
Equivalent non-electrical energy generated (NEG)	:	81.88 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	33.1 %
Externally cause unavailability (XUF)	:	0.3 %
Total off-line time	:	2839 hours

Annual Summary



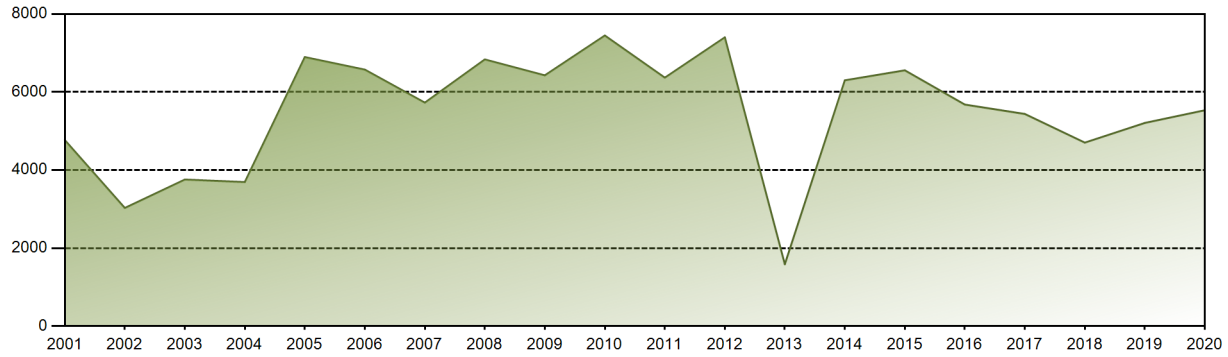
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	712.61	670.21	717.61	156.22	0.00	0.00	0.00	528.57	659.81	703.35	674.04	710.42	5532.83
EAF [%]	100.00	100.00	100.00	23.74	0.00	0.00	0.00	77.42	98.72	100.00	99.97	100.00	66.59
UCF [%]	100.00	100.00	100.00	23.74	0.00	0.00	0.00	79.74	100.00	100.00	99.97	100.00	66.89
LF [%]	103.55	104.10	104.27	23.46	0.00	0.00	0.00	76.80	99.07	102.20	101.21	103.23	68.09
OF [%]	100.00	100.00	100.00	27.08	0.00	0.00	0.00	85.75	100.00	100.00	100.00	100.00	67.68
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	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	0.03	0.00	0.00
PUF [%]	0.00	0.00	0.00	76.26	100.00	100.00	100.00	20.26	0.00	0.00	0.00	0.00	33.10
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.32	1.28	0.00	0.00	0.00	0.30

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Historical Summary

Lifetime energy generation	:	217354.41 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.14 %
Cumulative Energy Availability Factor (EAF)	:	63.98 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.53 %
Cumulative Unit Capability Factor (UCF)	:	65.9 %	Cumulative Planned Unavailability Factor (PUF)	:	29.57 %
Cumulative Load Factor (LF)	:	64.26 %	Cumulative Externally cause unavailability (XUF)	:	1.92 %
Cumulative Operating Factor (OF)	:	74.37 %			

Electricity Production (net) [GWh]

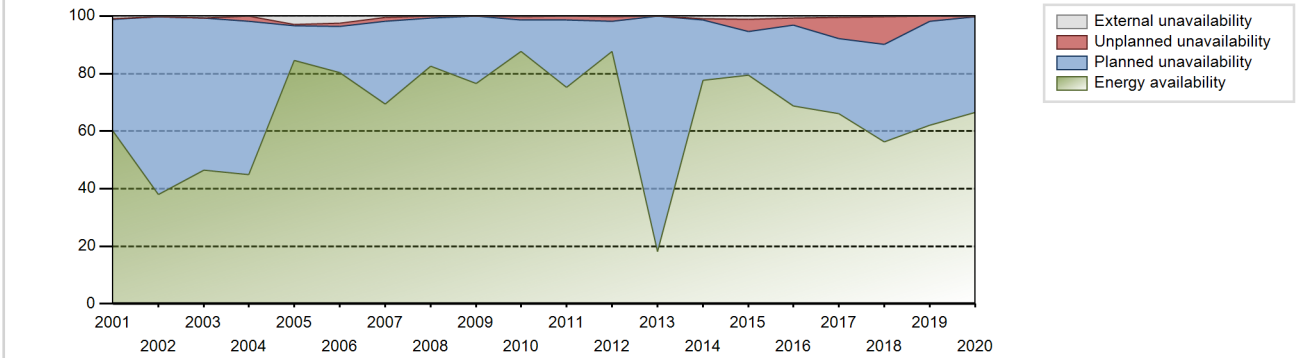


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1979	3613.90	6734	925	62.36	62.36	62.31	80.40	27.83	24.04	13.59	0.00
1980	6404.32	7658	925	78.45	79.02	78.82	87.18	10.04	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

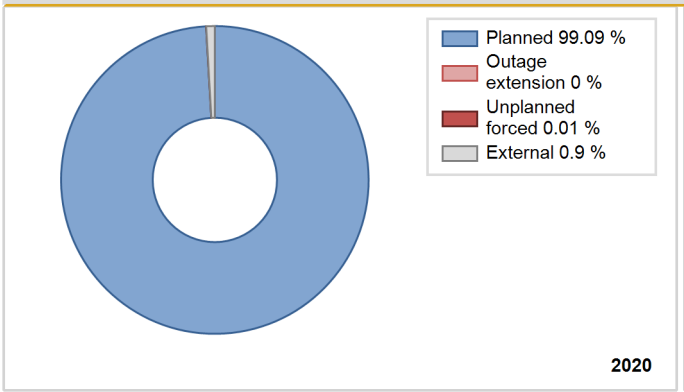
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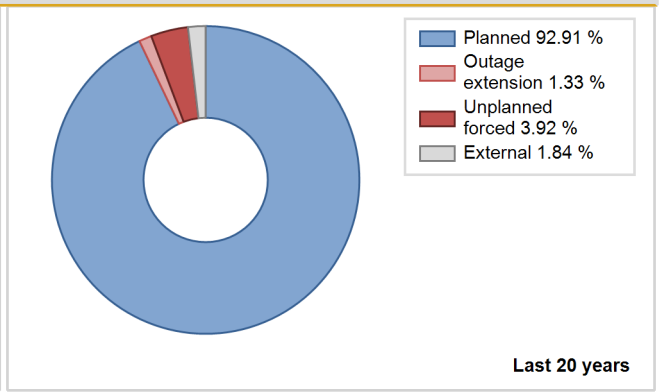
2016	5678.19	6425	925	68.85	69.57	69.88	73.14	3.29	2.37	28.06	0.72
2017	5437.61	6209	925	66.14	66.59	67.11	70.88	3.75	7.38	26.03	0.45
2018	4702.96	5689	925	56.25	56.48	58.04	64.94	11.38	9.58	33.94	0.22
2019	5207.62	5656	925	62.03	62.17	64.27	64.57	2.74	1.75	36.08	0.13
2020	5532.83	5945	925	66.59	66.89	68.09	67.68	0.00	0.00	33.10	0.30

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1979 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					110	
C. Inspection, maintenance or repair combined with refuelling	2839			1366		
D. Inspection, maintenance or repair without refuelling				625		
E. Testing of plant systems or components				13		
F. Major backfitting, refurbishment or upgrading activities with refuelling				100		
H. Nuclear regulatory requirements					5	
J. Grid limitation, failure or grid unavailability						5
L. Human factor related					3	
Z. Other					29	
Subtotal	2839			2104	147	5
Total	**2839**			**2256**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1979 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		44
12. Reactor I&C Systems		7
13. Reactor Auxiliary Systems		5
14. Safety Systems		2
15. Reactor Cooling Systems		17
16. Steam generation systems		3
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		7
32. Feedwater and Main Steam System		4
34. Miscellaneous Systems		14
41. Main Generator Systems		4
42. Electrical Power Supply Systems		1
Total		**110**

Highlights (2020)

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-April, September- December. Additional electricity generation amounted to 114745.325 MWh. The unit was in the routine maintenance outage from 2020.04.09 to 2020.08.05. 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.

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2020 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 (JSC 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	:	37 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

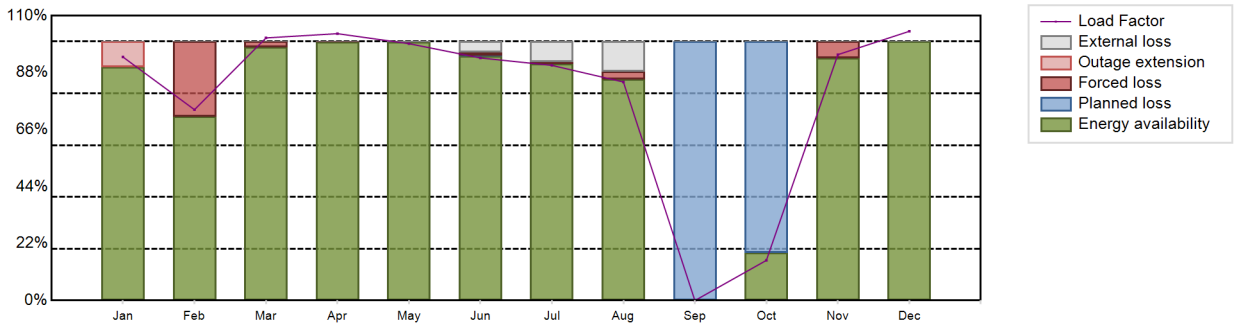
Operating coolant pressure [MPa]	:	7
Reactor outlet temperature [°C]	:	284
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP 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	:	DH / PH

Annual Production Results (2020)

Net Energy Production	:	6473.17 GW(e).h
Energy Availability Factor (EAF)	:	78.62 %
Unit Capability Factor (UCF)	:	80.58 %
Load Factor (LF)	:	79.67 %
Operating Factor (OF)	:	84.97 %
Equivalent non-electrical energy generated (NEG)	:	59.39 GW(e).h

Forced Loss Rate (FLR)	:	4.13 %
Unplanned Capability Loss Factor (UCL)	:	4.32 %
Planned Unavailability Factor (PUF)	:	15.11 %
Externally cause unavailability (XUF)	:	1.96 %
Total off-line time	:	1320 hours

Annual Summary



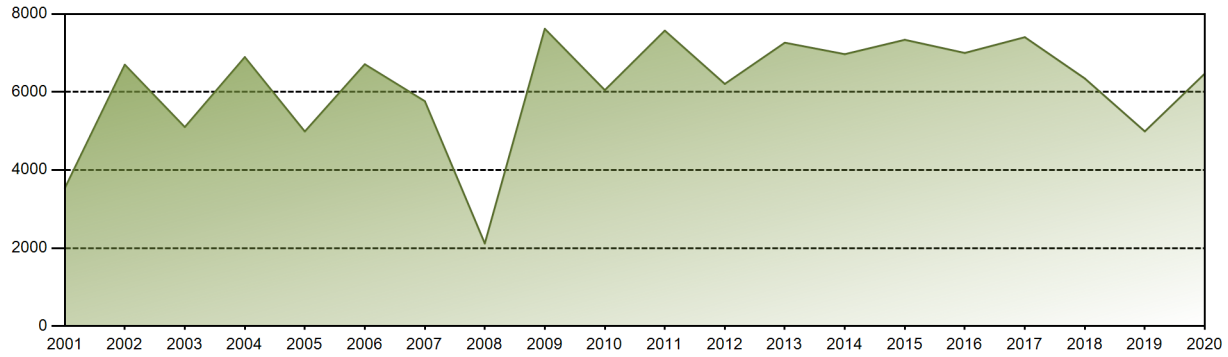
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	647.20	474.54	697.95	686.41	682.72	623.92	624.94	580.78	0.00	106.74	632.42	715.57	6473.17
EAF [%]	90.08	71.12	97.78	99.90	99.96	94.40	91.39	85.37	0.16	18.39	93.55	100.00	78.62
UCF [%]	90.08	71.12	97.78	99.90	100.00	98.42	99.14	96.81	0.16	18.39	93.55	100.00	80.58
LF [%]	94.04	73.71	101.42	103.06	99.20	93.68	90.81	84.39	0.00	15.51	94.96	103.98	79.67
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.42	23.92	94.86	100.00	84.97
FLR [%]	0.00	28.88	2.22	0.10	0.00	1.45	0.86	3.19	0.00	0.00	6.45	0.00	4.13
UCL [%]	9.92	28.88	2.22	0.10	0.00	1.45	0.86	3.19	0.00	0.00	6.45	0.00	4.32
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	99.84	81.61	0.00	0.00	15.11
XUF [%]	0.00	0.00	0.00	0.00	0.04	4.01	7.75	11.43	0.00	0.00	0.00	0.00	1.96

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Historical Summary

Lifetime energy generation	:	222978.59 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.86 %
Cumulative Energy Availability Factor (EAF)	:	74.02 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.41 %
Cumulative Unit Capability Factor (UCF)	:	75.08 %	Cumulative Planned Unavailability Factor (PUF)	:	21.51 %
Cumulative Load Factor (LF)	:	74.13 %	Cumulative Externally cause unavailability (XUF)	:	1.06 %
Cumulative Operating Factor (OF)	:	77.69 %			

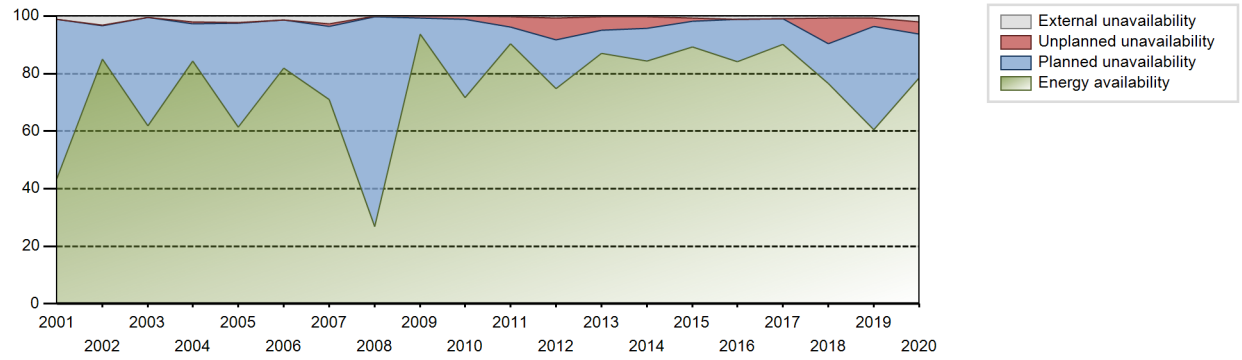
Electricity Production (net) [GWh]



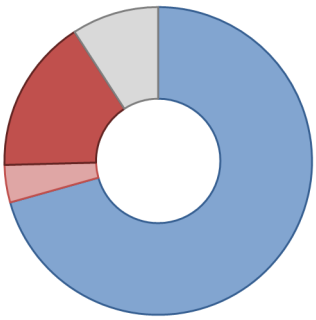
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	5479.24	6830	925	72.49	72.49	72.15	76.71	9.02	7.18	20.33	0.00
1985	6260.75	7250	925	77.59	77.93	77.26	82.76	7.60	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

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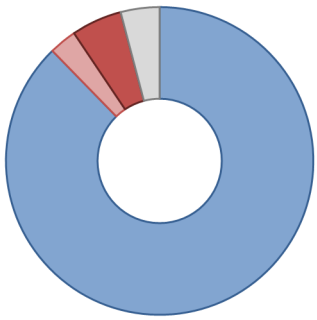
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		43			142	
C. Inspection, maintenance or repair combined with refuelling	1284			1111		
D. Inspection, maintenance or repair without refuelling				695		
E. Testing of plant systems or components				1		
J. Grid limitation, failure or grid unavailability						8
Subtotal	1284	43		1807	142	8
Total		**1327**			**1957**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		23
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems		3
14. Safety Systems		11
15. Reactor Cooling Systems	43	53
16. Steam generation systems		2
17. Safety I&C Systems (excluding reactor I&C)		3
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		4
32. Feedwater and Main Steam System		10
41. Main Generator Systems		9
42. Electrical Power Supply Systems		4
Total	**43**	**143**

Highlights (2020)

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-Desember. Additional electricity generation amounted to 150914.675 MWh. The unit was in the overhaul outage from 2020.09.01 to 2020.10.24. 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.

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2020 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 (JSC 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	:	35 years

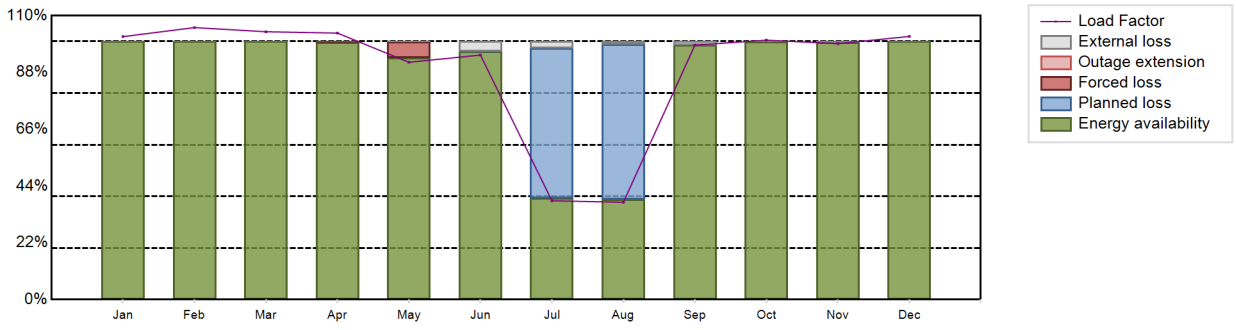
Design Characteristics

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 (2020)

Net Energy Production	:	7277.83 GW(e).h
Energy Availability Factor (EAF)	:	88.64 %
Unit Capability Factor (UCF)	:	89.46 %
Load Factor (LF)	:	89.57 %
Operating Factor (OF)	:	90.97 %
Equivalent non-electrical energy generated (NEG)	:	163.01 GW(e).h
Forced Loss Rate (FLR)	:	0.62 %
Unplanned Capability Loss Factor (UCL)	:	0.56 %
Planned Unavailability Factor (PUF)	:	9.98 %
Externally cause unavailability (XUF)	:	0.81 %
Total off-line time	:	793 hours

Annual Summary



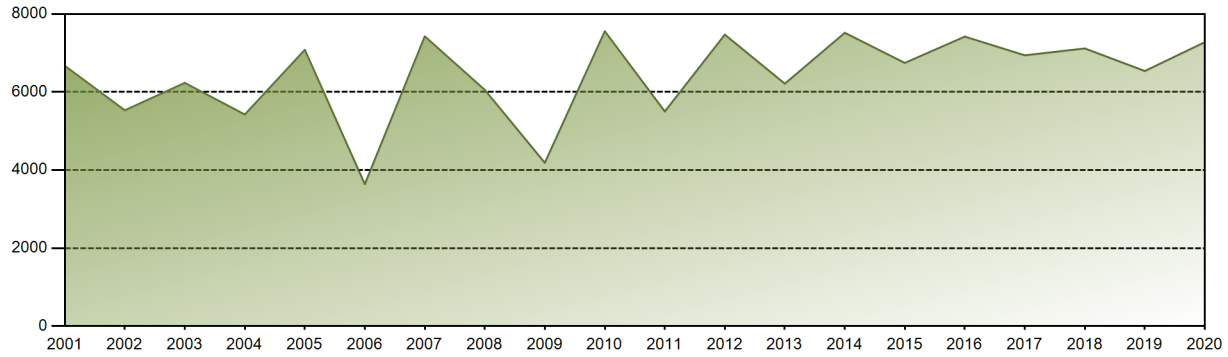
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	701.11	678.45	714.12	687.54	632.70	630.84	263.54	259.54	656.50	691.57	660.29	701.63	7277.83
EAF [%]	100.00	100.00	100.00	99.63	93.71	96.02	39.43	38.93	98.50	99.83	99.68	100.00	88.64
UCF [%]	100.00	100.00	100.00	99.63	93.75	99.94	42.10	40.09	100.00	100.00	100.00	100.00	89.46
LF [%]	101.88	105.38	103.77	103.23	91.94	94.72	38.29	37.71	98.57	100.49	99.14	101.95	89.57
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	45.56	47.85	100.00	100.00	100.00	100.00	90.97
FLR [%]	0.00	0.00	0.00	0.37	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.62
UCL [%]	0.00	0.00	0.00	0.37	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.06	57.90	59.91	0.00	0.00	0.00	0.00	9.98
XUF [%]	0.00	0.00	0.00	0.00	0.04	3.92	2.66	1.16	1.50	0.17	0.32	0.00	0.81

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Historical Summary

Lifetime energy generation	:	222192.96 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.57 %
Cumulative Energy Availability Factor (EAF)	:	77.49 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.09 %
Cumulative Unit Capability Factor (UCF)	:	78.52 %	Cumulative Planned Unavailability Factor (PUF)	:	19.39 %
Cumulative Load Factor (LF)	:	78.25 %	Cumulative Externally cause unavailability (XUF)	:	1.04 %
Cumulative Operating Factor (OF)	:	80.61 %			

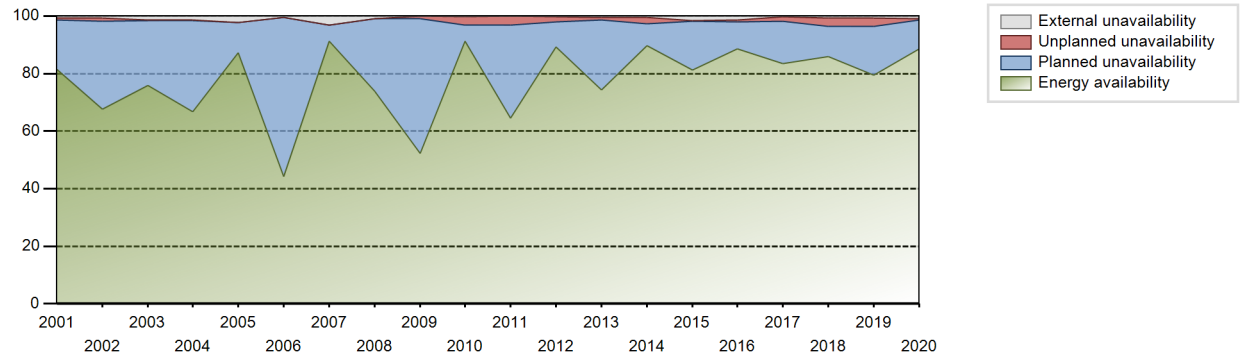
Electricity Production (net) [GWh]



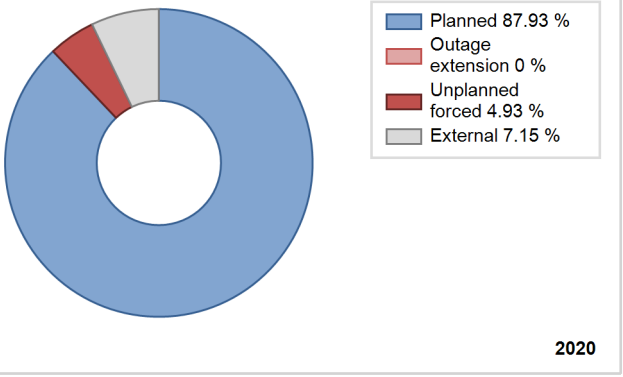
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	6328.54	7574	925	80.35	80.81	80.28	88.06	12.66	11.71	7.47	0.46
1987	6167.68	6704	1000	72.29	72.43	70.41	76.53	6.80	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

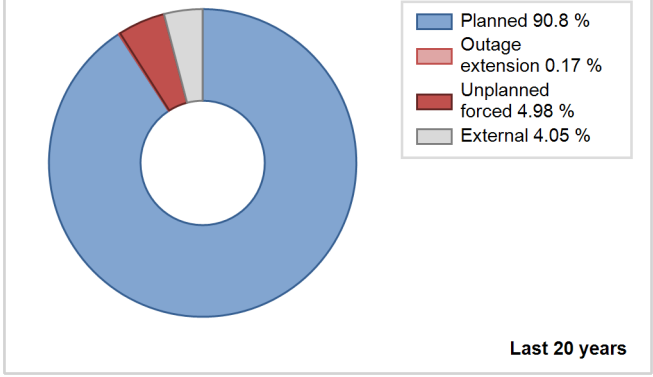
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 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	793			1134		
D. Inspection, maintenance or repair without refuelling				403		
F. Major backfitting, refurbishment or upgrading activities with refuelling				78		
J. Grid limitation, failure or grid unavailability						1
L. Human factor related					5	
Z. Other					6	
Subtotal	793			1615	82	1
Total	**793**			**1698**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		9
12. Reactor I&C Systems		14
15. Reactor Cooling Systems		11
16. Steam generation systems		0
31. Turbine and auxiliaries		4
32. Feedwater and Main Steam System		7
33. Circulating Water System		3
42. Electrical Power Supply Systems		23
Total		**71**

Highlights (2020)

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-May, September-December. Additional electricity generation amounted to 130641.45 MWh. The unit was in the routine maintenance outage from 2020.07.15 to 2020.08.17. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	AEM (JSC 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	:	2 years

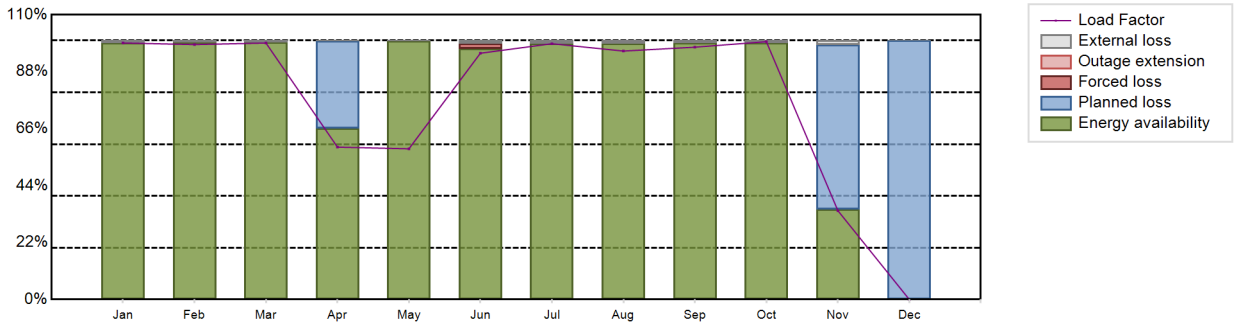
Design Characteristics

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

Annual Production Results (2020)

Net Energy Production	:	7530.82 GW(e).h	Forced Loss Rate (FLR)	:	0.18 %
Energy Availability Factor (EAF)	:	82.64 %	Unplanned Capability Loss Factor (UCL)	:	0.15 %
Unit Capability Factor (UCF)	:	83.44 %	Planned Unavailability Factor (PUF)	:	16.41 %
Load Factor (LF)	:	77.87 %	Externally cause unavailability (XUF)	:	0.8 %
Operating Factor (OF)	:	80.11 %	Total off-line time	:	1747 hours

Annual Summary



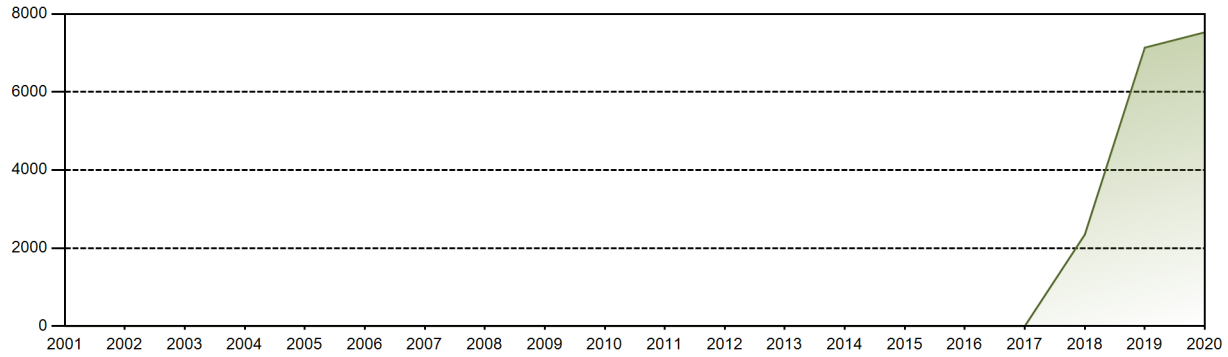
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	811.59	754.52	811.42	466.60	476.88	754.05	809.25	786.08	772.57	815.60	272.25	0.00	7530.82
EAF [%]	99.15	99.43	99.47	66.19	99.80	96.94	98.77	98.79	99.07	99.09	34.96	0.01	82.64
UCF [%]	100.00	100.00	100.00	66.43	100.00	98.18	100.00	100.00	100.00	100.00	36.68	0.01	83.44
LF [%]	99.08	98.46	99.06	58.86	58.22	95.12	98.79	95.96	97.46	99.57	34.34	0.00	77.87
OF [%]	100.00	100.00	100.00	63.47	61.69	100.00	100.00	100.00	100.00	100.00	36.81	0.00	80.11
FLR [%]	0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.18
UCL [%]	0.00	0.00	0.00	0.00	0.00	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.15
PUF [%]	0.00	0.00	0.00	33.57	0.00	0.00	0.00	0.00	0.00	0.00	63.32	99.99	16.41
XUF [%]	0.85	0.57	0.53	0.24	0.20	1.24	1.23	1.21	0.93	0.91	1.73	0.00	0.80

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Historical Summary

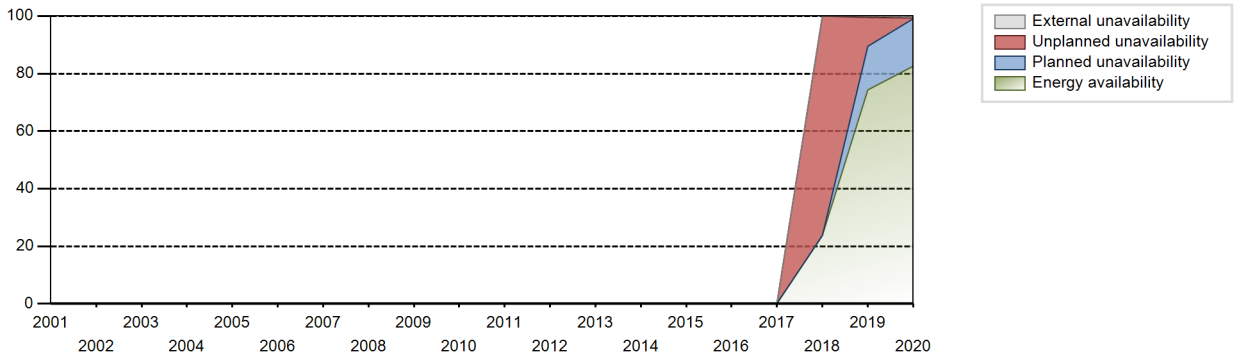
Lifetime energy generation	:	17012.85 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	10.87 %
Cumulative Energy Availability Factor (EAF)	:	74.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	10.47 %
Cumulative Unit Capability Factor (UCF)	:	74.98 %	Cumulative Planned Unavailability Factor (PUF)	:	14.55 %
Cumulative Load Factor (LF)	:	71.71 %	Cumulative Externally cause unavailability (XUF)	:	0.64 %
Cumulative Operating Factor (OF)	:	74.03 %			

Electricity Production (net) [GWh]

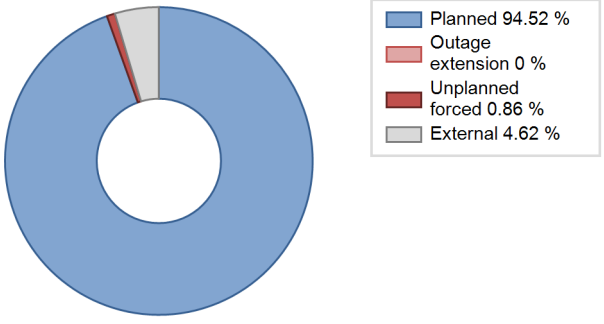


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	2344.91	3078	1085	23.75	23.75	20.26	25.14	76.25	76.25	0.00	0.00
2019	7137.13	6666	1101	74.35	74.93	74.00	76.10	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

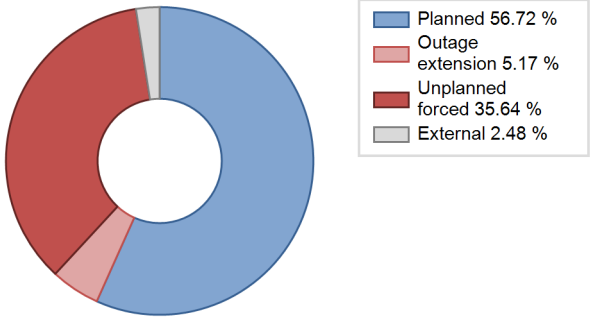
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2018 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					1021	
C. Inspection, maintenance or repair combined with refuelling	1200			1165		
D. Inspection, maintenance or repair without refuelling	243			112		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			321			148
Subtotal	1443		321	1277	1021	148
Total	**1764**			**2446**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2018 to 2020
	Hours Lost	Average hours lost per reactor-year
16. Steam generation systems		34
31. Turbine and auxiliaries		206
32. Feedwater and Main Steam System		159
41. Main Generator Systems		381
Total		**780**

Highlights (2020)

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 February, April-May. Additional electricity generation amounted to 140 MWh. The unit was in the routine maintenance outage from 2020.04.19 to 2020.04.30 and in the in the overhoul outage from 2020.11.12 to 2021.01.01. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	AEM (JSC 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)	:	1066 MWe

Key Dates

Construction Date	:	2010-04-15
Grid Date	:	2020-10-22
Commercial Date	:	2021-03-18
Age at end of year	:	0 years

Design Characteristics

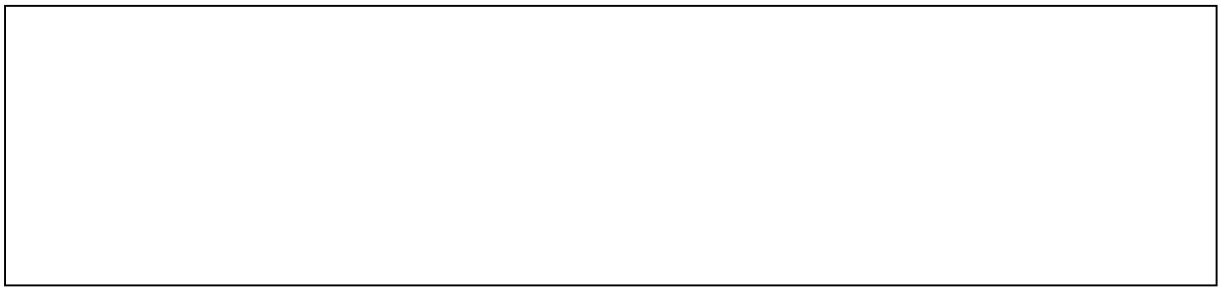
Primary Systems			Operating coolant pressure [MPa]	:	-
Reactor vessel centreline orientation	:	-	Reactor outlet temperature [°C]	:	-
Fuel material	:	-	Number of SG	:	-
Refuelling type	:	-	Containment type	:	-
Moderator material	:	-	Containment design pressure [MPa]	:	-
Average fuel enrichment [% of U235]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

Annual Production Results (2020)

Net Energy Production	:	659.54 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	:	462 hours

Annual Summary

No data found



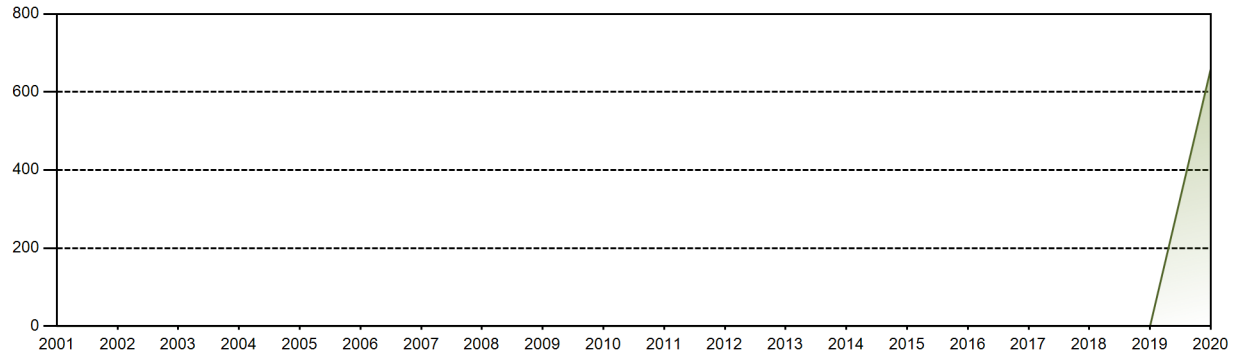
	Jan	Oct	Nov	Dec	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
GW(e)-h												
EAF [%]												
UCF [%]												
LF [%]												
OF [%]												
FLR [%]												
UCL [%]												
PUF [%]												
XUF [%]												

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Historical Summary

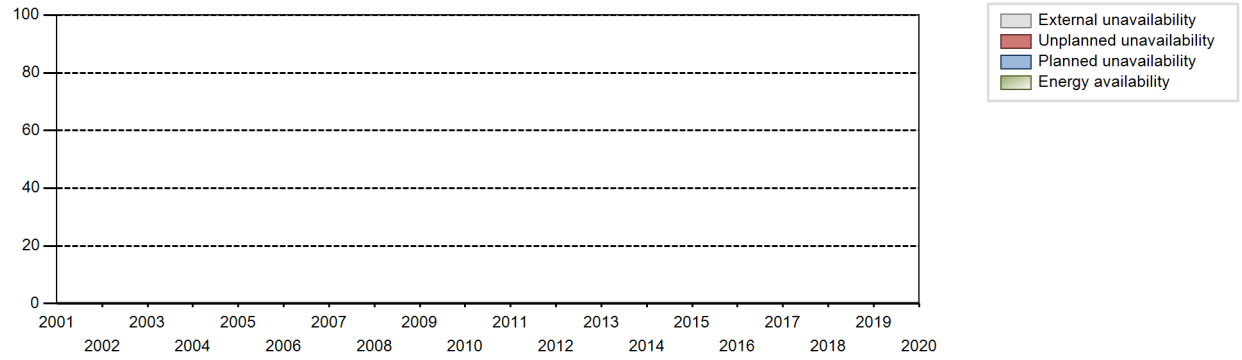
Lifetime energy generation	:	659.54 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	0 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	0 %	Cumulative Planned Unavailability Factor (PUF)	:	0 %
Cumulative Load Factor (LF)	:	0 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	0 %			

Electricity Production (net) [GWh]

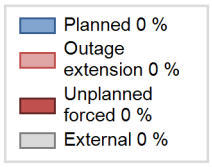


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]

Key Factors in Last 20 Years [%]



Energy Losses by Type



2020

No Data Available

Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2021 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
Subtotal						
Total	0			0		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2021 to 2020
	Hours Lost	Average hours lost per reactor-year
Total		

Highlights (2020)

Pilot operation

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2020 Operating Experience

RU-16 LENINGRAD-2 RUSSIA

Status at end of year	:	**Permanent Shutdown**
Operator	:	REA (Joint Stock Company 'Concern Rosenergoatom')
Owner	:	REA (Joint Stock Company 'Concern Rosenergoatom')
Reactor Supplier	:	AEM (JSC 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	:	1970-06-01
Grid Date	:	1975-07-11
Commercial Date	:	1976-02-11
Age at end of year	:	45 years

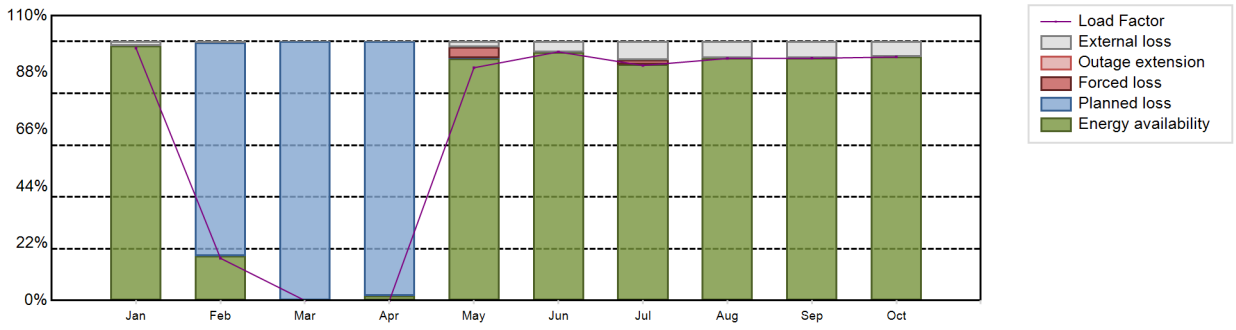
Design Characteristics

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]	:	22000
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]	:	14.5
Number of control rod assemblies	:	211
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	:	NA
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	:	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	:	DH / PH

Annual Production Results (2020)

Net Energy Production	:	4754.95 GW(e).h
Energy Availability Factor (EAF)	:	68.28 %
Unit Capability Factor (UCF)	:	71.67 %
Load Factor (LF)	:	67.53 %
Operating Factor (OF)	:	72.92 %
Equivalent non-electrical energy generated (NEG)	:	15.66 GW(e).h
Forced Loss Rate (FLR)	:	0.84 %
Unplanned Capability Loss Factor (UCL)	:	0.61 %
Planned Unavailability Factor (PUF)	:	27.73 %
Externally cause unavailability (XUF)	:	3.38 %
Total off-line time	:	2005 hours

Annual Summary



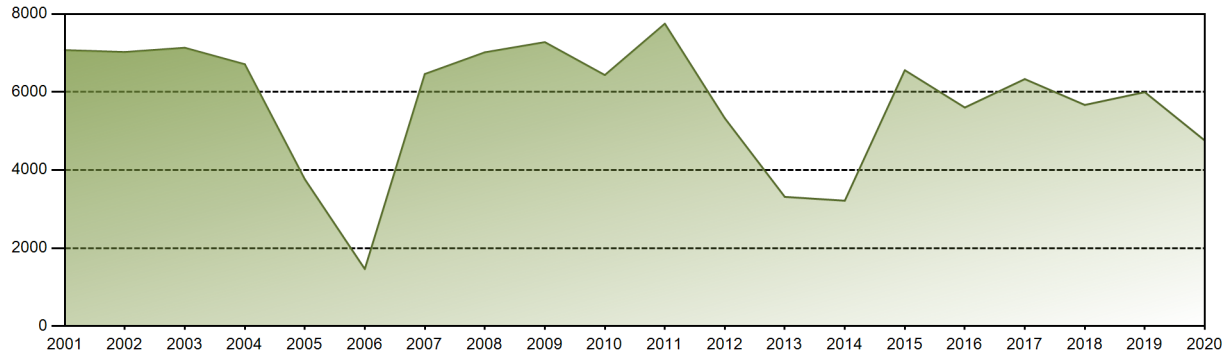
	Dec	Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Annual
GW(e)-h			670.79	105.08	0.00	0.00	618.70	639.49	624.66	643.32	622.98	647.24	4572.28
EAF [%]			98.39	17.13	0.00	1.73	93.30	95.87	91.07	93.73	93.71	94.18	68.28
UCF [%]			100.00	17.44	0.00	1.73	95.44	100.00	98.11	100.00	100.00	100.00	71.67
LF [%]			97.47	16.32	0.00	0.00	89.90	96.02	90.77	93.48	93.54	94.05	67.53
OF [%]			100.00	20.55	0.00	4.86	100.00	100.00	100.00	100.00	100.00	100.00	72.92
FLR [%]			0.00	0.00	0.00	0.00	4.11	0.00	1.89	0.00	0.00	0.00	0.84
UCL [%]			0.00	0.00	0.00	0.00	4.10	0.00	1.89	0.00	0.00	0.00	0.61
PUF [%]			0.00	82.56	100.00	98.27	0.47	0.00	0.00	0.00	0.00	0.00	27.73
XUF [%]			1.61	0.32	0.00	0.00	2.14	4.13	7.05	6.27	6.29	5.82	3.38

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Historical Summary

Lifetime energy generation	:	255713.79 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.21 %
Cumulative Energy Availability Factor (EAF)	:	70.12 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.24 %
Cumulative Unit Capability Factor (UCF)	:	70.93 %	Cumulative Planned Unavailability Factor (PUF)	:	25.83 %
Cumulative Load Factor (LF)	:	69.84 %	Cumulative Externally cause unavailability (XUF)	:	0.81 %
Cumulative Operating Factor (OF)	:	75.65 %			

Electricity Production (net) [GWh]

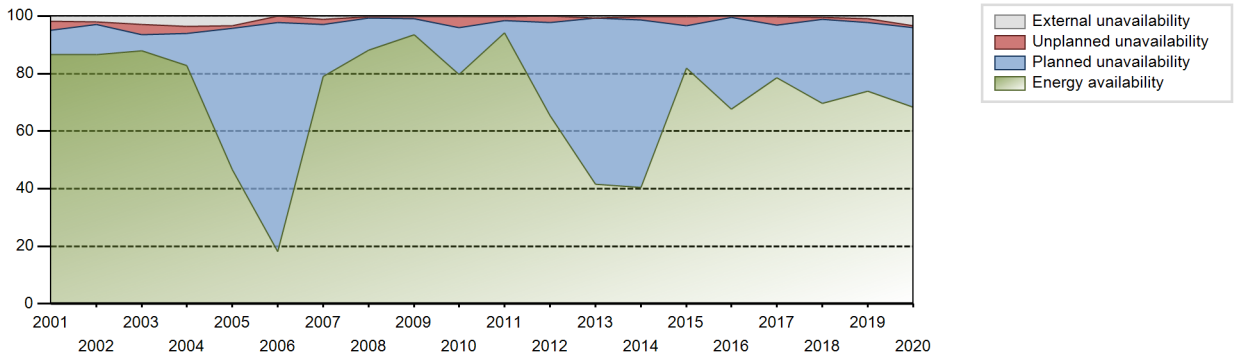


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	5492.29	7654	925	67.86	67.92	65.53	85.95	18.92	15.85	16.23	0.06
1977	5413.69	7337	925	67.08	67.17	66.81	83.76	17.69	14.43	18.40	0.09
1978	6310.80	8008	925	78.78	78.78	77.88	91.42	11.71	10.44	10.78	0.00
1979	5633.67	6954	925	70.08	70.08	69.53	79.38	11.10	8.75	21.17	0.00
1980	6351.84	7960	925	78.62	78.83	78.17	90.62	5.91	4.96	16.22	0.21
1981	5177.19	6057	925	61.97	61.97	63.89	69.14	15.79	11.62	26.41	0.00
1982	7266.78	8125	925	89.86	90.38	89.68	92.75	2.86	2.66	6.95	0.52
1983	6790.78	7479	925	83.56	84.24	83.81	85.38	2.47	2.13	13.63	0.69
1984	7145.90	7881	925	87.42	87.63	87.95	89.72	3.80	3.47	8.91	0.21
1985	5962.57	6604	925	74.32	74.36	73.58	75.39	5.13	4.02	21.62	0.04
1986	7152.34	7914	925	88.12	88.44	88.27	90.34	1.57	1.41	10.15	0.32
1987	7228.20	7513	1000	82.95	83.71	82.51	85.76	0.00	0.00	16.29	0.75
1988	6814.92	7417	925	83.59	83.59	83.87	84.44	0.06	0.05	16.36	0.00
1989	6111.49	7102	925	75.63	75.81	75.42	81.07	0.98	0.75	23.44	0.19
1990	5998.30	8125	925	75.34	75.47	74.03	92.75	21.18	20.28	4.25	0.13
1991	4410.75	7204	925	56.34	56.37	54.43	82.24	1.96	1.13	42.50	0.03
1992	0.00	0	925	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1993	0.00	0	925	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00
1994	164.10	660	925	2.31	2.31	2.03	7.53	0.00	0.00	97.69	0.00
1995	6812.05	8280	925	86.18	93.38	84.07	94.52	2.41	2.31	4.31	7.21
1996	7244.91	7922	925	89.06	89.42	89.17	90.19	2.42	2.22	8.36	0.36
1997	6587.14	7342	925	82.64	83.13	81.29	83.81	0.34	0.29	16.58	0.50
1998	5916.70	6643	925	72.45	73.43	73.02	75.83	5.96	4.65	21.91	0.98
1999	6557.78	7299	925	80.19	80.59	80.93	83.32	0.55	0.44	18.96	0.40
2000	7252.55	7972	925	88.59	90.13	89.26	90.76	1.41	1.29	8.58	1.53
2001	7073.50	7904	925	86.60	88.46	87.29	90.23	3.39	3.10	8.44	1.86
2002	7024.86	7961	925	86.58	88.71	86.69	90.88	0.97	0.87	10.42	2.13
2003	7134.43	8298	925	87.96	90.92	88.05	94.73	3.71	3.50	5.57	2.96
2004	6711.54	7832	925	82.87	86.40	82.60	89.16	2.88	2.56	11.04	3.52
2005	3763.24	4557	925	46.61	50.09	46.44	52.02	1.61	0.82	49.10	3.47
2006	1461.44	1760	925	18.13	18.13	18.04	20.09	7.77	2.17	79.70	0.00
2007	6461.37	7077	925	78.97	80.12	79.74	80.79	1.47	1.87	18.01	1.15
2008	7017.53	7810	925	88.06	88.26	86.37	88.91	0.53	0.47	11.27	0.20
2009	7278.61	8310	925	93.44	93.80	89.83	94.86	0.70	0.66	5.54	0.36
2010	6434.67	7352	925	79.65	79.98	79.41	83.93	1.63	3.72	16.31	0.33
2011	7751.04	8362	925	94.27	94.42	95.67	95.47	1.46	1.39	4.18	0.15
2012	5326.19	6317	925	65.45	65.51	65.55	71.91	1.91	2.20	32.29	0.05

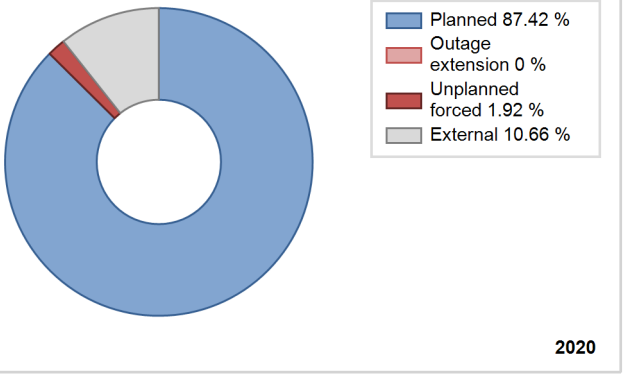
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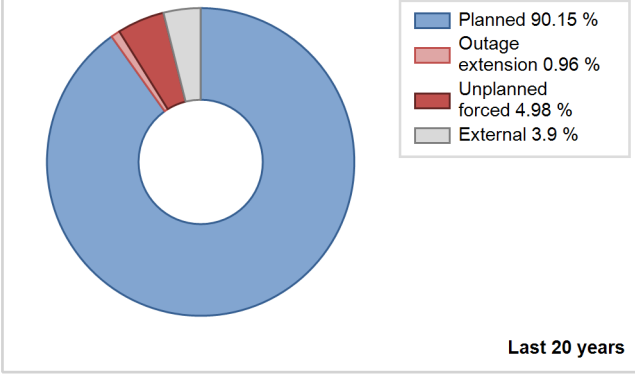
2013	3311.25	5181	925	41.63	42.40	40.86	59.14	0.04	0.02	57.59	0.76
2014	3213.99	4406	925	40.52	40.76	39.66	50.29	0.74	1.08	58.16	0.23
2015	6558.58	7316	925	81.96	82.14	80.94	83.52	3.73	3.18	14.68	0.18
2016	5602.15	6037	925	67.74	67.85	68.95	68.73	0.56	0.38	31.77	0.11
2017	6331.28	7160	925	78.58	78.83	78.13	81.74	3.67	3.00	18.16	0.25
2018	5668.25	6265	925	69.74	70.20	69.95	71.52	1.02	0.73	29.07	0.46
2019	5996.32	6791	925	73.94	74.94	74.00	77.52	1.69	1.29	23.77	1.00
2020	4754.95	5555	925	68.28	71.67	67.53	72.92	0.84	0.61	27.73	3.38

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1976 to 2020 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	1982			1083		
D. Inspection, maintenance or repair without refuelling				715		
E. Testing of plant systems or components				2	1	
G. Major backfitting, refurbishment or upgrading activities without refuelling				246		
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	24			1		
Subtotal	2006			2047	80	1
Total	**2006**			**2128**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1976 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		6
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		5
15. Reactor Cooling Systems		17
17. Safety I&C Systems (excluding reactor I&C)		6
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		4
32. Feedwater and Main Steam System		3
34. Miscellaneous Systems		18
35. All other I&C Systems		1
41. Main Generator Systems		2
42. Electrical Power Supply Systems		4
Total		**77**

Highlights (2020)

The Russian NPPs are operating in the baseload mode agreed with the Federal Tariffs Service. The unit was in the intermediate outage from 2020.02.06 to 2020.05.01. Unit shutdown 2020.11.10 for set-up operations for decommissioning. 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.

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2020 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 (JSC 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	:	1973-12-01
Grid Date	:	1979-12-07
Commercial Date	:	1980-06-29
Age at end of year	:	41 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]	:	22000
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]	:	14.5
Number of control rod assemblies	:	211
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

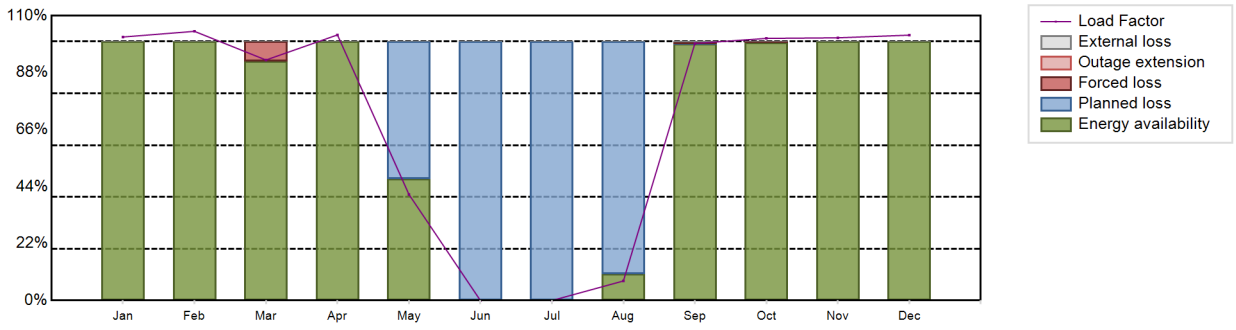
Operating coolant pressure [MPa]	:	7
Reactor outlet temperature [°C]	:	284
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.59
Output voltage [kV]	:	-
Primary means of condenser cooling	:	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	:	DH / PH

Annual Production Results (2020)

Net Energy Production	:	5765.23 GW(e).h
Energy Availability Factor (EAF)	:	70.51 %
Unit Capability Factor (UCF)	:	70.53 %
Load Factor (LF)	:	70.95 %
Operating Factor (OF)	:	71.37 %
Equivalent non-electrical energy generated (NEG)	:	71.42 GW(e).h

Forced Loss Rate (FLR)	:	1.02 %
Unplanned Capability Loss Factor (UCL)	:	0.72 %
Planned Unavailability Factor (PUF)	:	28.75 %
Externally cause unavailability (XUF)	:	0.01 %
Total off-line time	:	2515 hours

Annual Summary



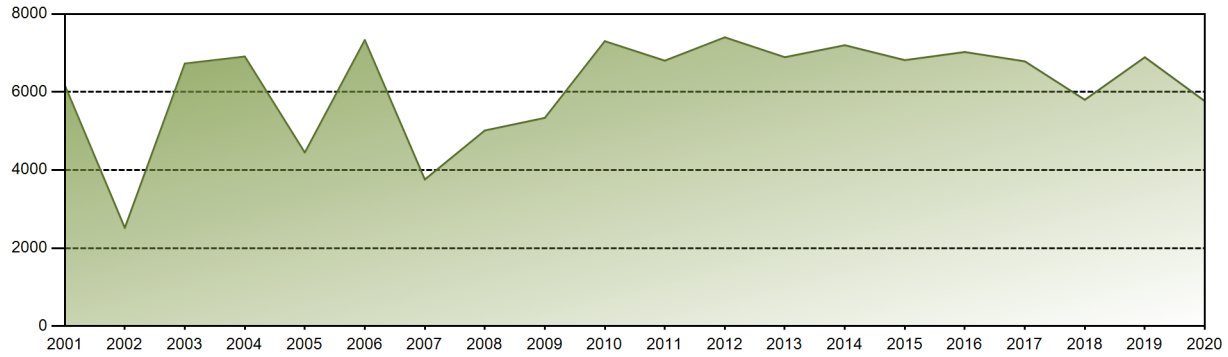
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	700.37	669.31	639.27	683.21	282.01	0.00	0.00	52.07	661.17	696.69	675.80	705.32	5765.23
EAF [%]	100.00	100.00	92.35	100.00	47.05	0.00	0.00	10.29	99.21	99.74	100.00	100.00	70.51
UCF [%]	100.00	100.00	92.35	100.00	47.05	0.00	0.00	10.29	99.34	99.74	100.00	100.00	70.53
LF [%]	101.77	103.96	92.89	102.58	40.98	0.00	0.00	7.57	99.27	101.23	101.47	102.49	70.95
OF [%]	100.00	100.00	93.82	100.00	48.39	0.00	0.00	16.53	100.00	100.00	100.00	100.00	71.37
FLR [%]	0.00	0.00	7.65	0.00	0.00	0.00	0.00	0.00	0.65	0.26	0.00	0.00	1.02
UCL [%]	0.00	0.00	7.65	0.00	0.00	0.00	0.00	0.00	0.65	0.26	0.00	0.00	0.72
PUF [%]	0.00	0.00	0.00	0.00	52.95	100.00	100.00	89.71	0.01	0.00	0.00	0.00	28.75
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.01

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Historical Summary

Lifetime energy generation	:	240635.95 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.76 %
Cumulative Energy Availability Factor (EAF)	:	73.43 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.95 %
Cumulative Unit Capability Factor (UCF)	:	74.28 %	Cumulative Planned Unavailability Factor (PUF)	:	22.77 %
Cumulative Load Factor (LF)	:	72.39 %	Cumulative Externally cause unavailability (XUF)	:	0.85 %
Cumulative Operating Factor (OF)	:	76.26 %			

Electricity Production (net) [GWh]

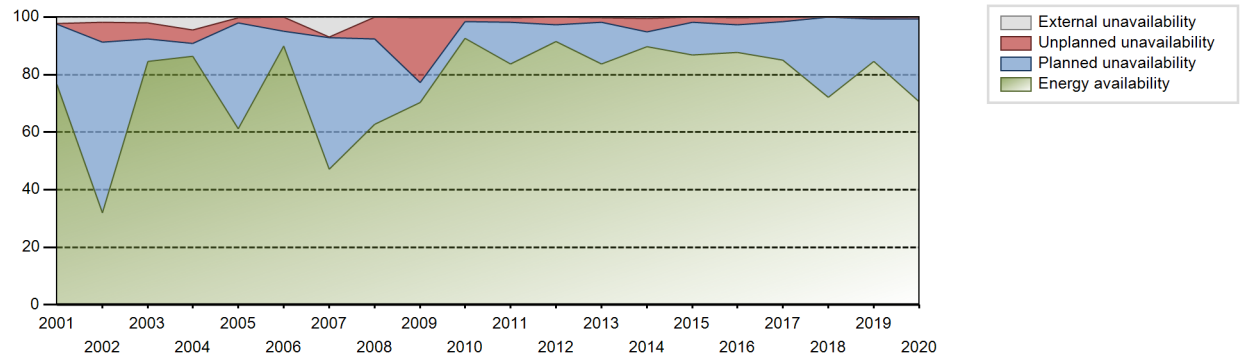


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	5345.39	7504	925	81.59	81.61	80.55	90.94	10.86	9.95	8.45	0.02
1981	6553.56	7528	925	81.35	81.66	80.88	85.94	9.31	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

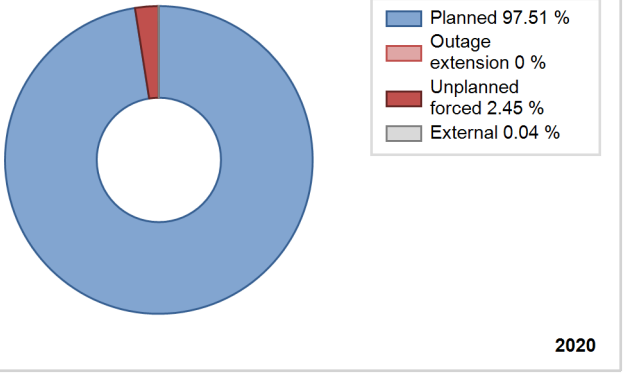
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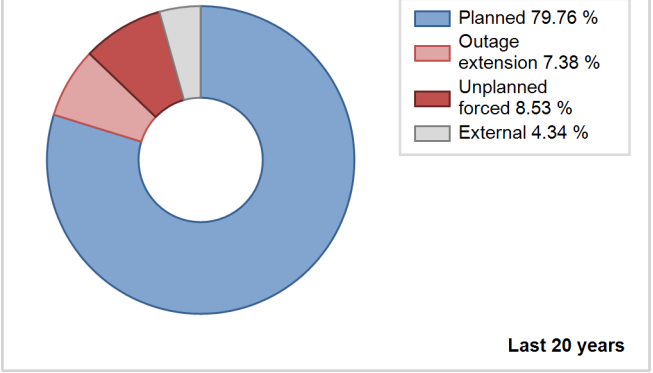
2017	6786.43	7460	925	84.94	84.96	83.75	85.16	1.87	1.62	13.42	0.03
2018	5801.48	6257	925	72.16	72.21	71.60	71.43	0.02	0.02	27.77	0.05
2019	6890.81	7642	925	84.69	84.85	85.04	87.24	0.65	0.56	14.59	0.16
2020	5765.23	6269	925	70.51	70.53	70.95	71.37	1.02	0.72	28.75	0.01

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		67			105	
C. Inspection, maintenance or repair combined with refuelling	2490			781		
D. Inspection, maintenance or repair without refuelling				942		
E. Testing of plant systems or components				1	17	
F. Major backfitting, refurbishment or upgrading activities with refuelling				129		
G. Major backfitting, refurbishment or upgrading activities without refuelling				79		
J. Grid limitation, failure or grid unavailability						3
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						13
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	2490	67		1932	126	17
Total	**2557**			**2075**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		10
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		54
32. Feedwater and Main Steam System		6
33. Circulating Water System		1
35. All other I&C Systems		17
41. Main Generator Systems		2
42. Electrical Power Supply Systems	67	13
Total	**67**	**123**

Highlights (2020)

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-May, August-December. Additional electricity generation amounted to 137449 MWh. The unit was in the routine maintenance outage from 2020.05.15 to 2020.0831. 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.

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2020 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 (JSC 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	:	1975-02-01
Grid Date	:	1981-02-09
Commercial Date	:	1981-08-29
Age at end of year	:	39 years

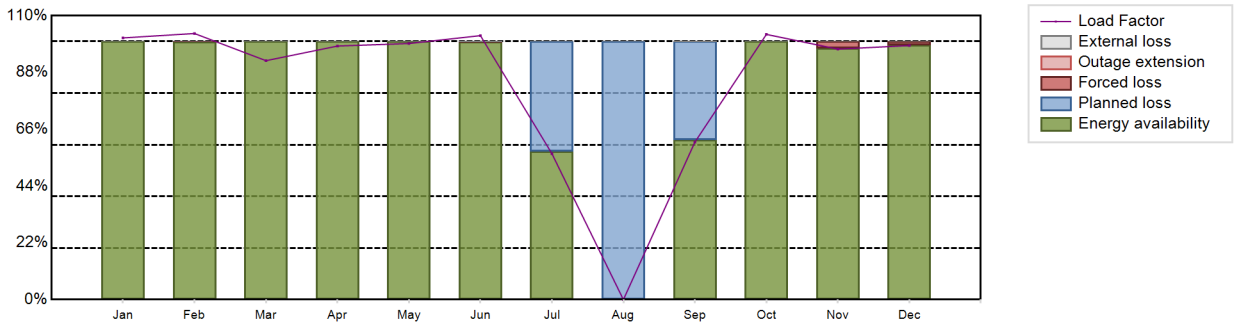
Design Characteristics

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]	:	22000
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]	:	14.5
Number of control rod assemblies	:	211
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	:	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	:	DH / PH

Annual Production Results (2020)

Net Energy Production	:	6842.29 GW(e).h
Energy Availability Factor (EAF)	:	84.44 %
Unit Capability Factor (UCF)	:	84.44 %
Load Factor (LF)	:	84.21 %
Operating Factor (OF)	:	85.22 %
Equivalent non-electrical energy generated (NEG)	:	105.76 GW(e).h
Forced Loss Rate (FLR)	:	0.42 %
Unplanned Capability Loss Factor (UCL)	:	0.35 %
Planned Unavailability Factor (PUF)	:	15.2 %
Externally cause unavailability (XUF)	:	0.01 %
Total off-line time	:	1298 hours

Annual Summary



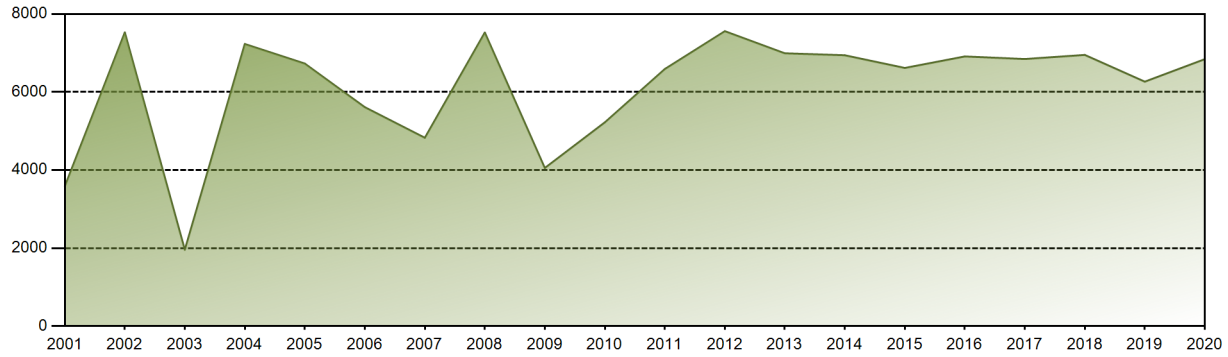
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	697.67	663.63	636.99	654.14	682.67	681.02	389.18	0.00	406.38	707.04	646.24	677.30	6842.29
EAF [%]	100.00	99.80	100.00	100.00	100.00	99.81	57.33	0.00	61.95	100.00	97.27	98.74	84.44
UCF [%]	100.00	99.80	100.00	100.00	100.00	99.90	57.33	0.00	61.96	100.00	97.27	98.74	84.44
LF [%]	101.38	103.08	92.56	98.22	99.20	102.26	56.55	0.00	61.02	102.74	97.03	98.42	84.21
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	60.22	0.00	64.17	100.00	100.00	100.00	85.22
FLR [%]	0.00	0.20	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	2.73	1.26	0.42
UCL [%]	0.00	0.20	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	2.73	1.26	0.35
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	42.67	100.00	38.04	0.00	0.00	0.00	15.20
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.01	0.00	0.00	0.00	0.01

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Historical Summary

Lifetime energy generation	:	231728.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.99 %
Cumulative Energy Availability Factor (EAF)	:	74.87 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.03 %
Cumulative Unit Capability Factor (UCF)	:	75.81 %	Cumulative Planned Unavailability Factor (PUF)	:	21.16 %
Cumulative Load Factor (LF)	:	74.05 %	Cumulative Externally cause unavailability (XUF)	:	0.94 %
Cumulative Operating Factor (OF)	:	77.54 %			

Electricity Production (net) [GWh]

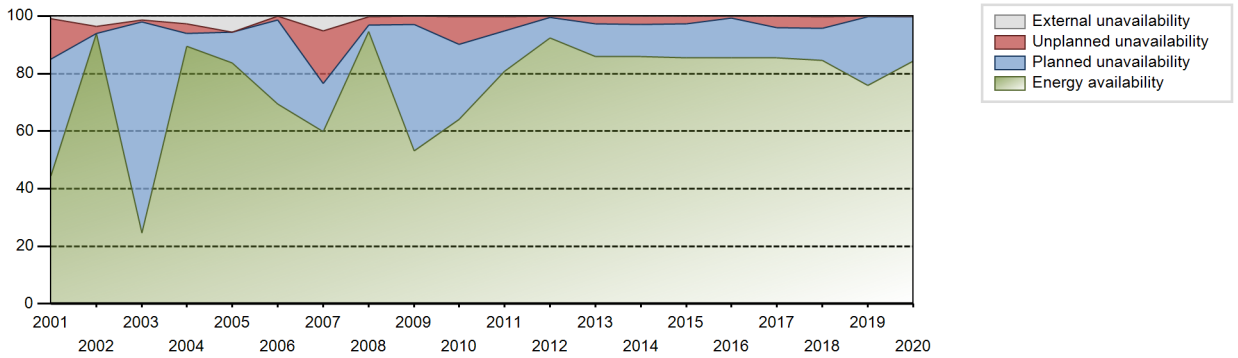


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	3931.27	6151	925	76.82	76.83	76.06	83.41	12.21	10.69	12.48	0.01
1982	6715.19	7609	925	83.59	83.72	82.87	86.86	4.43	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

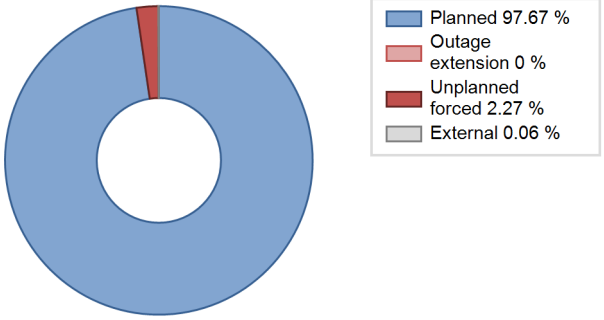
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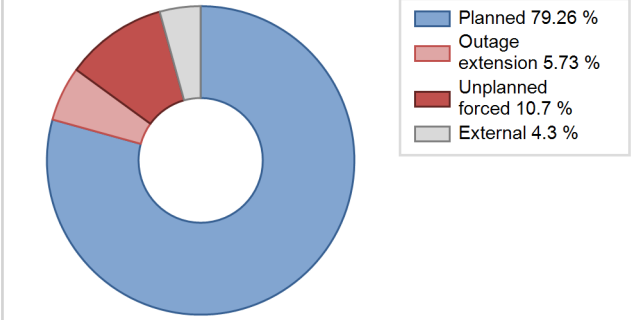
2018	6951.25	7499	925	84.68	84.83	85.79	85.61	4.62	4.11	11.06	0.15
2019	6265.79	6730	925	75.83	75.83	77.33	76.83	0.31	0.24	23.94	0.00
2020	6842.29	7486	925	84.44	84.44	84.21	85.22	0.42	0.35	15.20	0.01

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					85	
C. Inspection, maintenance or repair combined with refuelling	1298			1317		
D. Inspection, maintenance or repair without refuelling				214		
E. Testing of plant systems or components					0	
F. Major backfitting, refurbishment or upgrading activities with refuelling				162		
G. Major backfitting, refurbishment or upgrading activities without refuelling				102	35	
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	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					0	
Z. Other					19	1
Subtotal	1298			1795	140	13
Total	**1298**			**1948**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		7
12. Reactor I&C Systems		19
14. Safety Systems		1
15. Reactor Cooling Systems		19
16. Steam generation systems		11
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		**85**

Highlights (2020)

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-July, Septenber-December. Additional electricity generation amounted to 143974 MWh. The unit was in the routine maintenance outage from 2020.07.19 to 2020.09.15. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	AEM (JSC ATOMENERGOMASH)

Reactor Unit Details

Reactor type and model	:	PWR / VVER V-392M
Thermal power	:	3200 MWth
Gross electrical power	:	1180 MWe
Reference unit power (net)	:	1100 MWe

Key Dates

Construction Date	:	2008-06-24
Grid Date	:	2016-08-05
Commercial Date	:	2017-02-27
Age at end of year	:	4 years

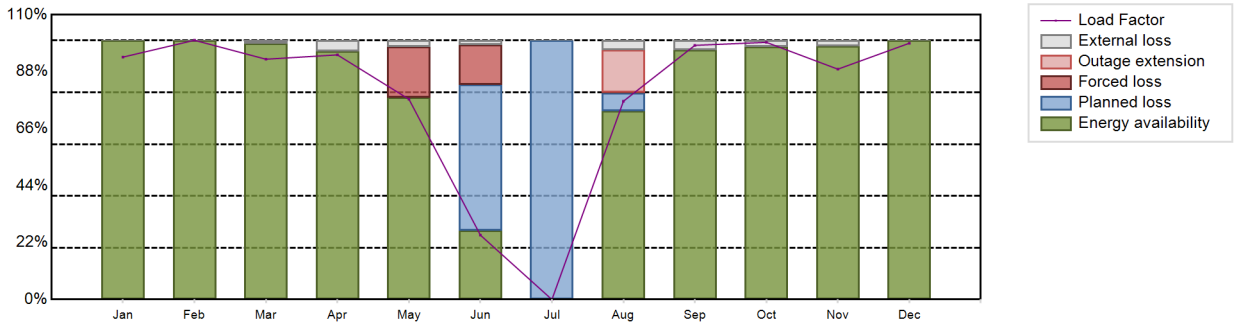
Design Characteristics

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

Annual Production Results (2020)

Net Energy Production	:	7602.46 GW(e).h	Forced Loss Rate (FLR)	:	3.44 %
Energy Availability Factor (EAF)	:	80.29 %	Unplanned Capability Loss Factor (UCL)	:	4.32 %
Unit Capability Factor (UCF)	:	82 %	Planned Unavailability Factor (PUF)	:	13.67 %
Load Factor (LF)	:	78.68 %	Externally cause unavailability (XUF)	:	1.71 %
Operating Factor (OF)	:	84.98 %	Total off-line time	:	1319 hours

Annual Summary



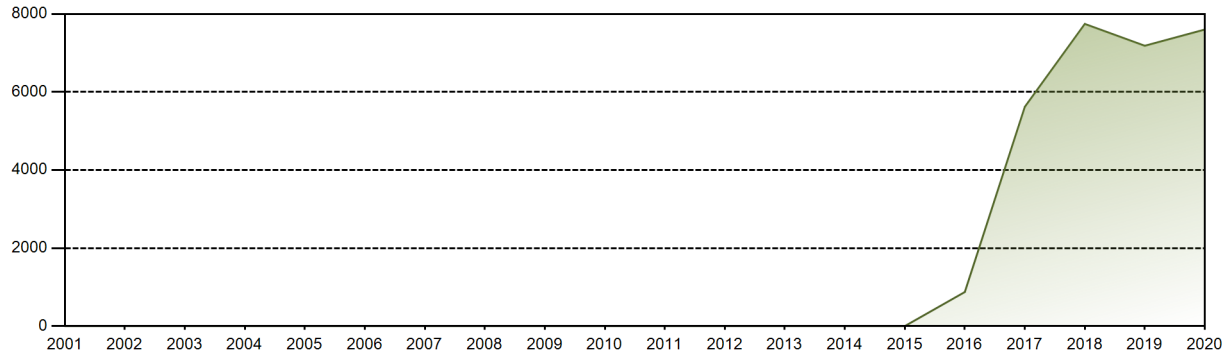
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	766.28	766.53	759.53	748.29	633.18	196.96	0.00	626.72	777.45	812.91	704.55	810.05	7602.46
EAF [%]	100.00	100.00	98.82	96.00	78.12	26.67	0.21	72.72	96.48	97.66	97.93	100.00	80.29
UCF [%]	100.00	100.00	100.00	100.00	80.51	28.23	0.21	76.26	100.00	100.00	100.00	100.00	82.00
LF [%]	93.63	100.12	92.81	94.48	77.37	24.87	0.00	76.58	98.16	99.33	88.96	98.98	78.68
OF [%]	100.00	100.00	100.00	100.00	100.00	43.89	0.00	77.02	100.00	100.00	100.00	100.00	84.98
FLR [%]	0.00	0.00	0.00	0.00	19.49	35.29	0.00	0.20	0.00	0.00	0.00	0.00	3.44
UCL [%]	0.00	0.00	0.00	0.00	19.49	15.39	0.00	16.65	0.00	0.00	0.00	0.00	4.32
PUF [%]	0.00	0.00	0.00	0.00	0.00	56.38	99.79	7.09	0.00	0.00	0.00	0.00	13.67
XUF [%]	0.00	0.00	1.18	4.00	2.39	1.56	0.00	3.54	3.52	2.34	2.07	0.00	1.71

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Historical Summary

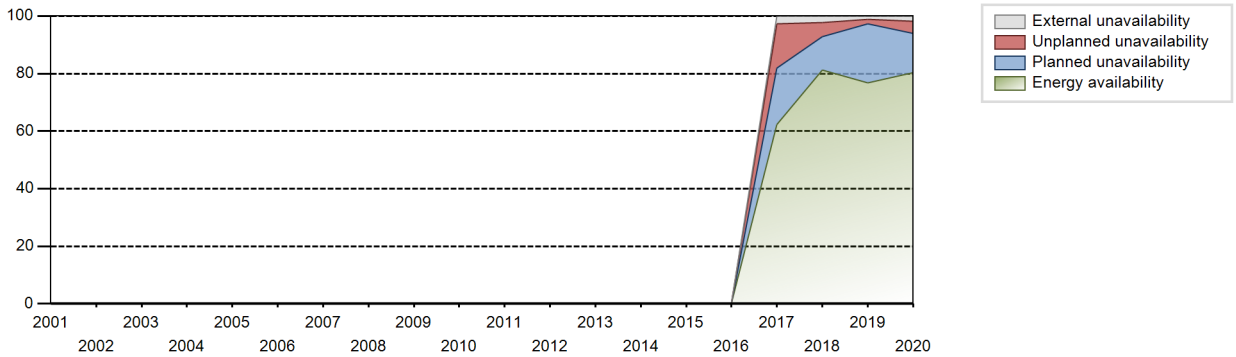
Lifetime energy generation	:	29029.46 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.94 %
Cumulative Energy Availability Factor (EAF)	:	75.7 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.15 %
Cumulative Unit Capability Factor (UCF)	:	77.66 %	Cumulative Planned Unavailability Factor (PUF)	:	16.19 %
Cumulative Load Factor (LF)	:	73.89 %	Cumulative Externally cause unavailability (XUF)	:	1.96 %
Cumulative Operating Factor (OF)	:	80.96 %			

Electricity Production (net) [GWh]

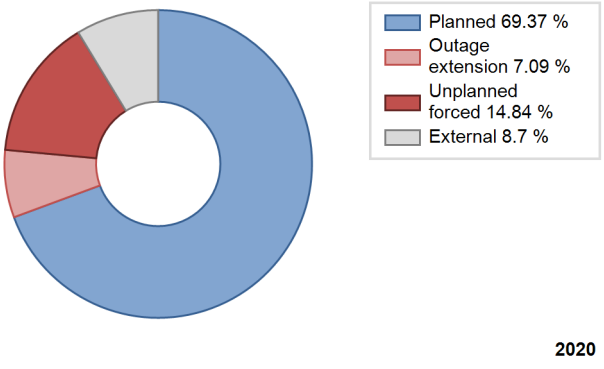


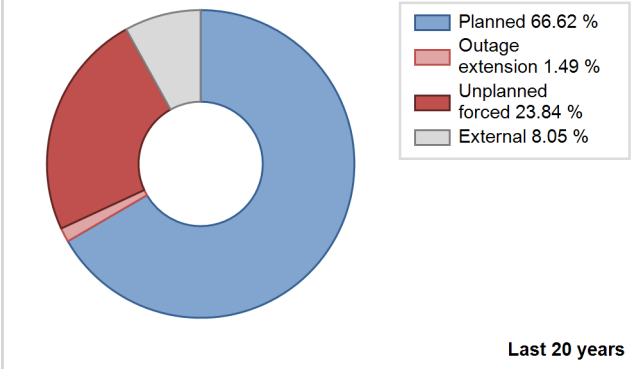
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2017	5620.47	6226	1114	62.35	65.08	60.87	75.08	19.08	15.34	19.58	2.73
2018	7746.87	7378	1114	81.34	83.60	79.38	84.22	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2017 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		136			289	
C. Inspection, maintenance or repair combined with refuelling	1197			1416		
Subtotal	1197	136		1416	289	
Total	**1333**			**1705**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2017 to 2020
	Hours Lost	Average hours lost per reactor-year
14. Safety Systems	123	31
31. Turbine and auxiliaries		67
32. Feedwater and Main Steam System		66
33. Circulating Water System	13	54
41. Main Generator Systems		59
Total	**136**	**277**

Highlights (2020)

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-February, December. Additional electricity generation amounted to 2261 MWh. The unit was in the intermediate outage from 2020.06.14 to 2020.08.03. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	AEM (JSC 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	:	1 years

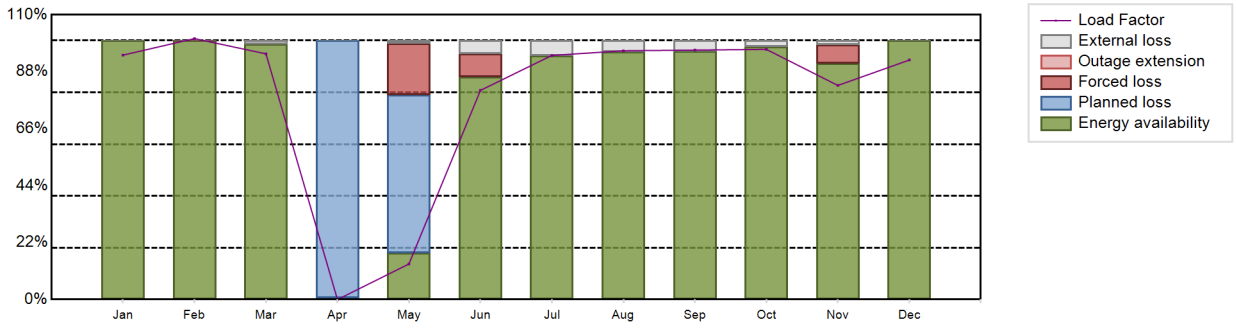
Design Characteristics

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

Annual Production Results (2020)

Net Energy Production	:	7602.61 GW(e).h	Forced Loss Rate (FLR)	:	3.46 %
Energy Availability Factor (EAF)	:	81.5 %	Unplanned Capability Loss Factor (UCL)	:	3 %
Unit Capability Factor (UCF)	:	83.68 %	Planned Unavailability Factor (PUF)	:	13.32 %
Load Factor (LF)	:	78.61 %	Externally cause unavailability (XUF)	:	2.18 %
Operating Factor (OF)	:	83.87 %	Total off-line time	:	1417 hours

Annual Summary



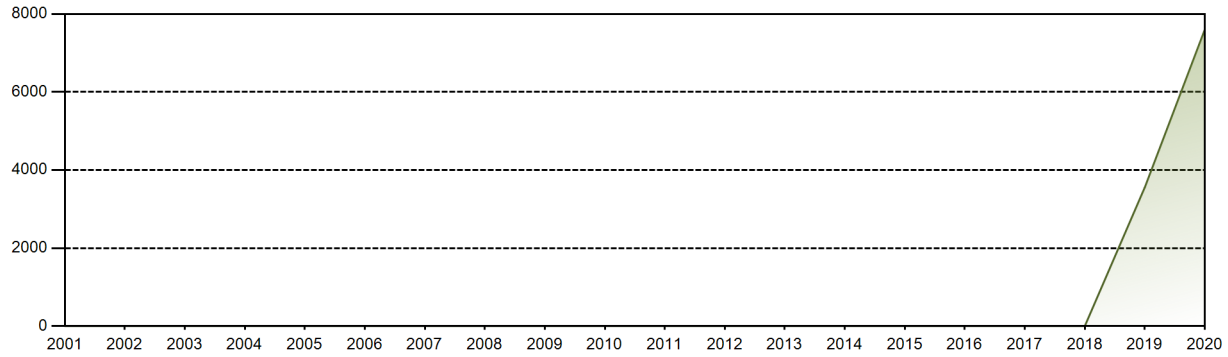
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	773.16	772.26	777.20	0.00	112.52	640.23	772.27	786.96	763.65	791.34	655.47	757.57	7602.61
EAF [%]	100.00	99.99	98.59	0.50	17.97	85.89	94.21	95.69	95.93	97.52	91.21	100.00	81.50
UCF [%]	100.00	99.99	100.00	0.50	19.03	91.09	100.00	100.00	100.00	100.00	92.95	100.00	83.68
LF [%]	94.39	100.78	94.88	0.00	13.74	80.76	94.28	96.07	96.33	96.61	82.69	92.48	78.61
OF [%]	100.00	100.00	100.00	0.56	19.35	92.78	100.00	100.00	100.00	100.00	93.19	100.00	83.87
FLR [%]	0.00	0.01	0.00	0.00	51.21	8.91	0.00	0.00	0.00	0.00	7.05	0.00	3.46
UCL [%]	0.00	0.01	0.00	0.00	19.98	8.91	0.00	0.00	0.00	0.00	7.05	0.00	3.00
PUF [%]	0.00	0.00	0.00	99.50	60.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.32
XUF [%]	0.00	0.00	1.41	0.00	1.06	5.20	5.79	4.31	4.07	2.48	1.73	0.00	2.18

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Historical Summary

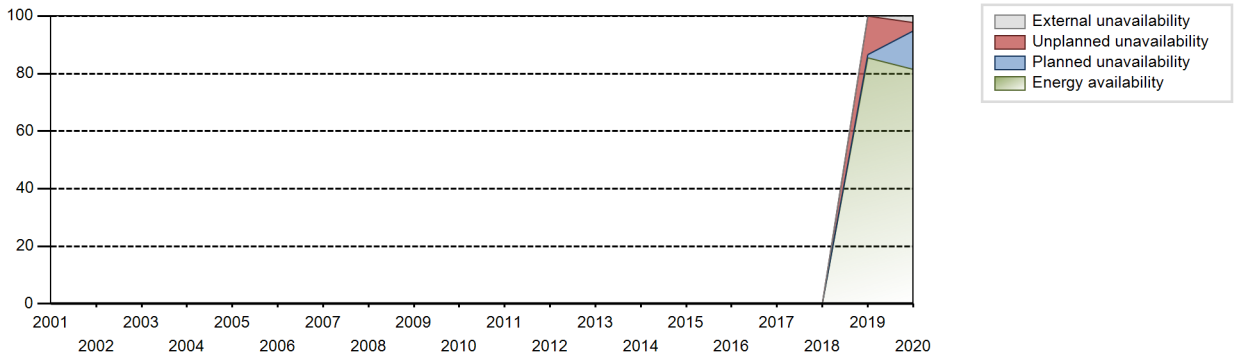
Lifetime energy generation	:	11159.61 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.08 %
Cumulative Energy Availability Factor (EAF)	:	82.07 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.49 %
Cumulative Unit Capability Factor (UCF)	:	83.93 %	Cumulative Planned Unavailability Factor (PUF)	:	11.58 %
Cumulative Load Factor (LF)	:	79.31 %	Cumulative Externally cause unavailability (XUF)	:	1.87 %
Cumulative Operating Factor (OF)	:	84.49 %			

Electricity Production (net) [GWh]

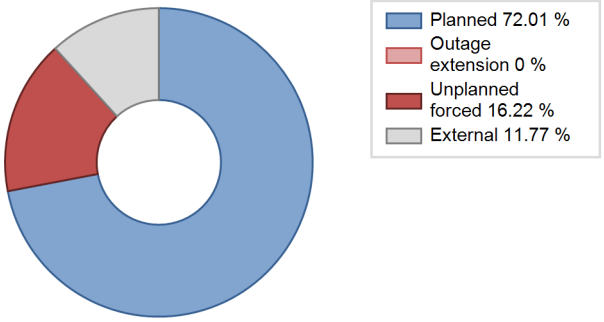


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2019	3557.06	4222	1101	85.48	85.48	83.47	88.25	13.57	13.43	1.09	0.00
2020	7602.61	7367	1101	81.50	83.68	78.61	83.87	3.46	3.00	13.32	2.18

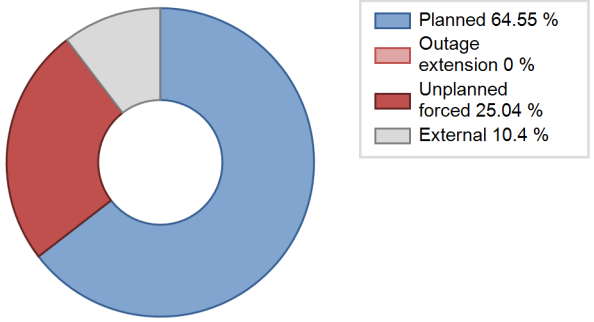
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

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Full Outages, Analysis by Cause

Outage Cause	2020			2019 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		228			345	
C. Inspection, maintenance or repair combined with refuelling	1170			1003		
L. Human factor related		21			18	
Subtotal	1170	249		1003	363	
Total		**1419**			**1366**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2019 to 2020
	Hours Lost	Average hours lost per reactor-year
15. Reactor Cooling Systems	21	12
31. Turbine and auxiliaries	33	20
32. Feedwater and Main Steam System	146	185
33. Circulating Water System	49	30
42. Electrical Power Supply Systems		7
Total	**249**	**254**

Highlights (2020)

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 Januare. Additional electricity generation amounted to 345 MWh. The unit was in the intermediate outage from 2020.04.01 to 2020.05.19. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	KTF (Kharkiv Turbine Factory)

Reactor Unit Details

Reactor type and model	:	PWR / VVER V-179
Thermal power	:	1375 MWth
Gross electrical power	:	417 MWe
Reference unit power (net)	:	385 MWe

Key Dates

Construction Date	:	1967-07-01
Grid Date	:	1972-12-28
Commercial Date	:	1973-03-24
Age at end of year	:	48 years

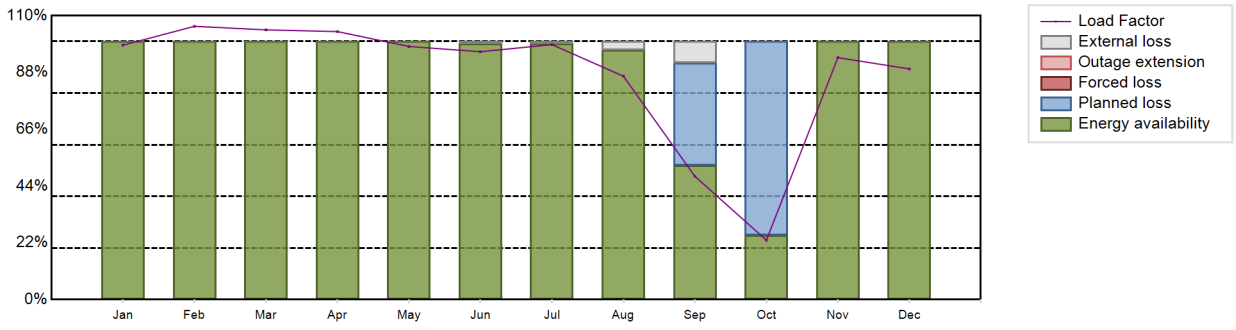
Design Characteristics

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]	:	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	:	73
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	:	-
HP cylinder inlet steam pressure [MPa]	:	4.4
Output voltage [kV]	:	-
Primary means of condenser cooling	:	-
Number of main condensate pumps	:	-
Number of FW pumps for full power operation	:	4
Number of on-site safety related diesel generators	:	-
Non-electrical applications	:	DH / PH

Annual Production Results (2020)

Net Energy Production	:	2945.24 GW(e).h
Energy Availability Factor (EAF)	:	89.27 %
Unit Capability Factor (UCF)	:	90.4 %
Load Factor (LF)	:	87.09 %
Operating Factor (OF)	:	90.57 %
Equivalent non-electrical energy generated (NEG)	:	85.13 GW(e).h
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	9.6 %
Externally cause unavailability (XUF)	:	1.13 %
Total off-line time	:	828 hours

Annual Summary



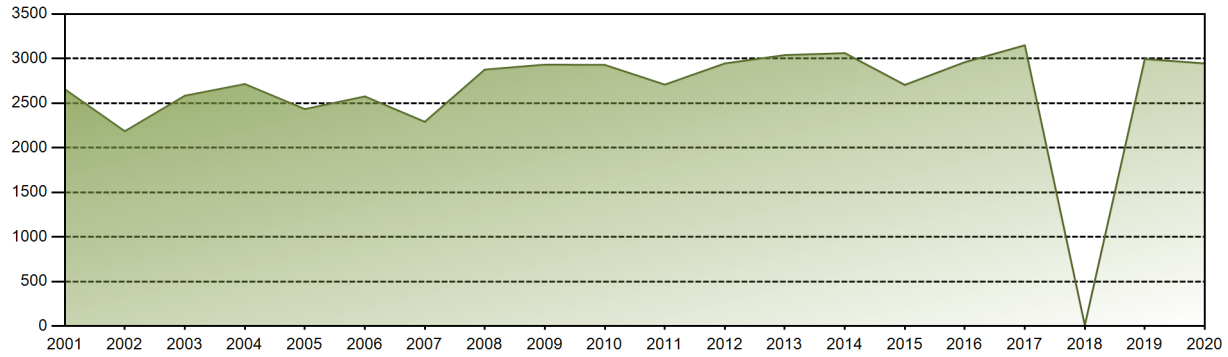
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	282.33	283.69	299.31	287.80	280.89	266.17	282.97	247.90	132.40	65.94	259.84	256.01	2945.24
EAF [%]	100.00	100.00	100.00	100.00	100.00	99.10	99.13	96.56	51.95	25.00	100.00	100.00	89.27
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	60.37	25.00	100.00	100.00	90.40
LF [%]	98.57	105.87	104.49	103.82	98.06	96.02	98.79	86.54	47.76	23.02	93.74	89.38	87.09
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	60.56	26.88	100.00	100.00	90.57
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	39.63	75.00	0.00	0.00	9.60
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.90	0.87	3.44	8.43	0.00	0.00	0.00	1.13

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Historical Summary

Lifetime energy generation	:	126123.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.47 %
Cumulative Energy Availability Factor (EAF)	:	77.96 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.79 %
Cumulative Unit Capability Factor (UCF)	:	79.29 %	Cumulative Planned Unavailability Factor (PUF)	:	16.92 %
Cumulative Load Factor (LF)	:	77.82 %	Cumulative Externally cause unavailability (XUF)	:	1.34 %
Cumulative Operating Factor (OF)	:	82.71 %			

Electricity Production (net) [GWh]

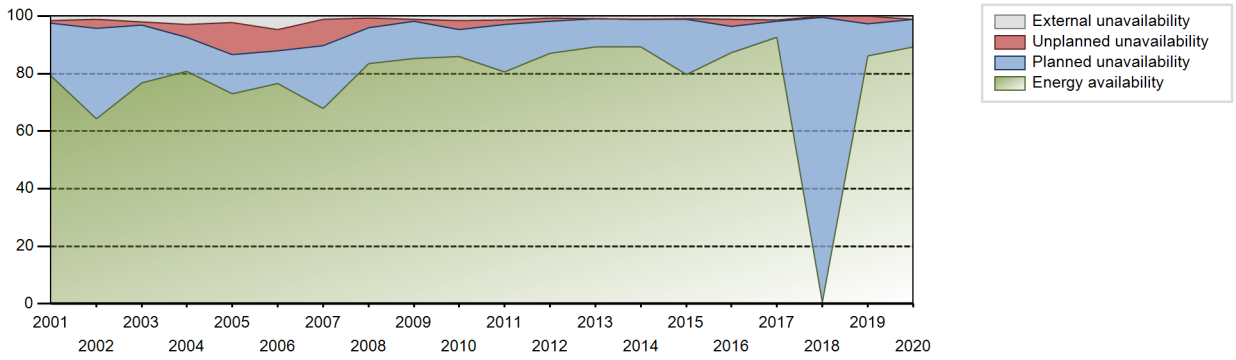


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	2570.51	8072	385	84.20	84.20	84.95	93.15	14.82	14.65	1.15	0.00
1974	2411.84	7159	385	71.28	71.28	71.51	81.72	15.90	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

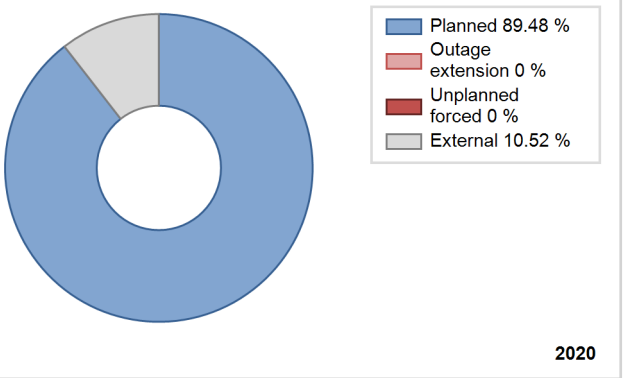
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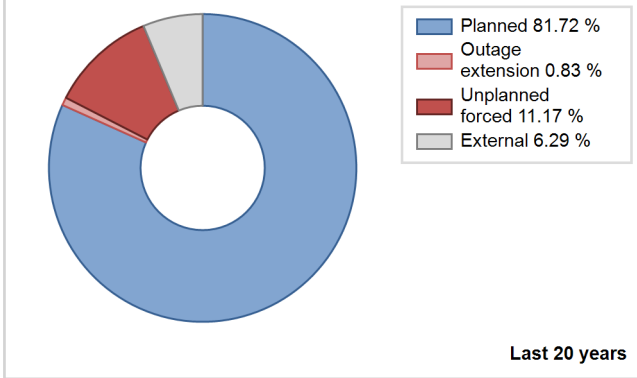
2010	2928.70	7727	385	85.82	87.48	86.84	88.21	3.36	3.04	9.48	1.66
2011	2707.55	7263	385	80.64	82.08	80.29	82.92	1.69	1.41	16.51	1.44
2012	2944.86	7707	385	87.14	87.87	87.08	87.74	1.22	1.09	11.04	0.73
2013	3038.98	7929	385	89.36	90.36	90.11	90.51	0.01	0.01	9.63	1.00
2014	3061.07	7932	385	89.26	90.33	90.75	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1973 to 2020 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	826			1236		
D.	Inspection, maintenance or repair without refuelling				93		
E.	Testing of plant systems or components				12		
F.	Major backfitting, refurbishment or upgrading activities with refuelling				57		
J.	Grid limitation, failure or grid unavailability						9
L.	Human factor related					2	
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					9	
Z.	Other				2	14	
Subtotal		826			1400	94	9
Total		**826**			**1503**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		7
12. Reactor I&C Systems		14
13. Reactor Auxiliary Systems		2
15. Reactor Cooling Systems		4
16. Steam generation systems		32
31. Turbine and auxiliaries		1
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		**70**

Highlights (2020)

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-May, October-December. Additional electricity generation amounted to 70689 MWh. The unit was in the intermediate outage from 2020.09.19 to 2020.10.23. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	KTF (Kharkiv Turbine Factory)

Reactor Unit Details

Reactor type and model	:	PWR / VVER V-187
Thermal power	:	3000 MWth
Gross electrical power	:	1000 MWe
Reference unit power (net)	:	950 MWe

Key Dates

Construction Date	:	1974-03-01
Grid Date	:	1980-05-31
Commercial Date	:	1981-02-20
Age at end of year	:	40 years

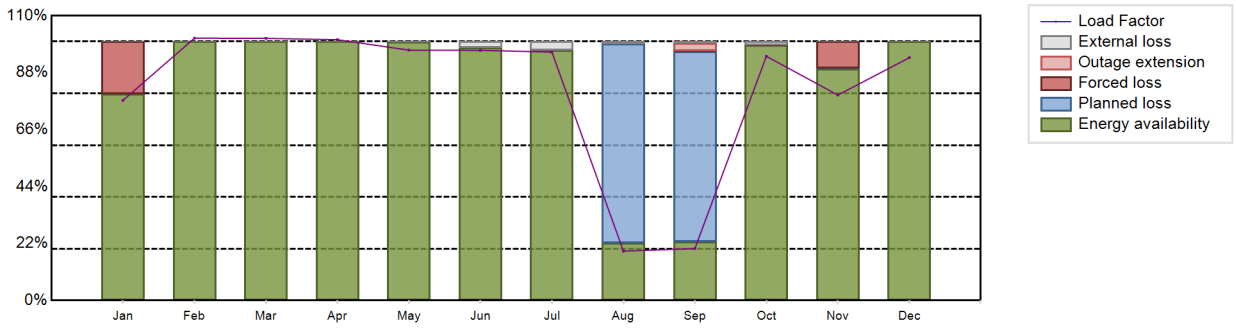
Design Characteristics

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]	:	-
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	:	109
Number of external reactor coolant loops	:	4
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	324
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	-
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.5
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 (2020)

Net Energy Production	:	6787.87 GW(e).h
Energy Availability Factor (EAF)	:	83.89 %
Unit Capability Factor (UCF)	:	84.6 %
Load Factor (LF)	:	81.34 %
Operating Factor (OF)	:	85.19 %
Equivalent non-electrical energy generated (NEG)	:	4.77 GW(e).h
Forced Loss Rate (FLR)	:	2.96 %
Unplanned Capability Loss Factor (UCL)	:	2.84 %
Planned Unavailability Factor (PUF)	:	12.56 %
Externally cause unavailability (XUF)	:	0.71 %
Total off-line time	:	1301 hours

Annual Summary



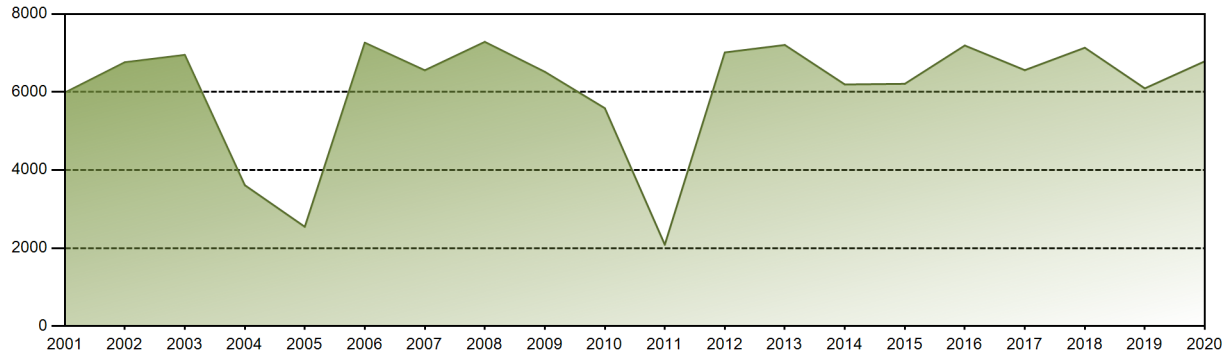
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	546.51	669.94	715.57	689.00	683.50	660.93	678.07	134.79	137.19	666.66	542.86	662.85	6787.87
EAF [%]	79.75	100.00	100.00	100.00	99.93	97.72	96.68	22.20	22.62	98.51	89.51	100.00	83.89
UCF [%]	79.75	100.00	100.00	100.00	100.00	100.00	100.00	22.96	23.16	99.97	89.51	100.00	84.60
LF [%]	77.32	101.32	101.24	100.73	96.70	96.63	95.94	19.07	20.06	94.32	79.37	93.78	81.34
OF [%]	80.65	100.00	100.00	100.00	100.00	100.00	100.00	23.25	26.94	100.00	91.67	100.00	85.19
FLR [%]	20.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.03	10.36	0.00	2.96
UCL [%]	20.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.37	0.03	10.35	0.00	2.84
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	77.04	73.47	0.00	0.14	0.00	12.56
XUF [%]	0.00	0.00	0.00	0.00	0.07	2.28	3.32	0.76	0.53	1.46	0.00	0.00	0.71

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Historical Summary

Lifetime energy generation	:	214583.17 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	12.08 %
Cumulative Energy Availability Factor (EAF)	:	66.47 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.28 %
Cumulative Unit Capability Factor (UCF)	:	67.29 %	Cumulative Planned Unavailability Factor (PUF)	:	21.43 %
Cumulative Load Factor (LF)	:	66.26 %	Cumulative Externally cause unavailability (XUF)	:	0.82 %
Cumulative Operating Factor (OF)	:	73.46 %			

Electricity Production (net) [GWh]

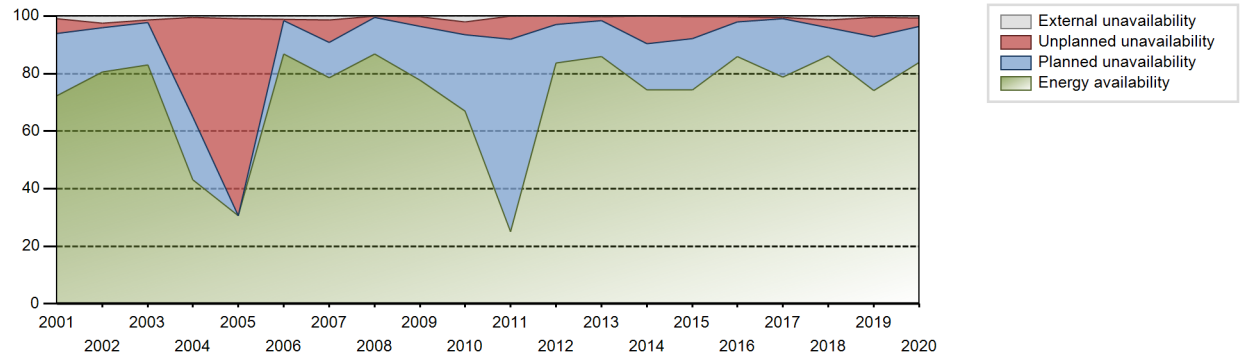


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	4639.79	6929	950	56.62	56.62	56.10	77.77	28.48	22.54	20.83	0.00
1982	5042.84	6631	950	60.89	60.89	60.60	75.70	25.30	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

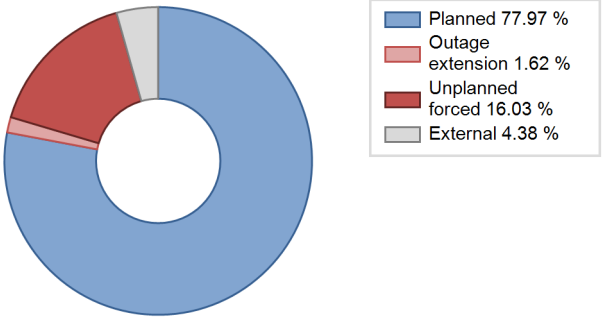
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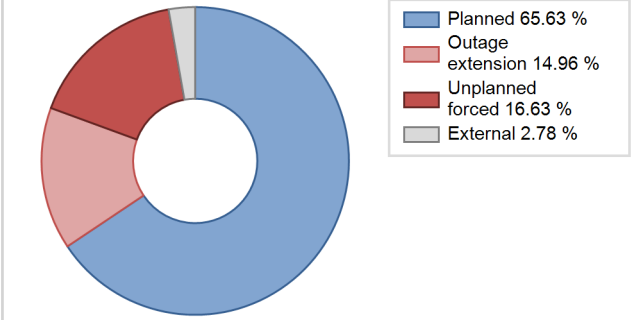
2018	7134.80	7766	950	86.22	87.70	85.73	88.65	0.99	2.46	9.84	1.48
2019	6092.49	6806	950	74.19	74.67	73.21	77.69	8.33	6.79	18.54	0.49
2020	6787.87	7483	950	83.89	84.60	81.34	85.19	2.96	2.84	12.56	0.71

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		204			626	
C. Inspection, maintenance or repair combined with refuelling	1057			1447		
D. Inspection, maintenance or repair without refuelling				309		
L. Human factor related					2	
Z. Other					11	
Subtotal	1057	204		1756	639	
Total	**1261**			**2395**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1981 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		241
12. Reactor I&C Systems		19
13. Reactor Auxiliary Systems		6
14. Safety Systems		2
15. Reactor Cooling Systems		52
16. Steam generation systems	144	218
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		13
32. Feedwater and Main Steam System		6
34. Miscellaneous Systems		6
35. All other I&C Systems		6
41. Main Generator Systems		50
42. Electrical Power Supply Systems	60	4
Total	**204**	**624**

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Highlights (2020)

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-April, November-December. Additional electricity generation amounted to 41203 MWh. The unit was in the intermediate outage from 2020.08.08 to 2020.09.22. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	KTF (Kharkiv Turbine Factory)

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	:	1981-09-01
Grid Date	:	2001-03-30
Commercial Date	:	2001-12-25
Age at end of year	:	19 years

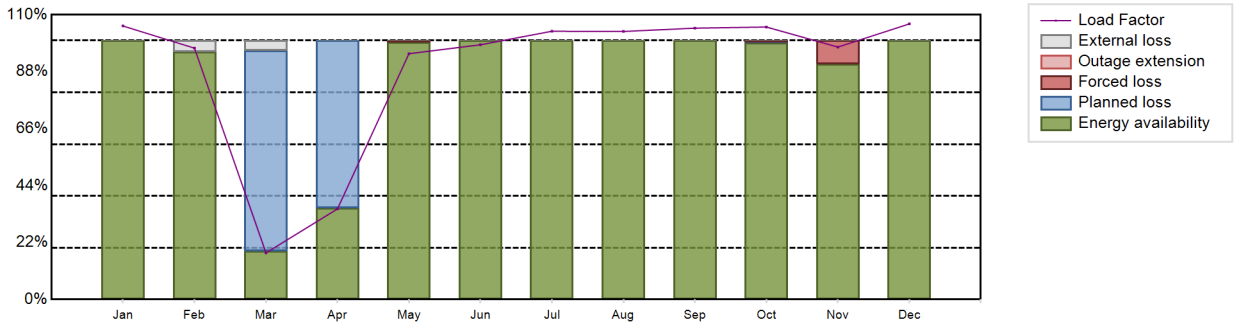
Design Characteristics

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 [%]	:	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]	:	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	:	-
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 (2020)

Net Energy Production	:	7443.25 GW(e).h
Energy Availability Factor (EAF)	:	86.6 %
Unit Capability Factor (UCF)	:	87.29 %
Load Factor (LF)	:	89.2 %
Operating Factor (OF)	:	87.53 %
Forced Loss Rate (FLR)	:	0.96 %
Unplanned Capability Loss Factor (UCL)	:	0.85 %
Planned Unavailability Factor (PUF)	:	11.86 %
Externally cause unavailability (XUF)	:	0.68 %
Total off-line time	:	1095 hours

Annual Summary



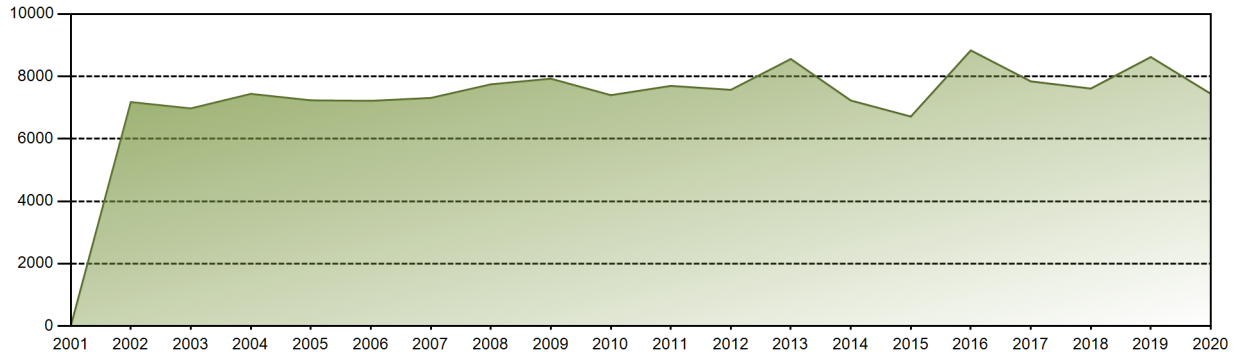
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	746.64	641.86	127.37	239.35	671.05	672.92	732.34	731.77	716.86	743.88	666.89	752.33	7443.25
EAF [%]	100.00	95.60	18.79	35.25	99.27	100.00	100.00	100.00	100.00	99.22	91.02	100.00	86.60
UCF [%]	100.00	100.00	22.75	35.25	99.27	100.00	100.00	100.00	100.00	99.22	91.02	100.00	87.29
LF [%]	105.64	97.07	18.02	34.99	94.94	98.38	103.61	103.53	104.80	105.25	97.50	106.44	89.20
OF [%]	100.00	100.00	23.12	36.11	100.00	100.00	100.00	100.00	100.00	100.00	91.25	100.00	87.53
FLR [%]	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.61	8.98	0.00	0.96
UCL [%]	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.61	8.98	0.00	0.85
PUF [%]	0.00	0.00	77.25	64.75	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	11.86
XUF [%]	0.00	4.40	3.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68

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Historical Summary

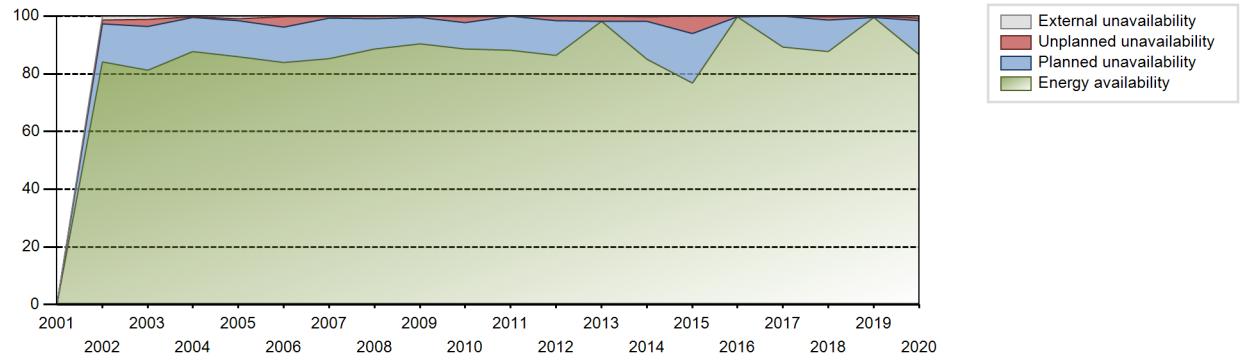
Lifetime energy generation	:	148500.84 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.19 %
Cumulative Energy Availability Factor (EAF)	:	88.05 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.33 %
Cumulative Unit Capability Factor (UCF)	:	88.37 %	Cumulative Planned Unavailability Factor (PUF)	:	10.3 %
Cumulative Load Factor (LF)	:	91.34 %	Cumulative Externally cause unavailability (XUF)	:	0.32 %
Cumulative Operating Factor (OF)	:	88.68 %			

Electricity Production (net) [GWh]



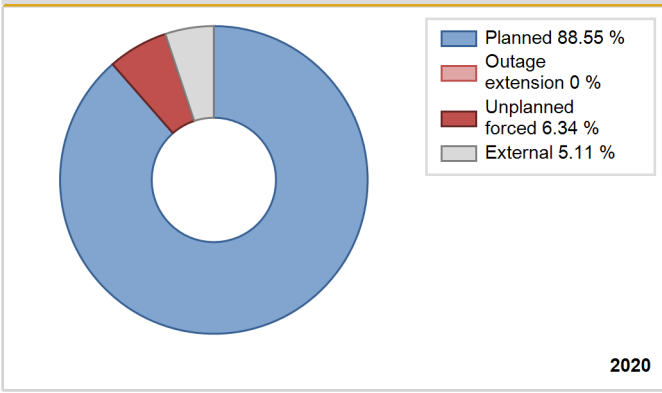
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2001	Data not provided										
2002	7176.18	7543	950	84.06	85.51	86.23	86.11	1.33	1.16	13.33	1.45
2003	6973.93	7154	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

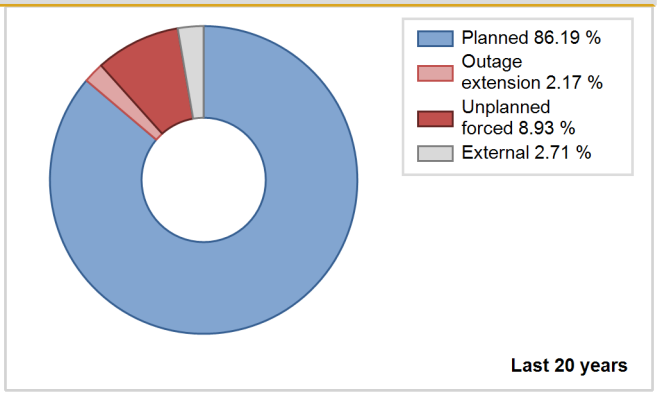
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2001 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		63			90	
C. Inspection, maintenance or repair combined with refuelling	1032			884		
D. Inspection, maintenance or repair without refuelling				7		
E. Testing of plant systems or components					2	
L. Human factor related					3	
Subtotal	1032	63		891	95	
Total	**1095**			**986**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2001 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		4
14. Safety Systems		2
16. Steam generation systems		36
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		1
33. Circulating Water System		2
35. All other I&C Systems		0
41. Main Generator Systems		32
42. Electrical Power Supply Systems	63	16
Total	**63**	**95**

Highlights (2020)

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-Desember. Additional electricity generation amounted to 309074.9 MWh. The unit was in the overhaul outage from 2020.03.08 to 2020.05.01. 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.

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2020 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 (JSC 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	:	10 years

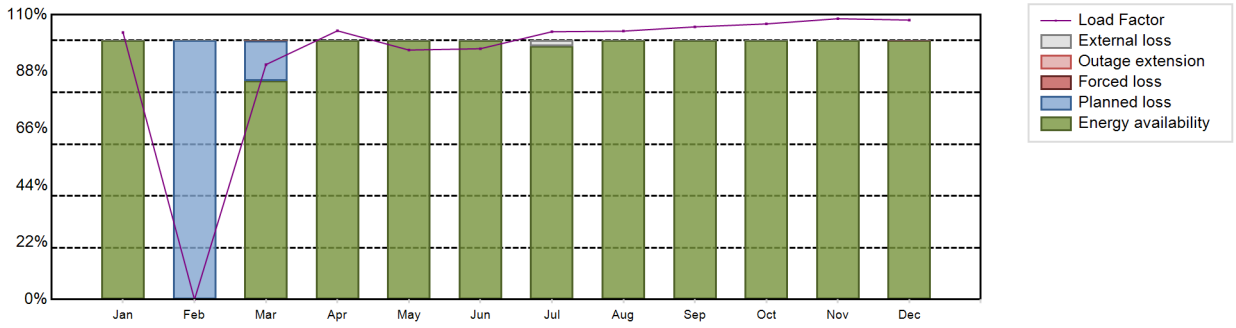
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	0.7
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 (2020)

Net Energy Production	:	7864.15 GW(e).h	Forced Loss Rate (FLR)	:	0.01 %
Energy Availability Factor (EAF)	:	90.61 %	Unplanned Capability Loss Factor (UCL)	:	0.01 %
Unit Capability Factor (UCF)	:	90.79 %	Planned Unavailability Factor (PUF)	:	9.21 %
Load Factor (LF)	:	94.24 %	Externally cause unavailability (XUF)	:	0.18 %
Operating Factor (OF)	:	90.87 %	Total off-line time	:	802 hours

Annual Summary



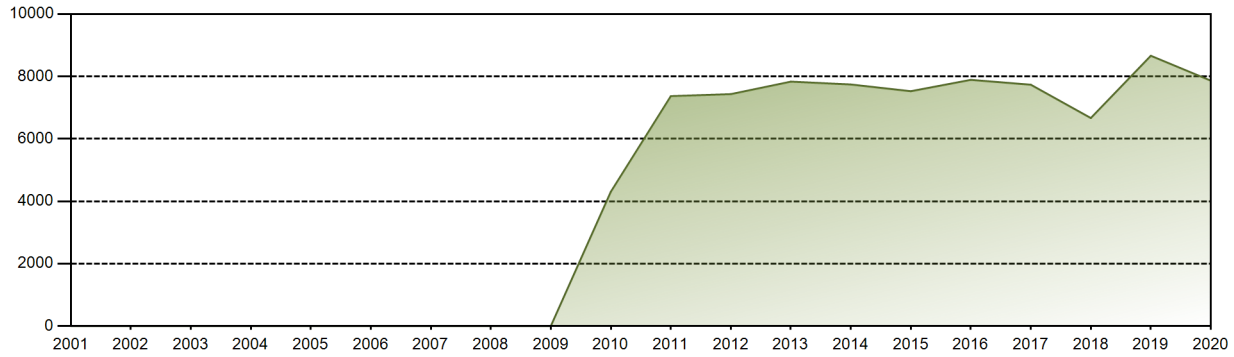
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	728.64	0.00	641.24	709.91	680.97	662.57	730.99	732.66	720.27	752.34	741.81	762.74	7864.15
EAF [%]	100.00	0.21	84.59	100.00	100.00	100.00	97.87	100.00	100.00	100.00	100.00	100.00	90.61
UCF [%]	100.00	0.21	84.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.79
LF [%]	103.09	0.00	90.72	103.79	96.35	96.87	103.42	103.66	105.30	106.44	108.45	107.91	94.24
OF [%]	100.00	0.57	85.22	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.87
FLR [%]	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
UCL [%]	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
PUF [%]	0.00	99.79	15.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.21
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	2.13	0.00	0.00	0.00	0.00	0.00	0.18

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Historical Summary

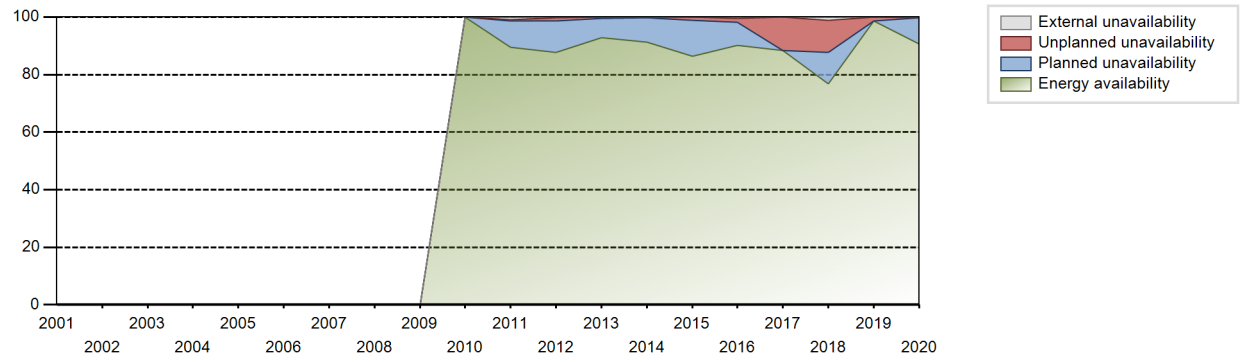
Lifetime energy generation	:	81022.05 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.1 %
Cumulative Energy Availability Factor (EAF)	:	89.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.87 %
Cumulative Unit Capability Factor (UCF)	:	89.58 %	Cumulative Planned Unavailability Factor (PUF)	:	7.55 %
Cumulative Load Factor (LF)	:	92.16 %	Cumulative Externally cause unavailability (XUF)	:	0.29 %
Cumulative Operating Factor (OF)	:	89.86 %			

Electricity Production (net) [GWh]



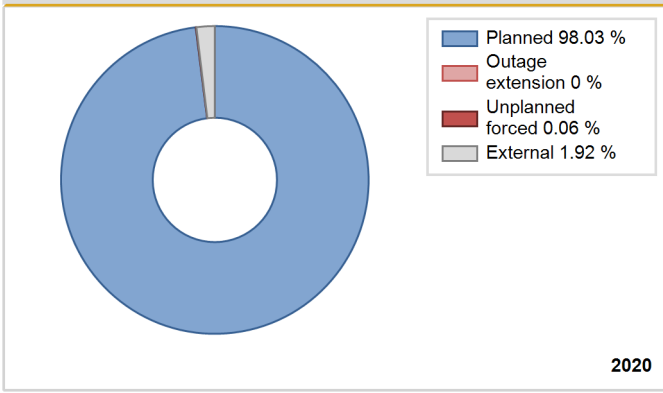
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2010	4303.76	6133	950	100.00	100.00	97.93	100.00	0.00	0.00	0.00	0.00
2011	7368.43	7944	950	89.41	90.23	88.55	90.70	0.63	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

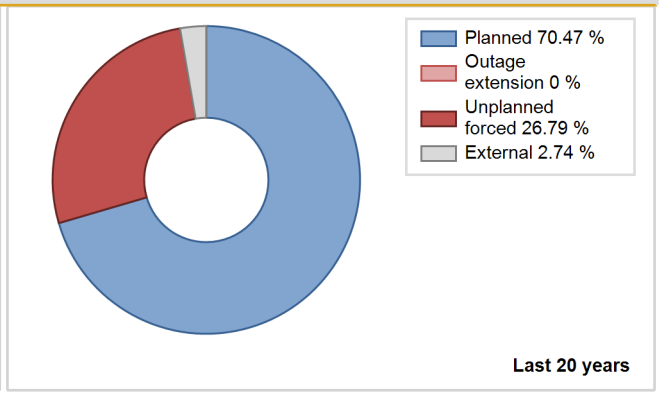
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2010 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					235	
C. Inspection, maintenance or repair combined with refuelling	803			593		
D. Inspection, maintenance or repair without refuelling				57		
J. Grid limitation, failure or grid unavailability						1
Subtotal	803			650	235	1
Total	**803**			**886**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2010 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		9
15. Reactor Cooling Systems		6
16. Steam generation systems		5
31. Turbine and auxiliaries		45
41. Main Generator Systems		101
42. Electrical Power Supply Systems		53
Total		**219**

Highlights (2020)

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, March-December. Additional electricity generation amounted to 370403.9 MWh. The unit was in the intermediate outage from 2020.02.01 to 2020.03.05. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	AEM (JSC ATOMENERGOMASH)

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	:	2009-09-15
Grid Date	:	2014-12-27
Commercial Date	:	2015-09-17
Age at end of year	:	6 years

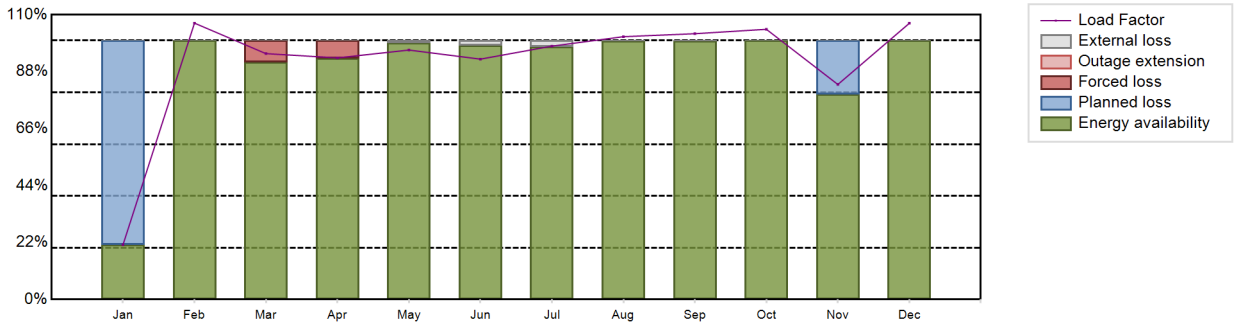
Design Characteristics

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

Annual Production Results (2020)

Net Energy Production	:	7651.88 GW(e).h	Forced Loss Rate (FLR)	:	1.38 %
Energy Availability Factor (EAF)	:	89.89 %	Unplanned Capability Loss Factor (UCL)	:	1.26 %
Unit Capability Factor (UCF)	:	90.36 %	Planned Unavailability Factor (PUF)	:	8.38 %
Load Factor (LF)	:	91.7 %	Externally cause unavailability (XUF)	:	0.47 %
Operating Factor (OF)	:	92 %	Total off-line time	:	703 hours

Annual Summary



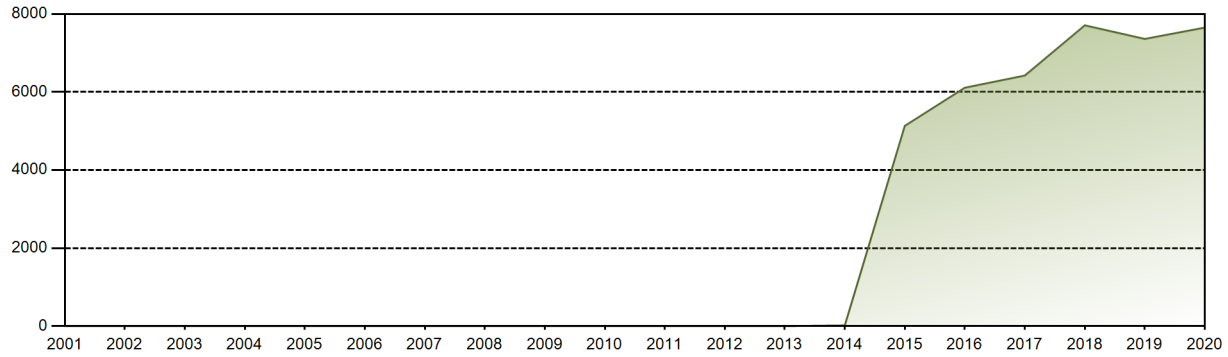
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	149.39	705.82	671.20	638.29	680.97	635.03	691.68	717.51	702.18	737.65	568.10	754.06	7651.88
EAF [%]	21.22	100.00	91.61	93.28	99.09	98.09	97.68	99.79	99.75	100.00	79.16	100.00	89.89
UCF [%]	21.22	100.00	91.61	93.28	100.00	100.00	100.00	100.00	100.00	100.00	79.16	100.00	90.36
LF [%]	21.14	106.75	94.96	93.32	96.35	92.84	97.86	101.52	102.66	104.36	83.06	106.69	91.70
OF [%]	21.51	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	83.47	100.00	92.00
FLR [%]	0.00	0.00	8.39	6.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.38
UCL [%]	0.00	0.00	8.39	6.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.26
PUF [%]	78.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.84	0.00	8.38
XUF [%]	0.00	0.00	0.00	0.00	0.91	1.91	2.32	0.21	0.25	0.00	0.00	0.00	0.47

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Historical Summary

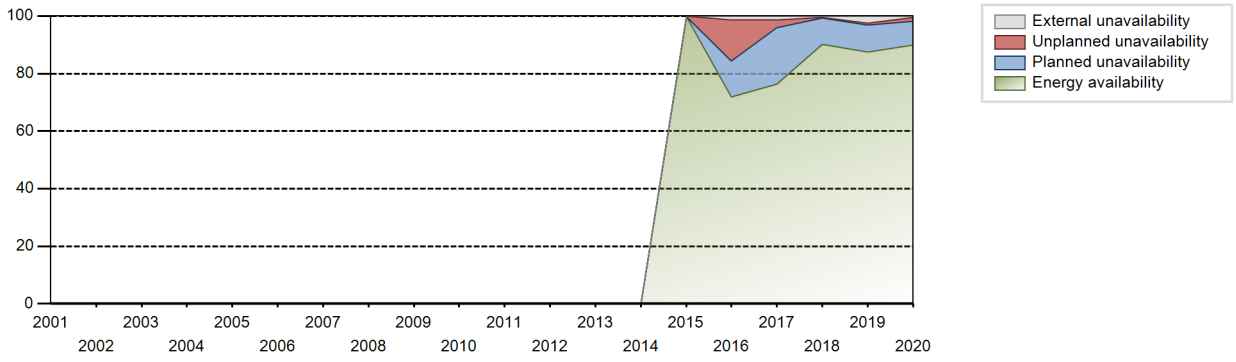
Lifetime energy generation	:	40386.58 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.99 %
Cumulative Energy Availability Factor (EAF)	:	83.98 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.64 %
Cumulative Unit Capability Factor (UCF)	:	85.19 %	Cumulative Planned Unavailability Factor (PUF)	:	11.17 %
Cumulative Load Factor (LF)	:	85.59 %	Cumulative Externally cause unavailability (XUF)	:	1.21 %
Cumulative Operating Factor (OF)	:	86.23 %			

Electricity Production (net) [GWh]

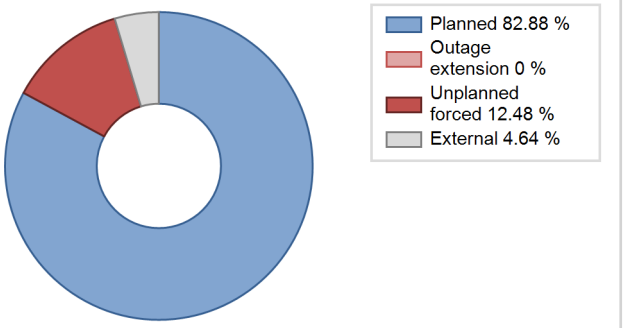


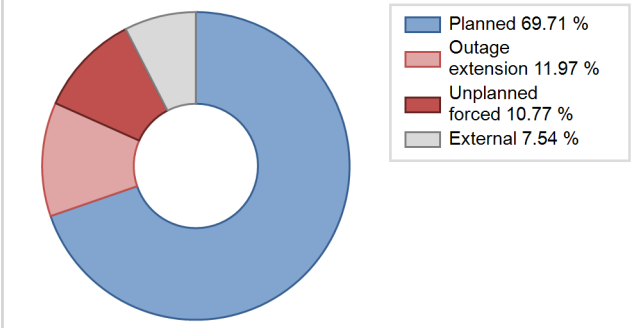
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2015	5132.22	7040	950	99.65	99.65	104.56	100.00	0.35	0.35	0.00	0.00
2016	6110.00	6728	950	71.98	73.43	73.22	76.59	5.40	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2015 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					238	
C. Inspection, maintenance or repair combined with refuelling	726			628		
D. Inspection, maintenance or repair without refuelling				19		
G. Major backfitting, refurbishment or upgrading activities without refuelling				318		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						13
Subtotal	726			965	238	13
Total	**726**			**1216**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2015 to 2020
	Hours Lost	Average hours lost per reactor-year
15. Reactor Cooling Systems		33
16. Steam generation systems		4
31. Turbine and auxiliaries		17
32. Feedwater and Main Steam System		3
33. Circulating Water System		1
42. Electrical Power Supply Systems		150
Total		**208**

Highlights (2020)

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 - December. Additional electricity generation amounted to 313085.6 MWh. The unit was in the routine maintenance outage from 2020.11.09 to 2020.11.15 and in the in the overhoul outage from 2020.01.01 to 2020.01.25. 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.

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2020 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 (JSC ATOMENERGOMASH)
Turbine Supplier	:	AEM (JSC 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	:	2 years

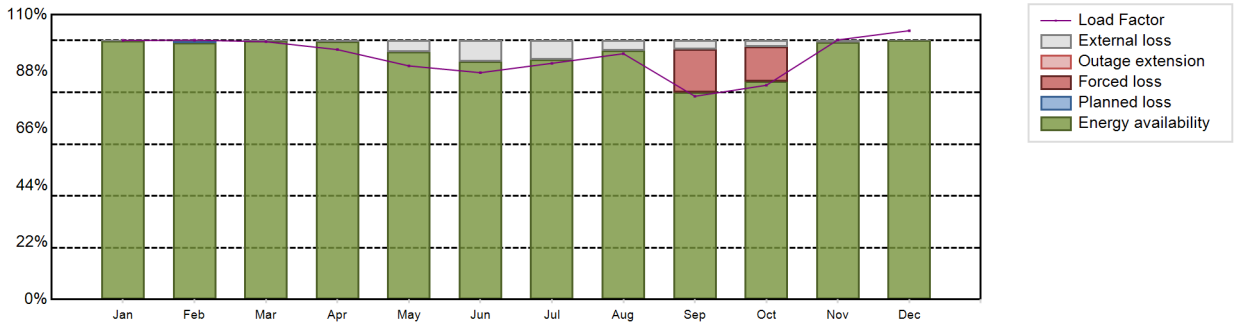
Design Characteristics

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

Annual Production Results (2020)

Net Energy Production	:	8066.5 GW(e).h	Forced Loss Rate (FLR)	:	2.5 %
Energy Availability Factor (EAF)	:	94.86 %	Unplanned Capability Loss Factor (UCL)	:	2.5 %
Unit Capability Factor (UCF)	:	97.45 %	Planned Unavailability Factor (PUF)	:	0.05 %
Load Factor (LF)	:	93.8 %	Externally cause unavailability (XUF)	:	2.58 %
Operating Factor (OF)	:	97.6 %	Total off-line time	:	211 hours

Annual Summary



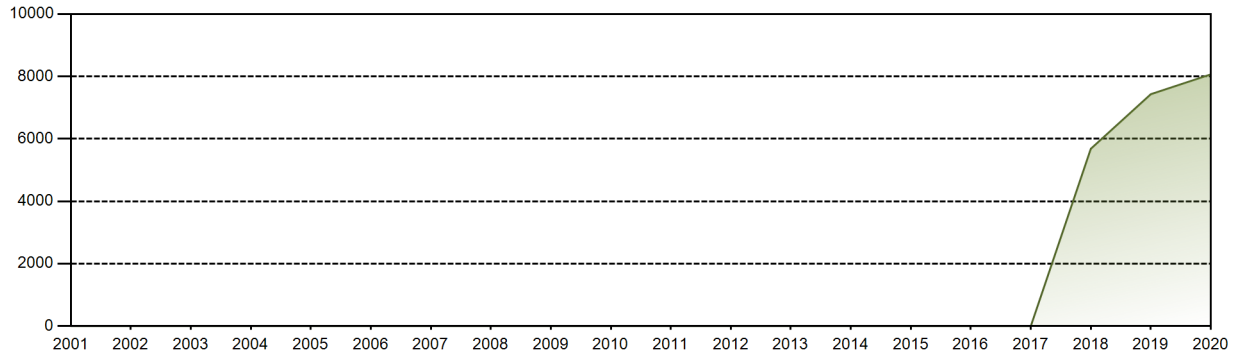
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	728.84	682.53	725.17	680.30	657.15	617.47	664.51	691.54	553.26	602.73	706.70	756.29	8066.50
EAF [%]	99.83	99.14	99.76	99.69	95.73	91.98	92.55	96.05	80.06	84.13	99.44	100.00	94.86
UCF [%]	100.00	99.32	100.00	100.00	100.00	100.00	100.00	100.00	83.54	86.44	100.00	100.00	97.45
LF [%]	100.06	100.17	99.56	96.51	90.22	87.60	91.23	94.94	78.49	82.75	100.26	103.83	93.80
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	83.75	87.37	100.00	100.00	97.60
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.46	13.56	0.00	0.00	2.50
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.46	13.56	0.00	0.00	2.50
PUF [%]	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
XUF [%]	0.17	0.17	0.24	0.31	4.27	8.02	7.45	3.95	3.48	2.31	0.56	0.00	2.58

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Historical Summary

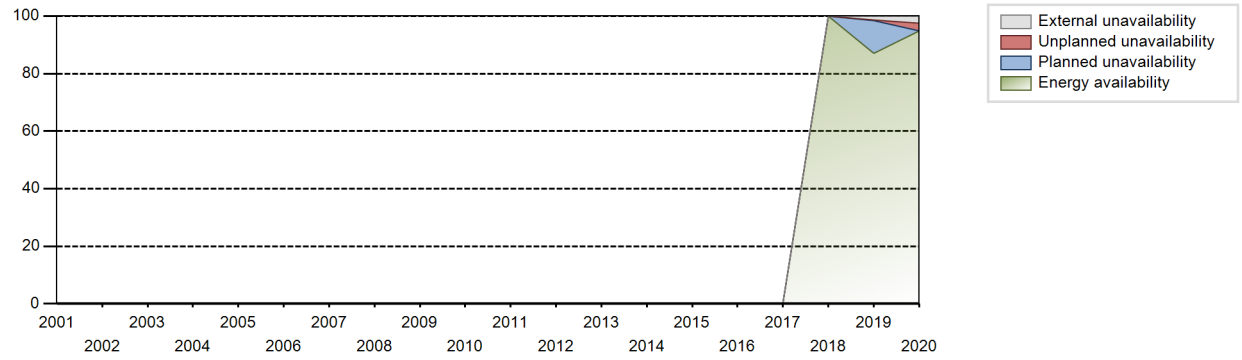
Lifetime energy generation	:	21112.2 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.34 %
Cumulative Energy Availability Factor (EAF)	:	91.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.27 %
Cumulative Unit Capability Factor (UCF)	:	93.65 %	Cumulative Planned Unavailability Factor (PUF)	:	5.08 %
Cumulative Load Factor (LF)	:	91.7 %	Cumulative Externally cause unavailability (XUF)	:	1.72 %
Cumulative Operating Factor (OF)	:	93.82 %			

Electricity Production (net) [GWh]

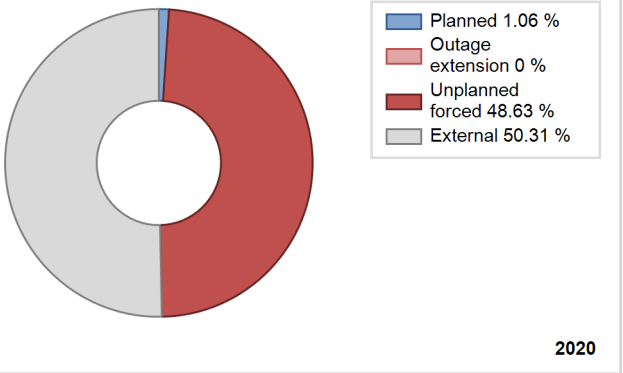


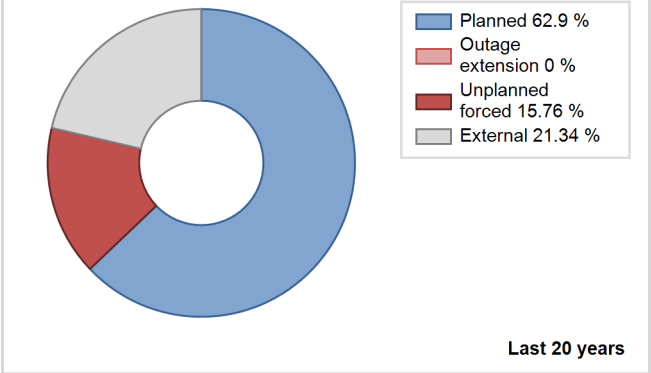
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2018	5681.92	6556	950	99.97	99.99	103.76	100.00	0.01	0.01	0.00	0.01
2019	7430.57	7751	979	87.01	88.29	86.64	88.48	0.40	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2018 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		216			108	
C. Inspection, maintenance or repair combined with refuelling				501		
L. Human factor related					4	
Subtotal		216		501	112	
Total		**216**			**613**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2018 to 2020
	Hours Lost	Average hours lost per reactor-year
16. Steam generation systems	28	14
32. Feedwater and Main Steam System	188	94
33. Circulating Water System		4
Total	**216**	**112**

Highlights (2020)

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 - April, November- December. Additional electricity generation amounted to 73199 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.

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2020 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 (JSC 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	:	1975-10-01
Grid Date	:	1982-12-09
Commercial Date	:	1983-09-30
Age at end of year	:	38 years

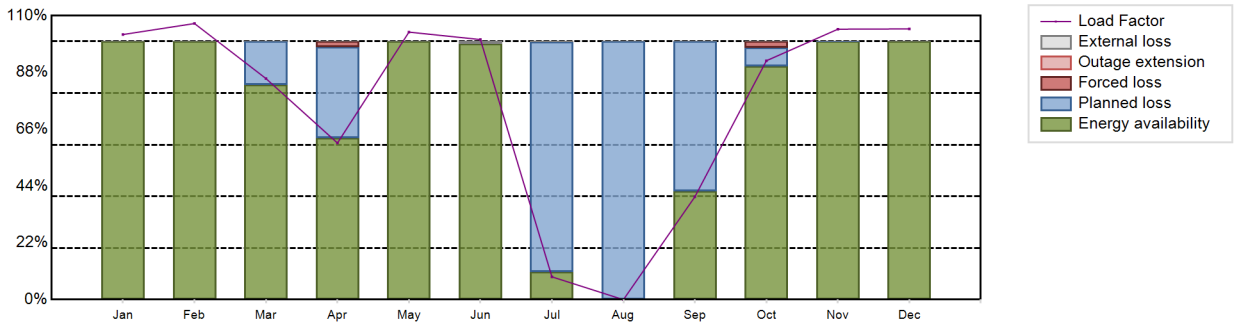
Design Characteristics

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]	:	22200
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]	:	14.5
Number of control rod assemblies	:	175
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	:	PH / DH

Annual Production Results (2020)

Net Energy Production	:	6155 GW(e).h
Energy Availability Factor (EAF)	:	73.88 %
Unit Capability Factor (UCF)	:	73.96 %
Load Factor (LF)	:	75.75 %
Operating Factor (OF)	:	78.89 %
Equivalent non-electrical energy generated (NEG)	:	62.87 GW(e).h
Forced Loss Rate (FLR)	:	0.51 %
Unplanned Capability Loss Factor (UCL)	:	0.38 %
Planned Unavailability Factor (PUF)	:	25.66 %
Externally cause unavailability (XUF)	:	0.08 %
Total off-line time	:	1854 hours

Annual Summary



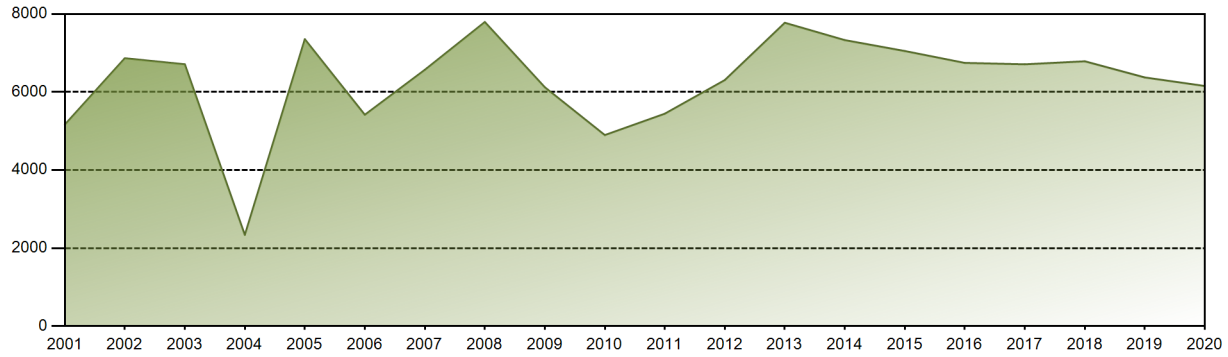
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	706.65	688.52	589.35	403.98	713.11	670.94	60.86	0.00	265.39	636.81	697.66	721.72	6155.00
EAF [%]	100.00	100.00	83.14	62.73	100.00	99.20	10.74	0.00	42.16	90.50	100.00	100.00	73.88
UCF [%]	100.00	100.00	83.14	62.73	100.00	100.00	10.94	0.00	42.16	90.50	100.00	100.00	73.96
LF [%]	102.68	106.95	85.64	60.66	103.62	100.74	8.84	0.00	39.85	92.53	104.75	104.87	75.75
OF [%]	100.00	100.00	84.14	66.67	100.00	100.00	13.17	0.00	85.28	100.00	100.00	100.00	78.89
FLR [%]	0.00	0.00	0.00	3.37	0.00	0.00	0.00	0.00	0.00	2.55	0.00	0.00	0.51
UCL [%]	0.00	0.00	0.00	2.19	0.00	0.00	0.00	0.00	0.00	2.37	0.00	0.00	0.38
PUF [%]	0.00	0.00	16.86	35.08	0.00	0.00	89.06	100.00	57.84	7.13	0.00	0.00	25.66
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.80	0.20	0.00	0.00	0.00	0.00	0.00	0.08

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Historical Summary

Lifetime energy generation	:	227572.27 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.41 %
Cumulative Energy Availability Factor (EAF)	:	73.87 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2 %
Cumulative Unit Capability Factor (UCF)	:	75.63 %	Cumulative Planned Unavailability Factor (PUF)	:	22.37 %
Cumulative Load Factor (LF)	:	74.43 %	Cumulative Externally cause unavailability (XUF)	:	1.76 %
Cumulative Operating Factor (OF)	:	77.13 %			

Electricity Production (net) [GWh]

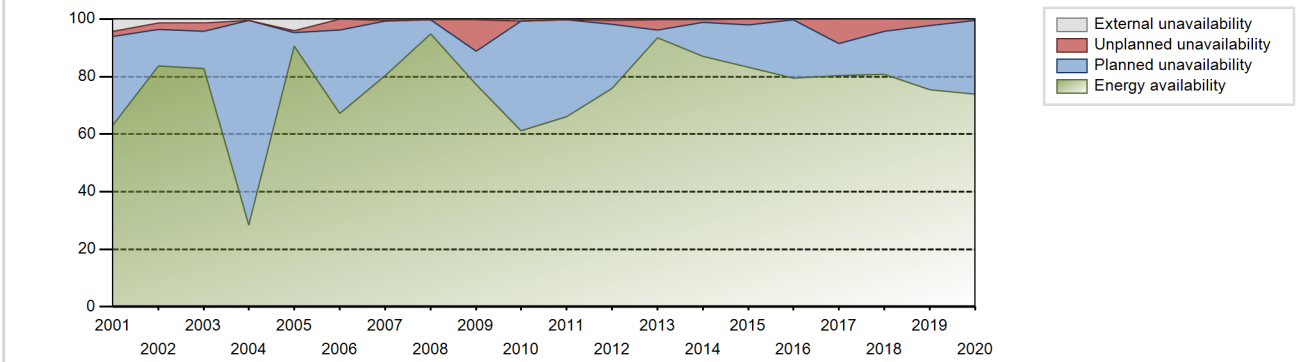


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	4744.20	7223	925	99.64	99.64	100.76	99.86	0.36	0.36	0.00	0.00
1984	6921.35	7830	925	84.23	84.23	85.18	89.14	2.64	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

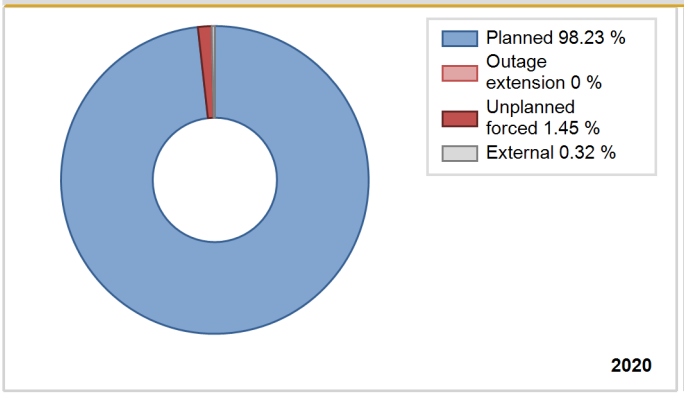
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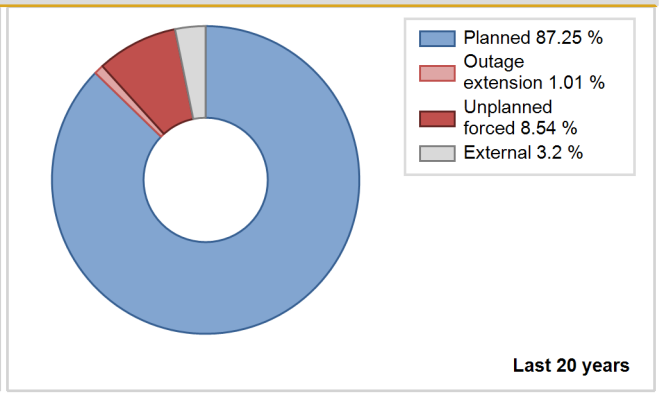
2020	6155.00	6930	925	73.88	73.96	75.75	78.89	0.51	0.38	25.66	0.08

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1983 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					99	
C. Inspection, maintenance or repair combined with refuelling	1854			1182		
D. Inspection, maintenance or repair without refuelling				286		
E. Testing of plant systems or components				20		
G. Major backfitting, refurbishment or upgrading activities without refuelling				276		
J. Grid limitation, failure or grid unavailability						5
L. Human factor related					1	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						12
Subtotal	1854			1764	100	17
Total	**1854**			**1881**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1983 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		21
12. Reactor I&C Systems		14
13. Reactor Auxiliary Systems		8
14. Safety Systems		14
15. Reactor Cooling Systems		23
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		8
42. Electrical Power Supply Systems		7
Total		**98**

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Highlights (2020)

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-June, October-December. Additional electricity generation amounted to 218181.6 MWh. The unit was in the routine maintenance outage from 2020.03.27 to 2020.04.17 and in the in the intermediate outage from 2020.07.05 to 2020.09.05. 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.

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2020 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 (JSC 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	:	1976-06-01
Grid Date	:	1985-05-31
Commercial Date	:	1985-07-02
Age at end of year	:	35 years

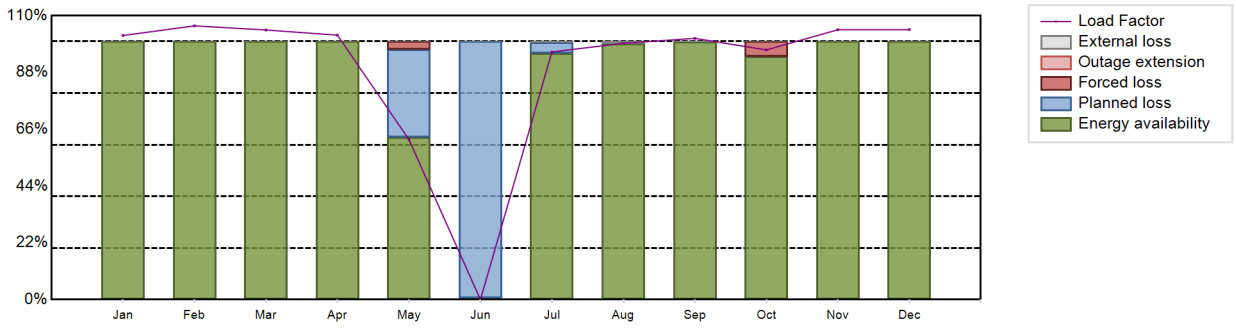
Design Characteristics

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]	:	22200
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]	:	14.5
Number of control rod assemblies	:	175
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	:	PH / DH

Annual Production Results (2020)

Net Energy Production	:	7313.92 GW(e).h
Energy Availability Factor (EAF)	:	87.74 %
Unit Capability Factor (UCF)	:	87.86 %
Load Factor (LF)	:	90.02 %
Operating Factor (OF)	:	89.23 %
Equivalent non-electrical energy generated (NEG)	:	98.65 GW(e).h
Forced Loss Rate (FLR)	:	0.86 %
Unplanned Capability Loss Factor (UCL)	:	0.76 %
Planned Unavailability Factor (PUF)	:	11.38 %
Externally cause unavailability (XUF)	:	0.11 %
Total off-line time	:	946 hours

Annual Summary



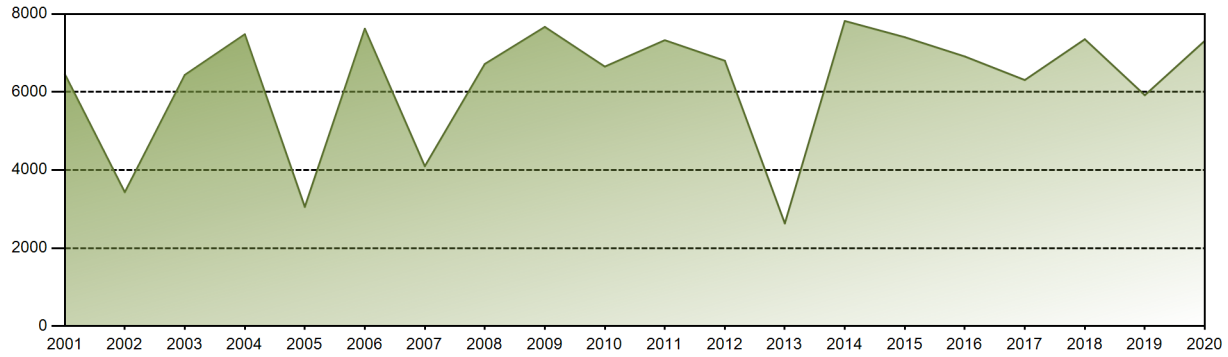
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	704.07	682.66	718.81	682.29	426.85	0.00	660.32	683.34	674.04	665.65	696.14	719.74	7313.92
EAF [%]	100.00	100.00	100.00	100.00	62.84	0.63	95.40	99.11	99.90	94.19	100.00	100.00	87.74
UCF [%]	100.00	100.00	100.00	100.00	62.84	0.63	95.76	100.00	100.00	94.19	100.00	100.00	87.86
LF [%]	102.31	106.04	104.45	102.45	62.02	0.00	95.95	99.29	101.21	96.72	104.52	104.58	90.02
OF [%]	100.00	100.00	100.00	100.00	68.01	1.67	100.00	100.00	100.00	100.00	100.00	100.00	89.23
FLR [%]	0.00	0.00	0.00	0.00	4.86	0.00	0.00	0.00	0.00	5.81	0.00	0.00	0.86
UCL [%]	0.00	0.00	0.00	0.00	3.21	0.00	0.00	0.00	0.00	5.81	0.00	0.00	0.76
PUF [%]	0.00	0.00	0.00	0.00	33.95	99.37	4.24	0.00	0.00	0.00	0.00	0.00	11.38
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.89	0.10	0.00	0.00	0.00	0.11

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Historical Summary

Lifetime energy generation	:	219978.3 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.88 %
Cumulative Energy Availability Factor (EAF)	:	75.74 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.33 %
Cumulative Unit Capability Factor (UCF)	:	77.61 %	Cumulative Planned Unavailability Factor (PUF)	:	20.06 %
Cumulative Load Factor (LF)	:	76.23 %	Cumulative Externally cause unavailability (XUF)	:	1.87 %
Cumulative Operating Factor (OF)	:	79.72 %			

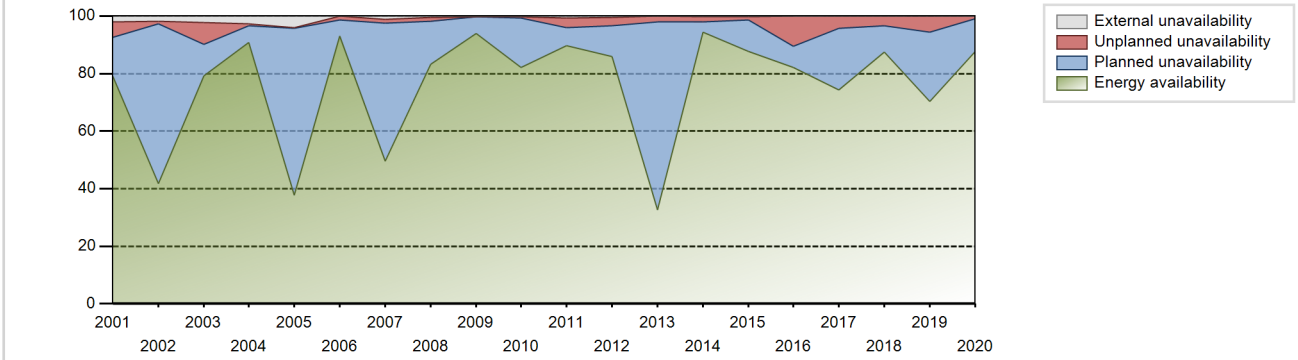
Electricity Production (net) [GWh]



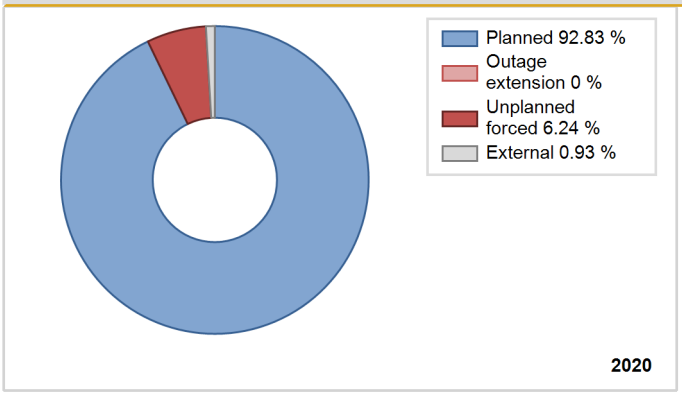
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	3623.94	4593	925	81.32	90.61	80.97	91.89	6.31	6.10	3.29	9.28
1986	6667.30	7442	925	82.57	82.57	82.28	84.95	1.56	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

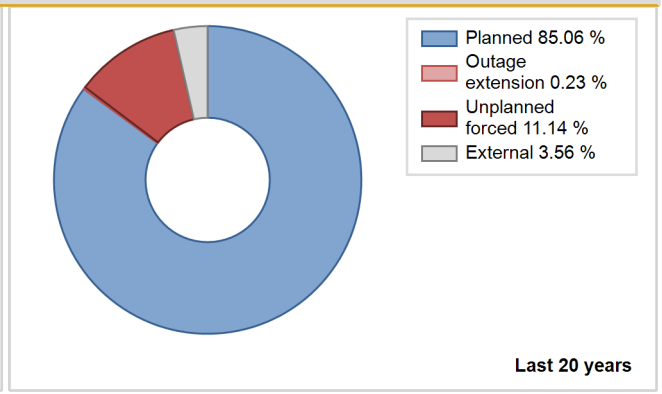
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 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	979			1012		
D. Inspection, maintenance or repair without refuelling				271		
F. Major backfitting, refurbishment or upgrading activities with refuelling				136		
G. Major backfitting, refurbishment or upgrading activities without refuelling				248		
J. Grid limitation, failure or grid unavailability						11
L. Human factor related					2	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						10
Z. Other					2	
Subtotal	979			1667	90	21
Total	**979**			**1778**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		5
14. Safety Systems		0
15. Reactor Cooling Systems		24
16. Steam generation systems		2
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		5
32. Feedwater and Main Steam System		9
34. Miscellaneous Systems		3
42. Electrical Power Supply Systems		14
Total		**89**

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Highlights (2020)

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-May, Jule-December. Additional electricity generation amounted to 192032.775 MWh. The unit was in the intermediate outage from 2020.05.22 to 2020.07.05. 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.

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2020 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 (JSC 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	:	1984-05-01
Grid Date	:	1990-01-17
Commercial Date	:	1990-10-12
Age at end of year	:	30 years

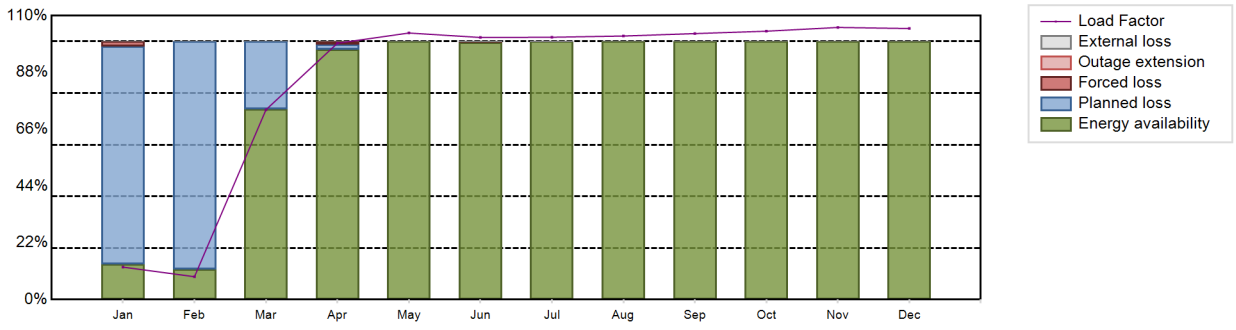
Design Characteristics

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]	:	22200
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]	:	14.5
Number of control rod assemblies	:	175
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	:	PH / DH

Annual Production Results (2020)

Net Energy Production	:	6927.47 GW(e).h
Energy Availability Factor (EAF)	:	83.21 %
Unit Capability Factor (UCF)	:	83.22 %
Load Factor (LF)	:	85.26 %
Operating Factor (OF)	:	86.79 %
Equivalent non-electrical energy generated (NEG)	:	59.98 GW(e).h
Forced Loss Rate (FLR)	:	0.35 %
Unplanned Capability Loss Factor (UCL)	:	0.29 %
Planned Unavailability Factor (PUF)	:	16.49 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1160 hours

Annual Summary



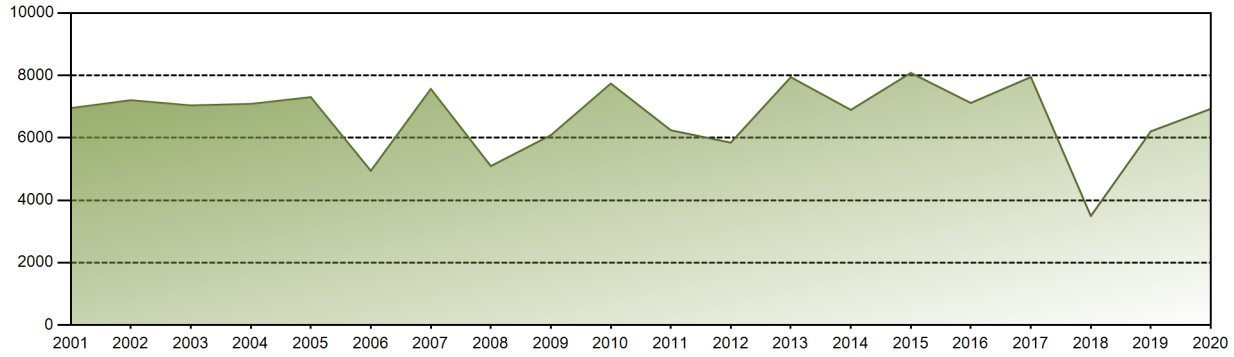
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	86.73	57.22	506.14	661.52	710.73	676.26	699.43	702.71	686.33	715.53	702.13	722.74	6927.47
EAF [%]	13.76	11.82	73.91	96.80	100.00	99.74	99.99	100.00	100.00	100.00	100.00	100.00	83.21
UCF [%]	13.76	11.82	73.91	96.80	100.00	99.74	100.00	100.00	100.00	100.00	100.00	100.00	83.22
LF [%]	12.60	8.89	73.55	99.33	103.27	101.54	101.63	102.11	103.05	103.97	105.42	105.02	85.26
OF [%]	16.26	22.84	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.79
FLR [%]	12.48	0.00	0.00	1.28	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.35
UCL [%]	1.96	0.00	0.00	1.25	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.29
PUF [%]	84.27	88.18	26.09	1.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.49
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00

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Historical Summary

Lifetime energy generation	:	199177.39 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.04 %
Cumulative Energy Availability Factor (EAF)	:	78.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.75 %
Cumulative Unit Capability Factor (UCF)	:	80.54 %	Cumulative Planned Unavailability Factor (PUF)	:	17.71 %
Cumulative Load Factor (LF)	:	80.07 %	Cumulative Externally cause unavailability (XUF)	:	1.61 %
Cumulative Operating Factor (OF)	:	81.27 %			

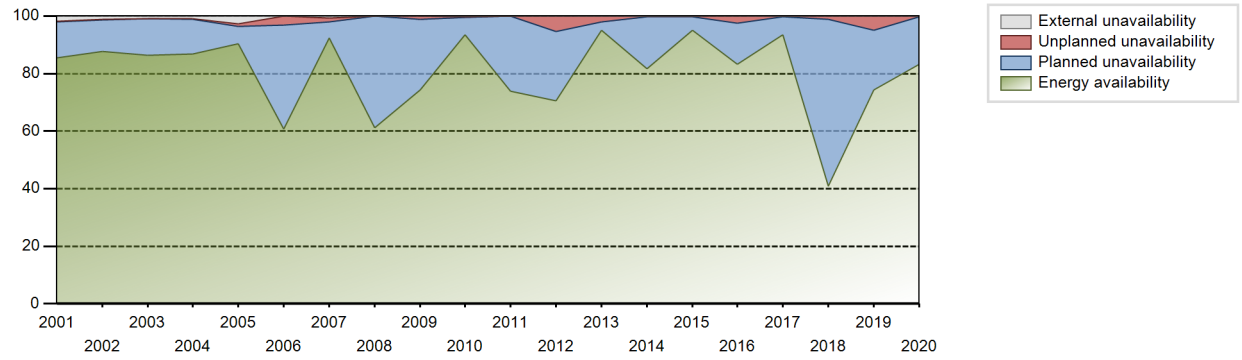
Electricity Production (net) [GWh]



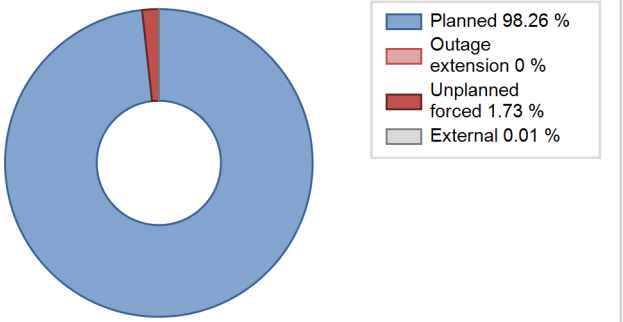
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	4570.76	6767	925	99.06	99.06	101.20	100.00	0.62	0.62	0.32	0.00
1991	6561.74	7338	925	80.87	80.87	80.98	83.77	3.91	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

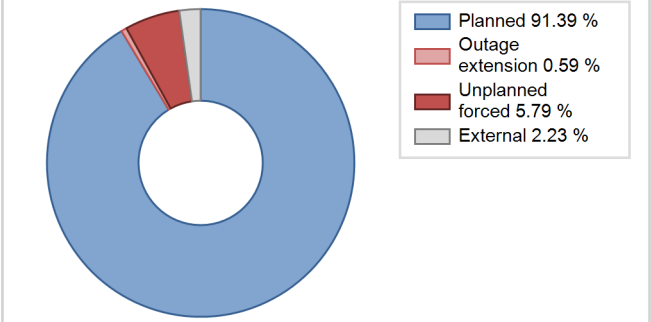
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1990 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					72	
C. Inspection, maintenance or repair combined with refuelling	1160			1005		
D. Inspection, maintenance or repair without refuelling				261		
F. Major backfitting, refurbishment or upgrading activities with refuelling				178		
G. Major backfitting, refurbishment or upgrading activities without refuelling				103		
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)						53
Z. Other					18	
Subtotal	1160			1547	92	54
Total	**1160**			**1693**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1990 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		14
12. Reactor I&C Systems		14
13. Reactor Auxiliary Systems		3
15. Reactor Cooling Systems		9
16. Steam generation systems		3
31. Turbine and auxiliaries		8
32. Feedwater and Main Steam System		4
34. Miscellaneous Systems		4
35. All other I&C Systems		4
41. Main Generator Systems		2
42. Electrical Power Supply Systems		8
Total		**73**

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Highlights (2020)

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, March-December. Additional electricity generation amounted to 228664.625 MWh. The unit was in the routine maintenance outage from 2020.01.06 to 2020.02.23. 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.

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2020 Operating Experience

SK-13 BOHUNICE-3 SLOVAKIA



Status at end of year	:	**Operational**
Operator	:	SE (SLOVENSKÉ ELEKTRÁRNE , AS.)
Owner	:	SE (SLOVENSKÉ ELEKTRÁRNE , AS.)
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	:	36 years

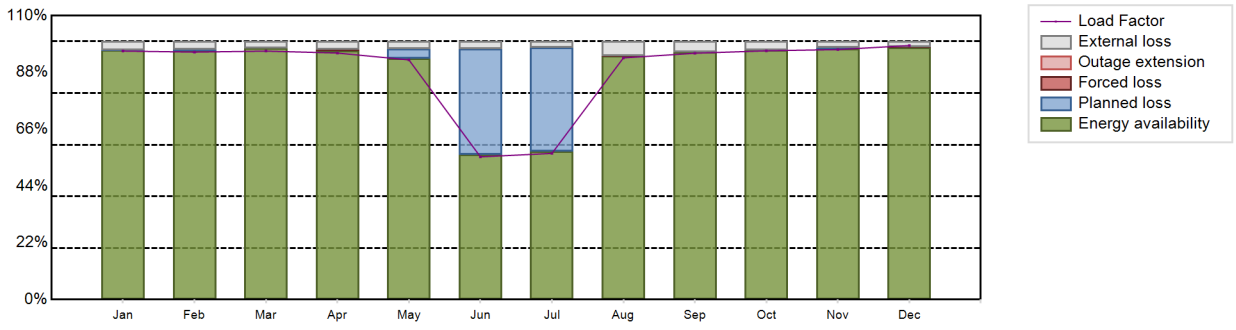
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.25
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]	:	13.4
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]	:	4.32
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 (2020)

Net Energy Production	:	3683.59 GW(e).h	Forced Loss Rate (FLR)	:	0.09 %
Energy Availability Factor (EAF)	:	89.64 %	Unplanned Capability Loss Factor (UCL)	:	0.08 %
Unit Capability Factor (UCF)	:	92.78 %	Planned Unavailability Factor (PUF)	:	7.14 %
Load Factor (LF)	:	89.11 %	Externally cause unavailability (XUF)	:	3.14 %
Operating Factor (OF)	:	93.76 %	Total off-line time	:	548 hours
Equivalent non-electrical energy generated (NEG)	:	56.31 GW(e).h			

Annual Summary



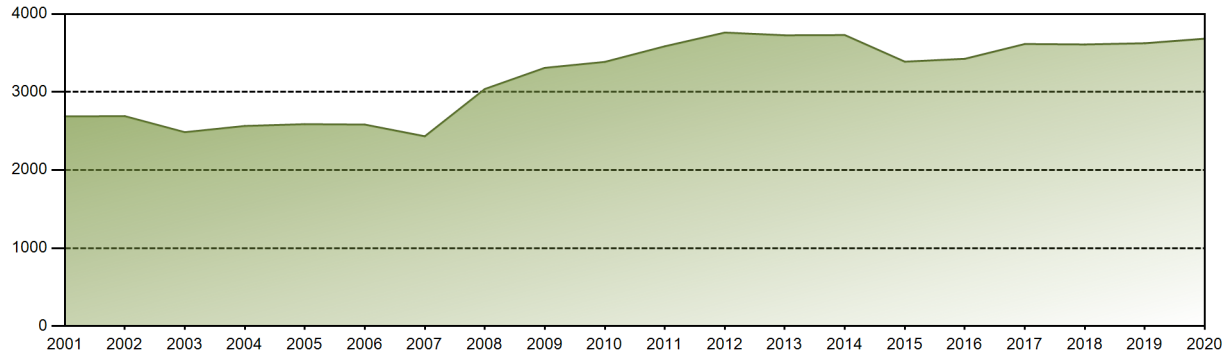
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	337.42	314.30	336.92	323.87	325.38	187.59	198.48	328.13	323.64	338.20	328.47	341.19	3683.59
EAF [%]	96.64	96.29	97.50	96.38	93.51	56.21	57.50	94.32	95.88	96.69	97.25	97.60	89.64
UCF [%]	99.96	99.49	100.00	99.57	96.39	59.00	59.99	99.83	100.00	100.00	99.62	99.61	92.78
LF [%]	96.29	95.88	96.28	95.50	92.85	55.32	56.64	93.64	95.43	96.38	96.86	98.41	89.11
OF [%]	100.00	100.00	100.00	100.00	100.00	63.75	61.42	100.00	100.00	100.00	100.00	100.00	93.76
FLR [%]	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.39	0.09
UCL [%]	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.39	0.08
PUF [%]	0.04	0.51	0.00	0.00	3.61	41.00	40.01	0.00	0.00	0.00	0.38	0.00	7.14
XUF [%]	3.32	3.20	2.50	3.19	2.88	2.80	2.49	5.51	4.12	3.31	2.36	2.01	3.14

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Historical Summary

Lifetime energy generation	:	109127.57 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.17 %
Cumulative Energy Availability Factor (EAF)	:	81.41 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.13 %
Cumulative Unit Capability Factor (UCF)	:	84.66 %	Cumulative Planned Unavailability Factor (PUF)	:	14.21 %
Cumulative Load Factor (LF)	:	79.91 %	Cumulative Externally cause unavailability (XUF)	:	3.24 %
Cumulative Operating Factor (OF)	:	85.53 %			

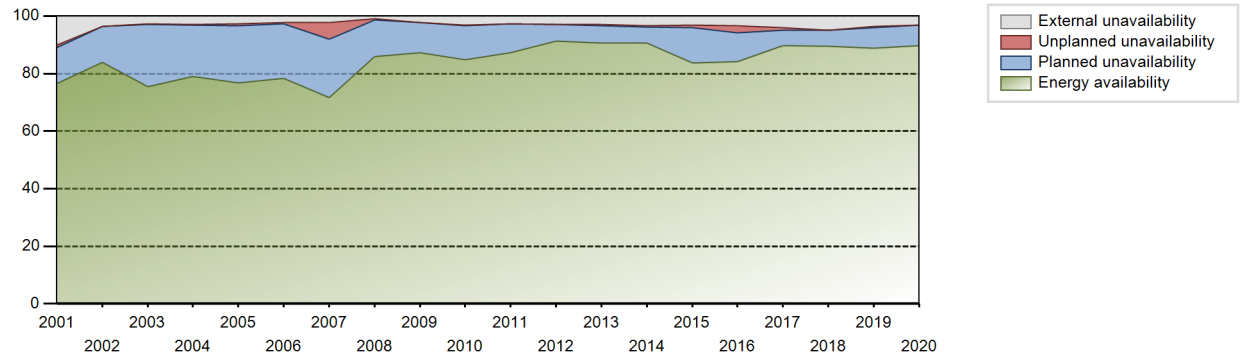
Electricity Production (net) [GWh]



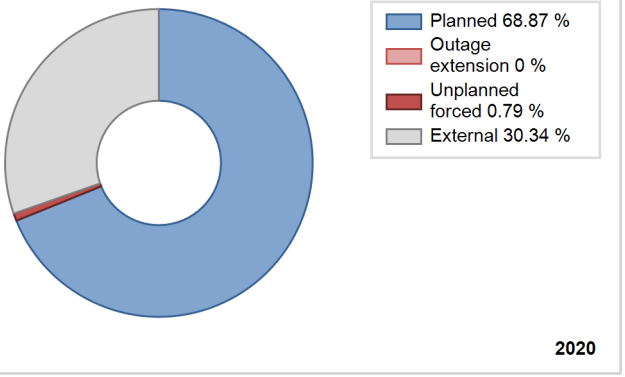
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	2721.56	7057	408	76.82	76.82	74.45	78.87	1.66	1.30	21.89	0.00
1986	2674.14	7089	408	75.40	75.43	74.82	80.92	7.77	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

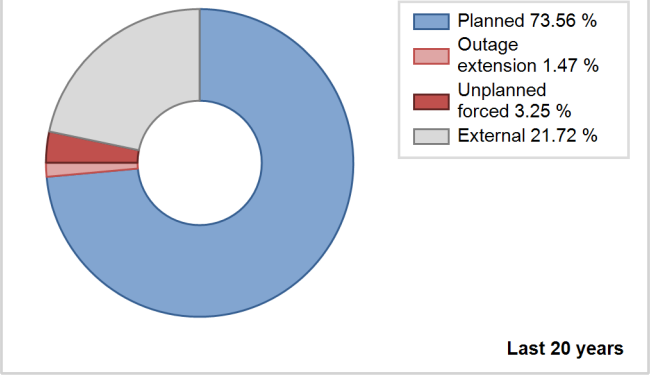
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					80	
C. Inspection, maintenance or repair combined with refuelling	548			1086		
D. Inspection, maintenance or repair without refuelling				92		
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
Subtotal	548			1178	80	7
Total	**548**			**1265**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		6
12. Reactor I&C Systems		5
13. Reactor Auxiliary Systems		4
14. Safety Systems		1
15. Reactor Cooling Systems		11
16. Steam generation systems		25
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		0
32. Feedwater and Main Steam System		8
33. Circulating Water System		1
35. All other I&C Systems		0
41. Main Generator Systems		1
42. Electrical Power Supply Systems		19
Total		**82**

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Highlights (2020)

16.02.2020 ordered power reduction - reactor power decreasing to 82,2 % due to main condenser TG32 tubes leakage repair. Steam extraction for district heating exchanger. From 09.03. 2020 to 27.03.2020 ancillary services actuation - secondary frequency control. 18.04.2020 ordered power reduction - reactor power decreasing to 80,4 % due to main condenser TG32 tubes leakage repair and ordered power reduction "–20 MW" reduced energy demand on market. From 29.05.2020 to 03.06.2020 reactor power decreasing to 56 % due to circulating water circuit isolation valves repair (valves in front of main condenser and cooling towers) - approved power reduction. 17.06. - 19.06.2020 coast-down operation. From 20.06.2020 annual maintenance and refuelling, start-up operation, scheduled measuring and testing. 26.08. - 27.08.2020 TG31 shutdown by means of push-button „danger“ after condensate pumps shutdown due to signal „ condensate demineralizer (BUK) TG31 impassibility“. Reactor power decreasing to 58 %. 14.11.2020 ordered power reduction - reactor power decreasing to 79,5 % due to main condenser TG32 tubes leakage repair. 26.12.2020 ordered power reduction - reactor power decreasing to 79,6 % due to main condenser TG31 tubes leakage repair. From 09.2020 steam extraction for district heating exchanger.

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2020 Operating Experience

SK-14 BOHUNICE-4 SLOVAKIA



Status at end of year	:	**Operational**
Operator	:	SE (SLOVENSKÉ ELEKTRÁRNE , AS.)
Owner	:	SE (SLOVENSKÉ ELEKTRÁRNE , AS.)
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	:	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]	:	1.25
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

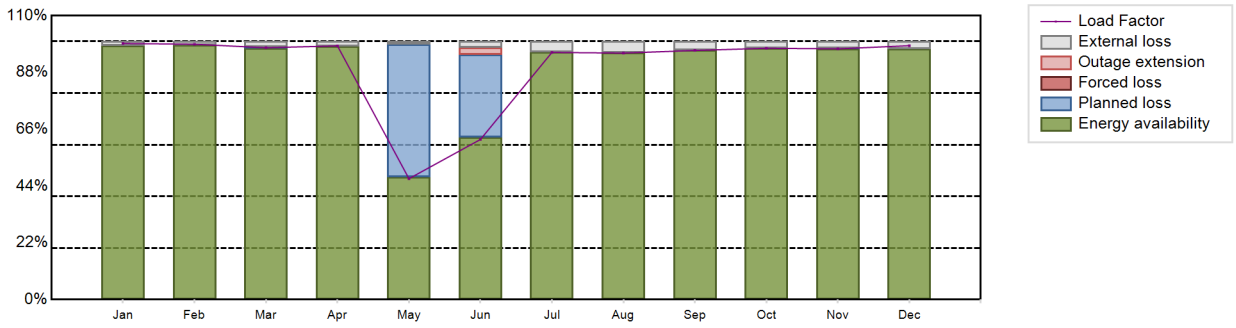
Operating coolant pressure [MPa]	:	12.0
Reactor outlet temperature [°C]	:	295
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.245
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	4.32
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 (2020)

Net Energy Production	:	3730.79 GW(e).h
Energy Availability Factor (EAF)	:	90.19 %
Unit Capability Factor (UCF)	:	92.71 %
Load Factor (LF)	:	90.26 %
Operating Factor (OF)	:	92.93 %
Equivalent non-electrical energy generated (NEG)	:	43.83 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0.23 %
Planned Unavailability Factor (PUF)	:	7.06 %
Externally cause unavailability (XUF)	:	2.52 %
Total off-line time	:	621 hours

Annual Summary



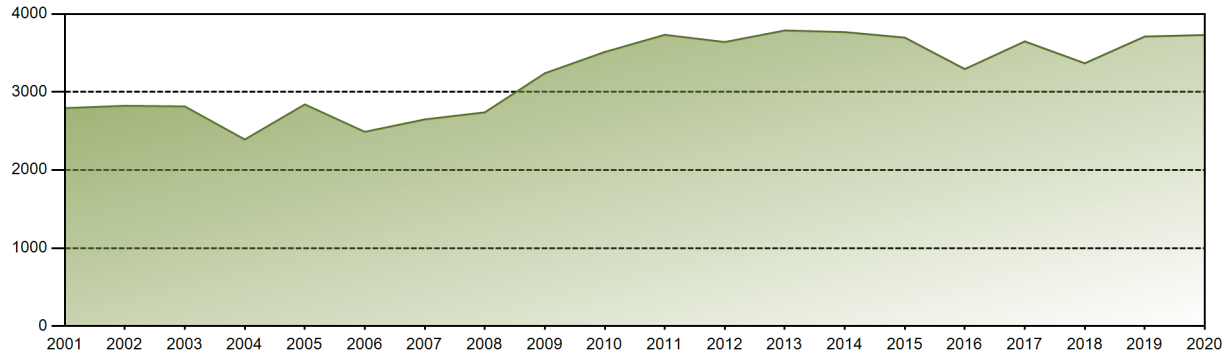
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	347.70	324.23	341.46	333.30	164.21	210.38	335.49	334.64	327.30	341.62	329.41	341.04	3730.79
EAF [%]	98.48	98.63	97.47	98.24	47.47	62.80	95.95	95.54	96.59	97.40	97.06	97.06	90.19
UCF [%]	100.00	100.00	99.53	100.00	48.52	65.12	100.00	100.00	100.00	100.00	99.65	100.00	92.71
LF [%]	99.22	98.91	97.57	98.28	46.86	62.04	95.74	95.50	96.52	97.36	97.14	98.37	90.26
OF [%]	100.00	100.00	100.00	100.00	48.79	66.67	100.00	100.00	100.00	100.00	100.00	100.00	92.93
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	2.82	0.00	0.00	0.00	0.00	0.00	0.00	0.23
PUF [%]	0.00	0.00	0.47	0.00	51.48	32.06	0.00	0.00	0.00	0.00	0.35	0.00	7.06
XUF [%]	1.52	1.37	2.07	1.76	1.05	2.32	4.05	4.46	3.41	2.60	2.58	2.94	2.52

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Historical Summary

Lifetime energy generation	:	108107 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.2 %
Cumulative Energy Availability Factor (EAF)	:	82.45 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.29 %
Cumulative Unit Capability Factor (UCF)	:	85.54 %	Cumulative Planned Unavailability Factor (PUF)	:	13.17 %
Cumulative Load Factor (LF)	:	81.07 %	Cumulative Externally cause unavailability (XUF)	:	3.1 %
Cumulative Operating Factor (OF)	:	86.43 %			

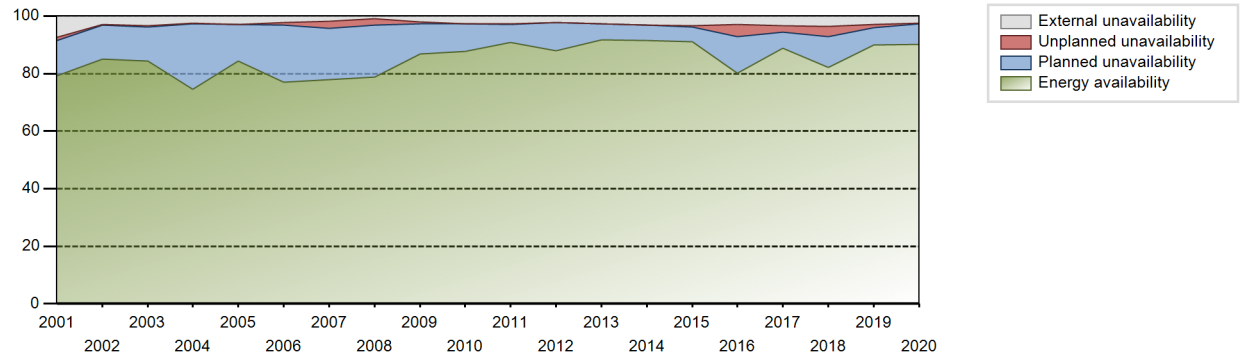
Electricity Production (net) [GWh]



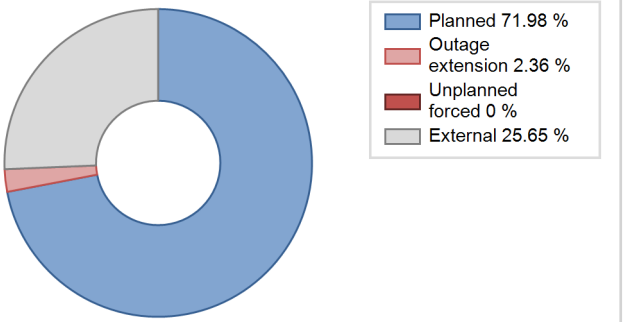
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	1083.50	3177	408	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1986	2887.85	7294	408	80.98	80.98	80.80	83.26	3.11	2.60	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

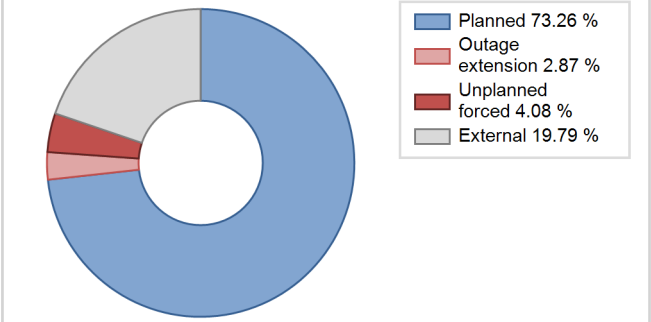
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		20			54	
C. Inspection, maintenance or repair combined with refuelling	600			1045		
D. Inspection, maintenance or repair without refuelling				44		
E. Testing of plant systems or components				1	0	
F. Major backfitting, refurbishment or upgrading activities with refuelling				16		
J. Grid limitation, failure or grid unavailability						0
L. Human factor related					9	
Subtotal	600	20		1106	63	0
Total		**620**			**1169**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		14
12. Reactor I&C Systems		5
15. Reactor Cooling Systems		6
16. Steam generation systems		28
17. Safety I&C Systems (excluding reactor I&C)		3
32. Feedwater and Main Steam System	20	5
33. Circulating Water System		0
34. Miscellaneous Systems		1
35. All other I&C Systems		0
42. Electrical Power Supply Systems		1
Total	**20**	**63**

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Highlights (2020)

I.-IV.2020 operation at full power in base load mode. Steam extraction for district heating exchanger. 20.03.2020 reactor power decreasing to 75 % due to main condenser TG42 tubes leakage location and blinding (approved power reduction). 13.04.2020 ordered power reduction – reactor power decreasing to 95,8 % (reduced energy demand on market). V.-VI.2020 annual maintenance and refuelling, annual maintenance unplanned extension, start-up operation, scheduled measuring and testing. 24.06.2020 ancillary services certification (secondary frequency control). 28.11.2020 reactor power decreasing to 77,7 % due to main condenser TG41 tubes leakage location and blinding (approved power reduction - planned). IX.-XII.2020 steam extraction for district heating exchanger. Operation without any failures.

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2020 Operating Experience

SK-6 MOCHOVCE-1 SLOVAKIA



Status at end of year	:	**Operational**
Operator	:	SE (SLOVENSKÉ ELEKTRÁRNE , AS.)
Owner	:	SE (SLOVENSKÉ ELEKTRÁRNE , AS.)
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	:	470 MWe
Reference unit power (net)	:	436 MWe

Key Dates

Construction Date	:	1983-10-13
Grid Date	:	1998-07-04
Commercial Date	:	1998-10-29
Age at end of year	:	22 years

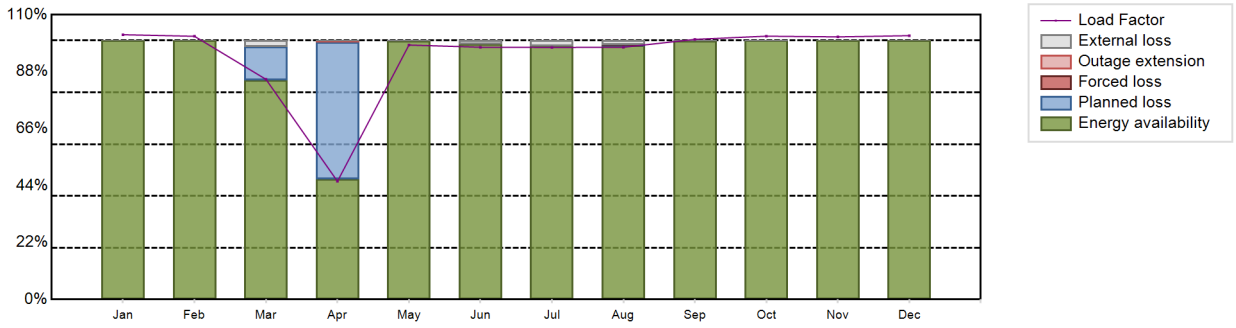
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.25
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]	:	12.0
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]	:	4.32
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	:	none

Annual Production Results (2020)

Net Energy Production	:	3610.02 GW(e).h
Energy Availability Factor (EAF)	:	93.82 %
Unit Capability Factor (UCF)	:	94.52 %
Load Factor (LF)	:	94.27 %
Operating Factor (OF)	:	94.75 %
Forced Loss Rate (FLR)	:	0.02 %
Unplanned Capability Loss Factor (UCL)	:	0.07 %
Planned Unavailability Factor (PUF)	:	5.42 %
Externally cause unavailability (XUF)	:	0.69 %
Total off-line time	:	461 hours

Annual Summary



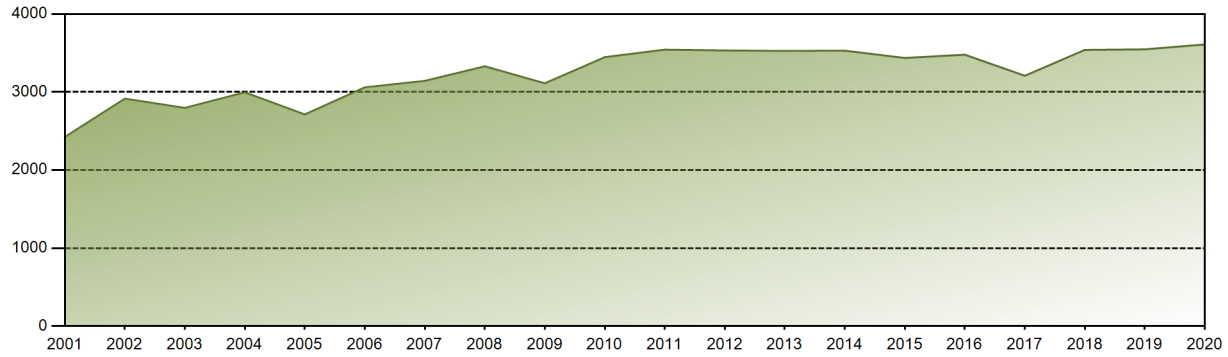
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	331.77	308.53	275.49	143.31	318.81	305.88	315.87	315.99	315.41	329.96	318.44	330.55	3610.01
EAF [%]	100.00	100.00	84.79	46.51	99.76	98.51	97.87	98.08	99.77	100.00	100.00	100.00	93.82
UCF [%]	100.00	100.00	87.25	46.57	100.00	100.00	100.00	99.72	100.00	100.00	100.00	100.00	94.52
LF [%]	102.28	101.67	85.04	45.65	98.28	97.44	97.38	97.41	100.47	101.72	101.44	101.90	94.27
OF [%]	100.00	100.00	87.62	48.75	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.75
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.02
UCL [%]	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.07
PUF [%]	0.00	0.00	12.75	52.84	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	5.42
XUF [%]	0.00	0.00	2.46	0.06	0.24	1.49	2.13	1.64	0.23	0.00	0.00	0.00	0.69

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Historical Summary

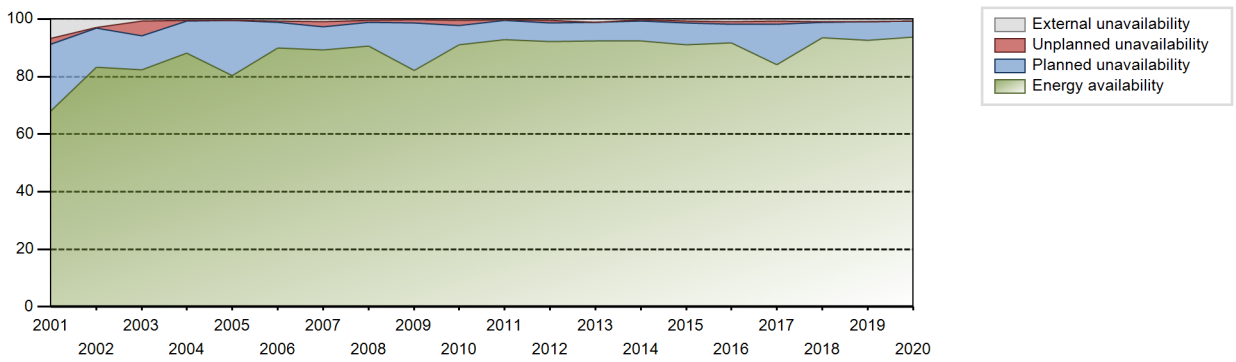
Lifetime energy generation	:	70941.75 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.97 %
Cumulative Energy Availability Factor (EAF)	:	86.9 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.01 %
Cumulative Unit Capability Factor (UCF)	:	88.51 %	Cumulative Planned Unavailability Factor (PUF)	:	10.48 %
Cumulative Load Factor (LF)	:	86.04 %	Cumulative Externally cause unavailability (XUF)	:	1.61 %
Cumulative Operating Factor (OF)	:	89.4 %			

Electricity Production (net) [GWh]



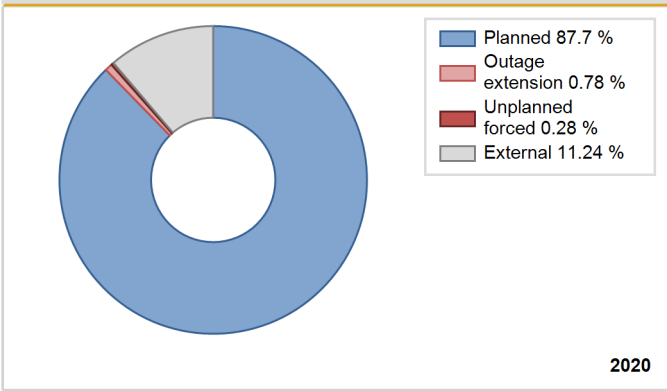
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1998	936.28	3343	408	94.96	96.83	93.54	98.98	3.17	3.17	0.00	1.87
1999	2376.14	6397	404	65.82	70.37	67.14	73.03	3.19	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

Key Factors in Last 20 Years [%]

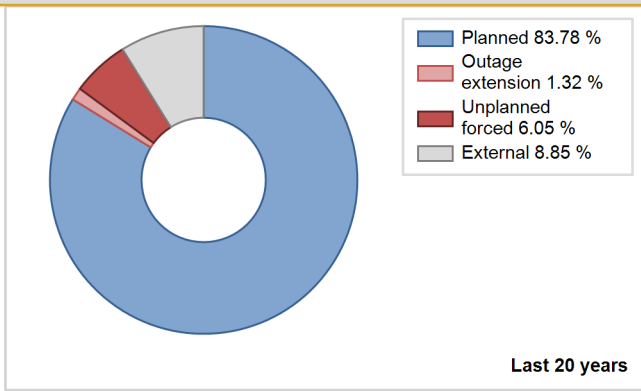


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1998 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		4			49	
C. Inspection, maintenance or repair combined with refuelling	456			832		
D. Inspection, maintenance or repair without refuelling				31		
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					8	
Z. Other					3	
Subtotal	456	4		863	60	3
Total	**460**			**926**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1998 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		6
14. Safety Systems		7
15. Reactor Cooling Systems	4	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		0
35. All other I&C Systems		0
41. Main Generator Systems		1
42. Electrical Power Supply Systems		15
Total	**4**	**52**

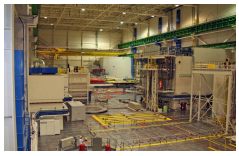
Highlights (2020)

MOCHOVCE 1 unit was operated at full power in base load mode in 2020. Unit provided grid supporting services for load following - frequency and secondary power control for grid adjustment and tertiary power control. Load-following losses for a period were 13.6 GWh . Over the reporting period there was only one forced unplanned event - Reactor power reduction to 73% due to inadvertent actuation of the reactor coolant pump power relay, occurred in August, with losses of 0.7 GWh. Throughout the year there was no automatic reactor scram and no unplanned full outage. Planned energy loses of 223.6 GWh were caused by general overhaul with refueling in April and supporting services recertifications. Other factors affecting energy generation were limitations due to coast-down operation and environmental conditions.

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2020 Operating Experience

SK-7 MOCHOVCE-2 SLOVAKIA



Status at end of year	:	**Operational**
Operator	:	SE (SLOVENSKÉ ELEKTRÁRNE , AS.)
Owner	:	SE (SLOVENSKÉ ELEKTRÁRNE , AS.)
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	:	501 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	:	21 years

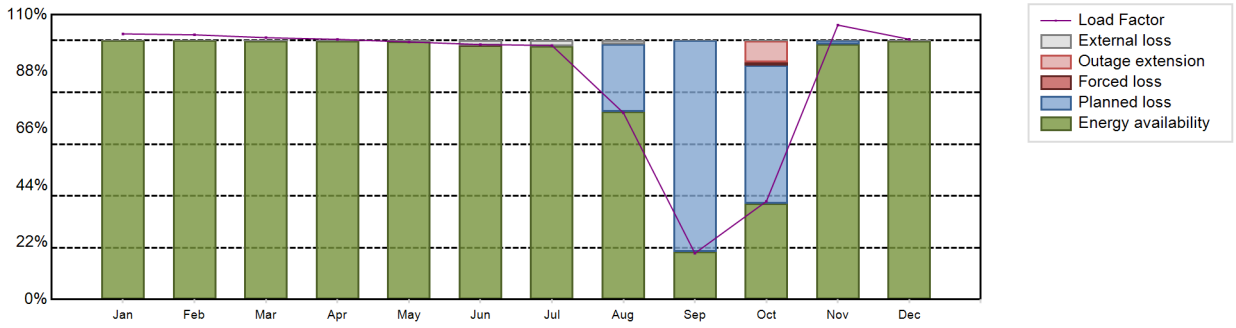
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.25
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	22
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]	:	13.49
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]	:	4.32
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	:	none

Annual Production Results (2020)

Net Energy Production	:	3332.8 GW(e).h
Energy Availability Factor (EAF)	:	85.26 %
Unit Capability Factor (UCF)	:	85.77 %
Load Factor (LF)	:	86.47 %
Operating Factor (OF)	:	92.35 %
Forced Loss Rate (FLR)	:	0.11 %
Unplanned Capability Loss Factor (UCL)	:	0.79 %
Planned Unavailability Factor (PUF)	:	13.44 %
Externally cause unavailability (XUF)	:	0.5 %
Total off-line time	:	672 hours

Annual Summary



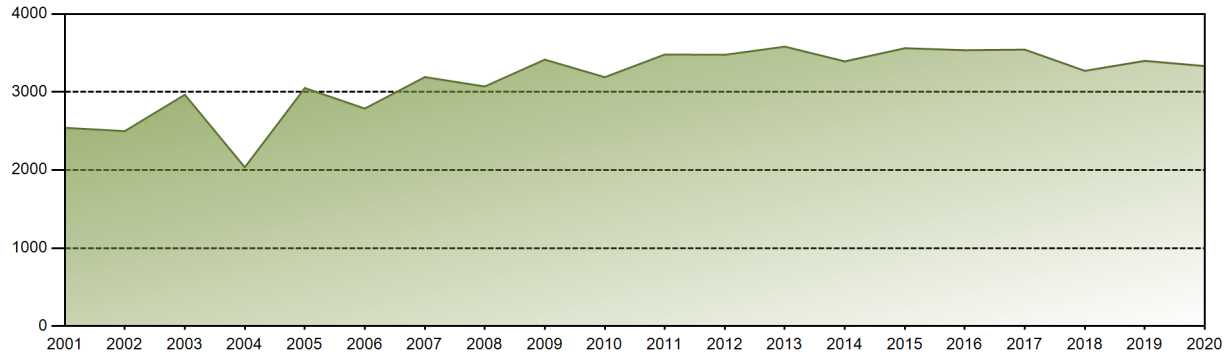
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	332.79	310.22	328.05	315.40	322.63	309.10	318.26	233.86	56.10	122.98	332.75	350.66	3332.80
EAF [%]	100.00	100.00	99.94	99.87	99.61	98.18	97.87	72.46	18.46	37.17	98.62	99.94	85.26
UCF [%]	100.00	100.00	100.00	100.00	100.00	99.99	100.00	73.87	18.46	37.24	98.62	100.00	85.77
LF [%]	102.59	102.23	101.13	100.47	99.46	98.47	98.11	72.09	17.87	37.91	106.00	100.49	86.47
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	37.08	70.70	100.00	100.00	92.35
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	2.92	0.00	0.00	0.11
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	9.40	0.00	0.00	0.79
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.13	81.54	53.36	1.38	0.00	13.44
XUF [%]	0.00	0.00	0.06	0.13	0.39	1.82	2.13	1.42	0.00	0.07	0.00	0.06	0.50

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Historical Summary

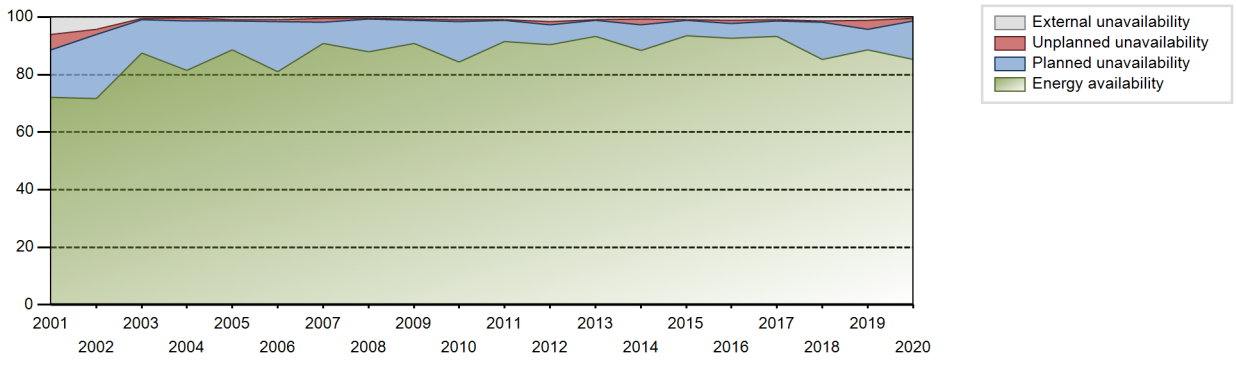
Lifetime energy generation	:	65945.34 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.77 %
Cumulative Energy Availability Factor (EAF)	:	87.06 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.12 %
Cumulative Unit Capability Factor (UCF)	:	88.41 %	Cumulative Planned Unavailability Factor (PUF)	:	10.47 %
Cumulative Load Factor (LF)	:	85.12 %	Cumulative Externally cause unavailability (XUF)	:	1.35 %
Cumulative Operating Factor (OF)	:	89.25 %			

Electricity Production (net) [GWh]



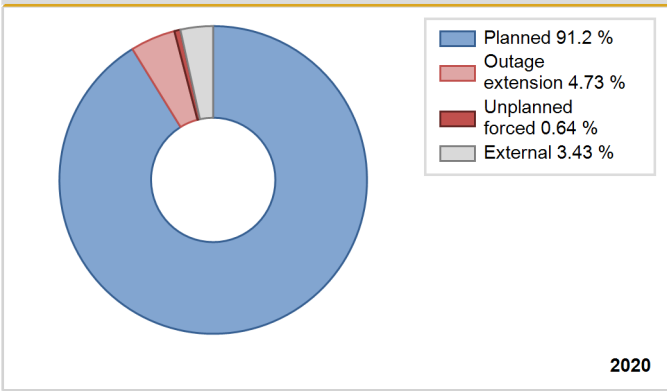
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2000	2641.42	7513	404	87.87	91.55	83.34	89.56	1.67	1.56	6.89	3.68
2001	2540.88	6967	404	72.10	78.17	71.80	79.53	6.46	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

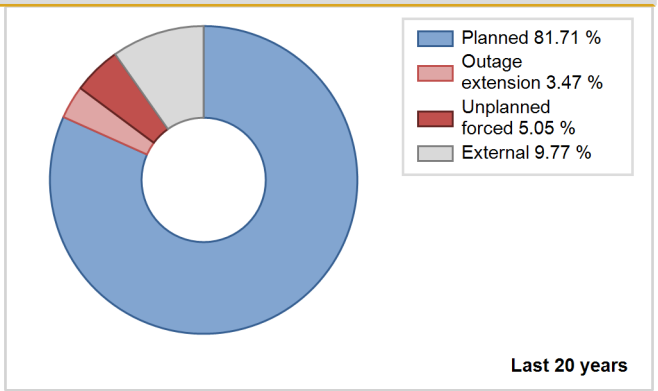
Key Factors in Last 20 Years [%]



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Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2000 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		70			63	
C. Inspection, maintenance or repair combined with refuelling	600			788		
D. Inspection, maintenance or repair without refuelling				76		
L. Human factor related					5	
Subtotal	600	70		864	68	
Total		**670**			**932**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2000 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		1
13. Reactor Auxiliary Systems		3
14. Safety Systems		7
15. Reactor Cooling Systems	62	28
16. Steam generation systems		9
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries	8	2
33. Circulating Water System		1
41. Main Generator Systems		3
42. Electrical Power Supply Systems		3
Total	**70**	**62**

RUP revision during the year (2020) due to power uprate

RUP at the end of previous year : 436 [MWe]

Month	Capacity [MWe]	Power Uprate	Main modifications	Description
December	469	Extended power uprate (>7%)	Balance of plant	The RUPnet was increased from 436 to 468.8 MWe after the completion of the modernization project in order to increase the efficiency of the unit. During this projekt, the important equipment of secondary circuit was replaced, such as the high-pressur

Highlights (2020)

MOCHOVCE 2 unit was largely operated at full power in base load mode in 2020. Unit provided grid supporting services for load following - frequency and secondary power control for grid adjustment and tertiary power control. Load-following losses for a period were 4.6 GWh . Throughout the year there was no automatic reactor scram. Unplanned outages caused forced losses of 32.9 GWh. The most of them 29.0 GWh were caused by the extension of the general overhaul. Planned energy loses of 558.5 GWh were caused by general overhaul with refueling and by operation with one turbogenerator before and after the general overhaul. During these planned outages the major balance-of-plant equipment was replaced and modified in order to increase the efficiency of the unit. The result of this project was the increase of gross electrical power from 470 MW to 500 MW.

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2020 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	:	39 years

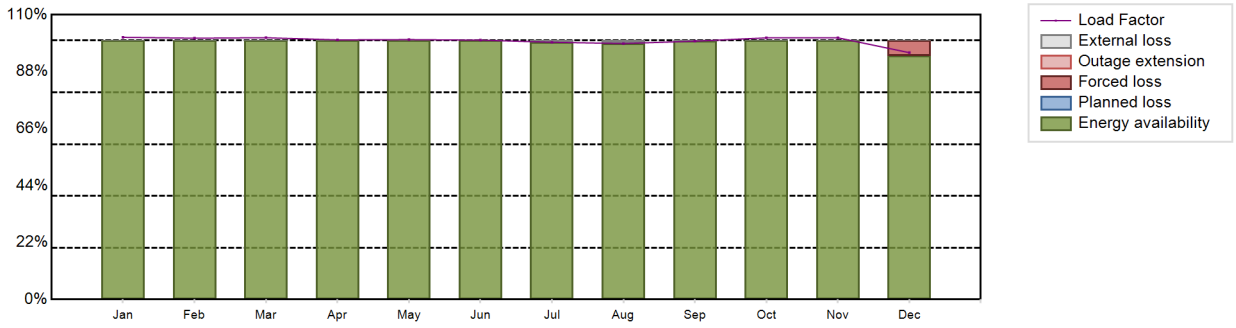
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.8
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	:	none

Annual Production Results (2020)

Net Energy Production	:	6040.85 GW(e).h	Forced Loss Rate (FLR)	:	0.49 %
Energy Availability Factor (EAF)	:	99.34 %	Unplanned Capability Loss Factor (UCL)	:	0.49 %
Unit Capability Factor (UCF)	:	99.51 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	99.96 %	Externally cause unavailability (XUF)	:	0.17 %
Operating Factor (OF)	:	99.59 %	Total off-line time	:	36 hours

Annual Summary



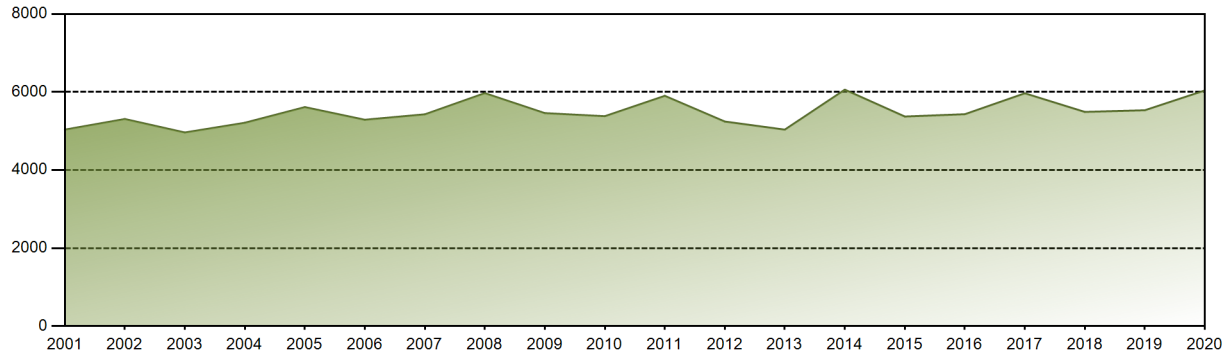
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	518.26	483.36	517.59	496.73	513.80	496.25	508.58	506.03	494.24	517.29	500.70	488.02	6040.85
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	99.36	98.86	99.77	100.00	100.00	94.26	99.34
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.26	99.51
LF [%]	101.25	100.94	101.12	100.28	100.38	100.18	99.36	98.86	99.77	101.06	101.08	95.34	99.96
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.16	99.59
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.74	0.49
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.74	0.49
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	0.64	1.14	0.23	0.00	0.00	0.00	0.17

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Historical Summary

Lifetime energy generation	:	189296.82 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.4 %
Cumulative Energy Availability Factor (EAF)	:	86.37 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.54 %
Cumulative Unit Capability Factor (UCF)	:	87.42 %	Cumulative Planned Unavailability Factor (PUF)	:	11.03 %
Cumulative Load Factor (LF)	:	85.86 %	Cumulative Externally cause unavailability (XUF)	:	1.06 %
Cumulative Operating Factor (OF)	:	87.78 %			

Electricity Production (net) [GWh]

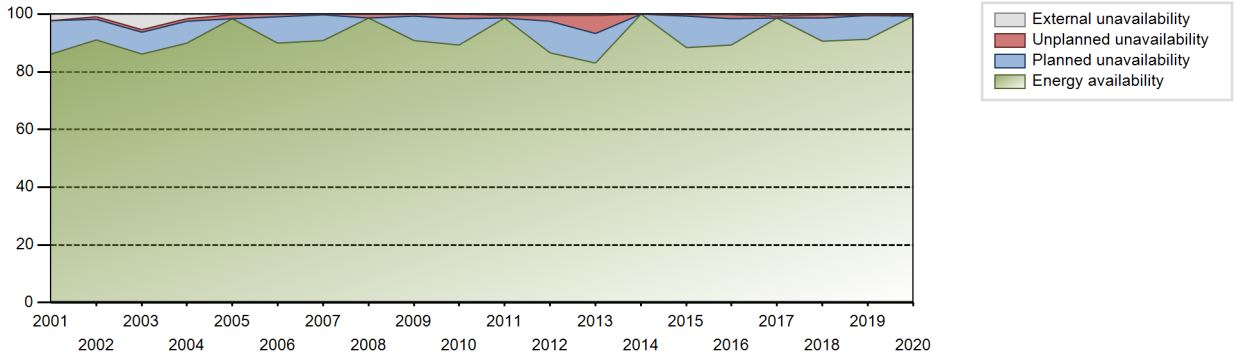


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	3724.10	6255	632	69.63	69.63	67.27	71.40	5.54	4.08	26.29	0.00
1984	4207.60	7073	632	79.80	79.80	75.79	80.52	5.16	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

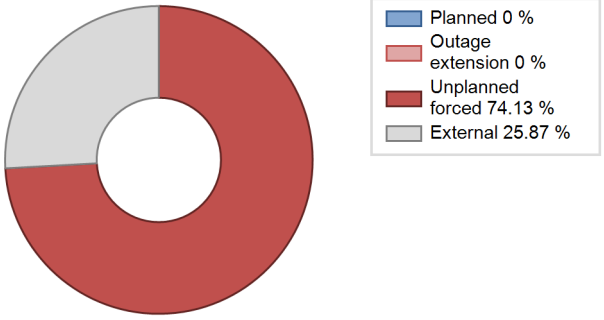
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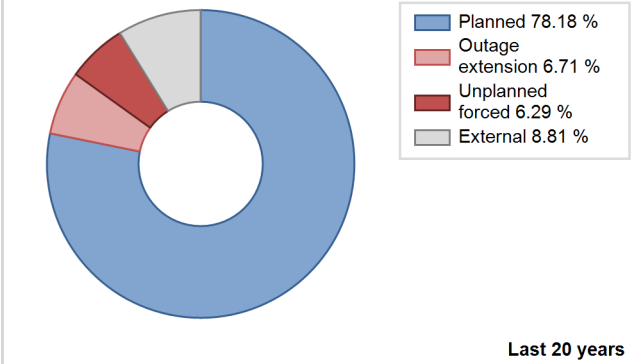
2020	6040.85	8748	688	99.34	99.51	99.96	99.59	0.49	0.49	0.00	0.17

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1983 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					131	
C. Inspection, maintenance or repair combined with refuelling				834		
D. Inspection, maintenance or repair without refuelling				129		
E. Testing of plant systems or components				40	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				18		
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		48			1	
Subtotal		48		1021	134	4
Total		**48**			**1159**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		15
12. Reactor I&C Systems	35	4
13. Reactor Auxiliary Systems		3
14. Safety Systems		3
15. Reactor Cooling Systems		11
16. Steam generation systems		11
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		25
32. Feedwater and Main Steam System		35
33. Circulating Water System		3
35. All other I&C Systems		0
41. Main Generator Systems		7
42. Electrical Power Supply Systems		14
Total	**35**	**133**

Highlights (2020)

Reactor trip due to earthqake on 29.12.2020.

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2020 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	:	970 MWe
Reference unit power (net)	:	930 MWe

Key Dates

Construction Date	:	1976-07-01
Grid Date	:	1984-04-04
Commercial Date	:	1984-07-21
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]	:	3.9
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

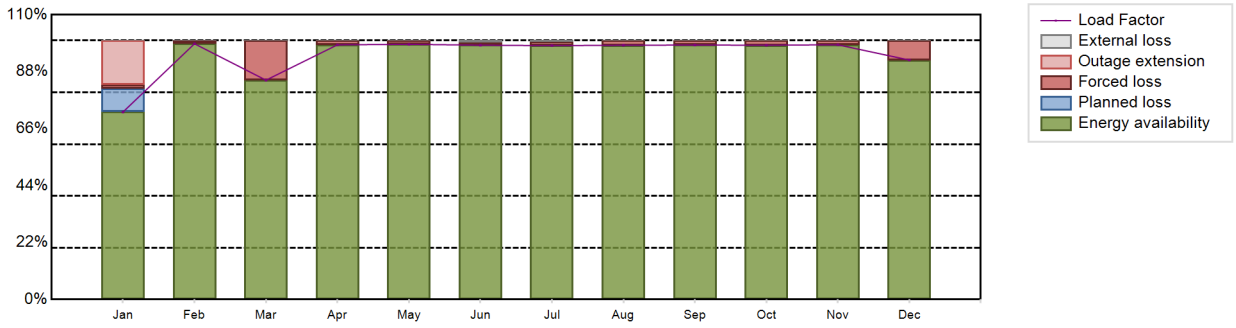
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	314.9
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	0.5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7719.38 GW(e).h
Energy Availability Factor (EAF)	:	94.52 %
Unit Capability Factor (UCF)	:	94.6 %
Load Factor (LF)	:	94.49 %
Operating Factor (OF)	:	97.59 %

Forced Loss Rate (FLR)	:	3.28 %
Unplanned Capability Loss Factor (UCL)	:	4.65 %
Planned Unavailability Factor (PUF)	:	0.76 %
Externally cause unavailability (XUF)	:	0.08 %
Total off-line time	:	212 hours

Annual Summary



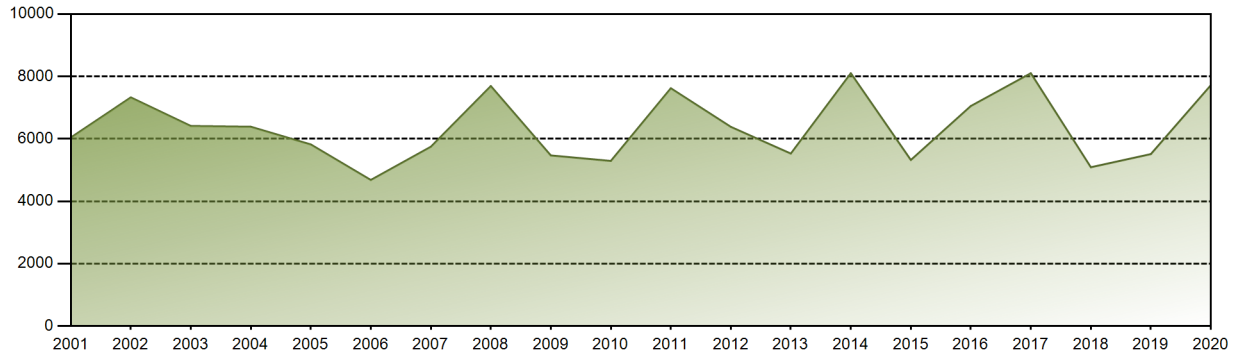
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	501.07	639.34	586.20	658.64	681.90	657.75	678.56	679.55	658.14	679.60	658.71	639.92	7719.38
EAF [%]	72.49	98.79	84.80	98.36	98.56	98.30	98.08	98.22	98.29	98.22	98.37	92.48	94.52
UCF [%]	72.49	98.79	84.80	98.36	98.56	98.81	98.56	98.22	98.29	98.22	98.37	92.48	94.60
LF [%]	72.42	98.77	84.72	98.36	98.55	98.23	98.07	98.21	98.29	98.22	98.37	92.49	94.49
OF [%]	83.06	100.00	88.44	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.59
FLR [%]	2.24	1.21	15.20	1.64	1.44	1.19	1.44	1.78	1.71	1.78	1.63	7.52	3.28
UCL [%]	18.59	1.21	15.20	1.64	1.44	1.19	1.44	1.78	1.71	1.78	1.63	7.52	4.65
PUF [%]	8.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.51	0.48	0.00	0.00	0.00	0.00	0.00	0.08

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Historical Summary

Lifetime energy generation	:	211938.22 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.59 %
Cumulative Energy Availability Factor (EAF)	:	74.05 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.98 %
Cumulative Unit Capability Factor (UCF)	:	77.32 %	Cumulative Planned Unavailability Factor (PUF)	:	15.69 %
Cumulative Load Factor (LF)	:	72.21 %	Cumulative Externally cause unavailability (XUF)	:	3.28 %
Cumulative Operating Factor (OF)	:	78.28 %			

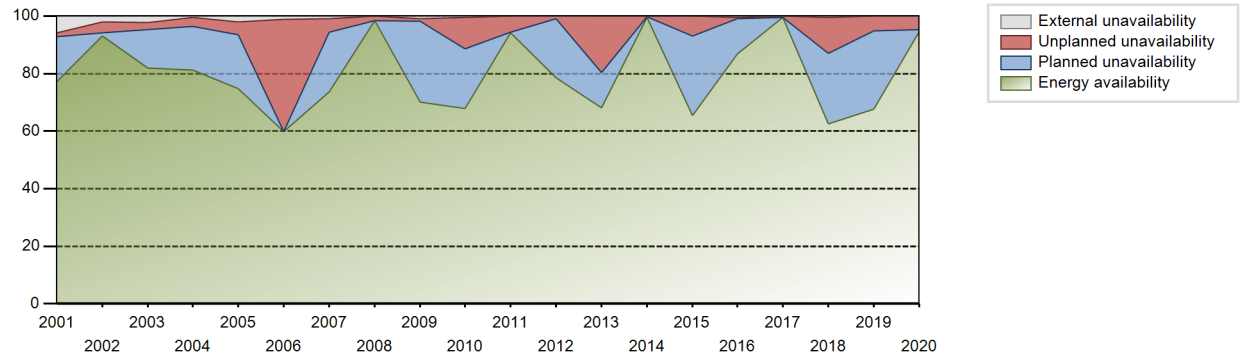
Electricity Production (net) [GWh]



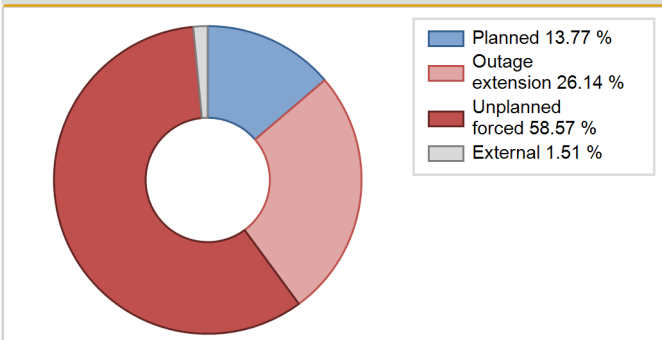
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	3949.53	5063	920	91.26	91.46	86.35	95.26	8.50	8.50	0.03	0.20
1985	4004.30	4986	920	53.49	53.49	49.69	56.92	45.38	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

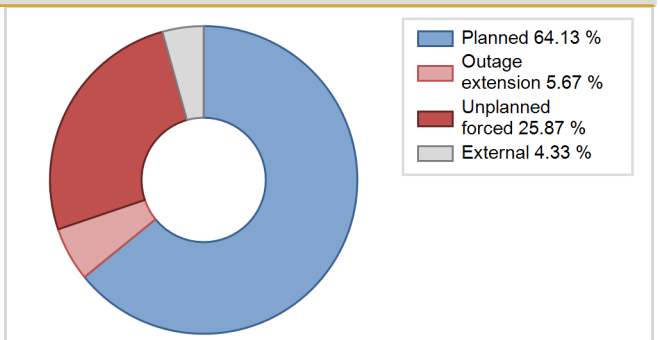
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		212			374	
C. Inspection, maintenance or repair combined with refuelling				1201	12	
D. Inspection, maintenance or repair without refuelling				135		
E. Testing of plant systems or components				3	11	
J. Grid limitation, failure or grid unavailability						0
L. Human factor related					11	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				44		
Z. Other					38	
Subtotal		212		1383	446	0
Total		**212**			**1829**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	126	53
12. Reactor I&C Systems		22
13. Reactor Auxiliary Systems		1
14. Safety Systems		2
15. Reactor Cooling Systems		73
16. Steam generation systems		0
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		51
32. Feedwater and Main Steam System		34
33. Circulating Water System	86	6
35. All other I&C Systems		0
41. Main Generator Systems		119
42. Electrical Power Supply Systems		42
Total	**212**	**404**

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2020 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	:	35 years

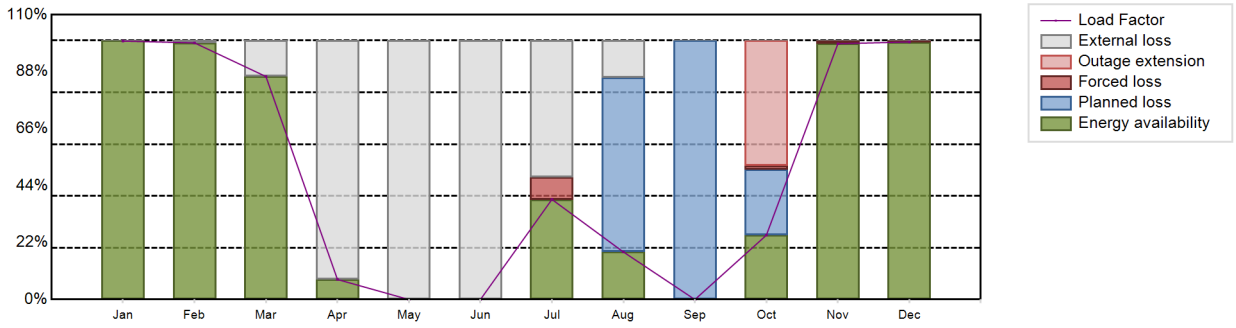
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.5
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	314.9
Fuel material	:	UO2	Number of SG	:	3
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.5
Average fuel enrichment [% of U235]	:	3.9	**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]	:	46000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	5.5
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]	:	17.6	Number of main condensate pumps	:	3
Number of control rod assemblies	:	32	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 (2020)

Net Energy Production	:	3896.22 GW(e).h	Forced Loss Rate (FLR)	:	1.25 %
Energy Availability Factor (EAF)	:	47.72 %	Unplanned Capability Loss Factor (UCL)	:	5.1 %
Unit Capability Factor (UCF)	:	78.86 %	Planned Unavailability Factor (PUF)	:	16.05 %
Load Factor (LF)	:	47.69 %	Externally cause unavailability (XUF)	:	31.14 %
Operating Factor (OF)	:	53.13 %	Total off-line time	:	4117 hours

Annual Summary



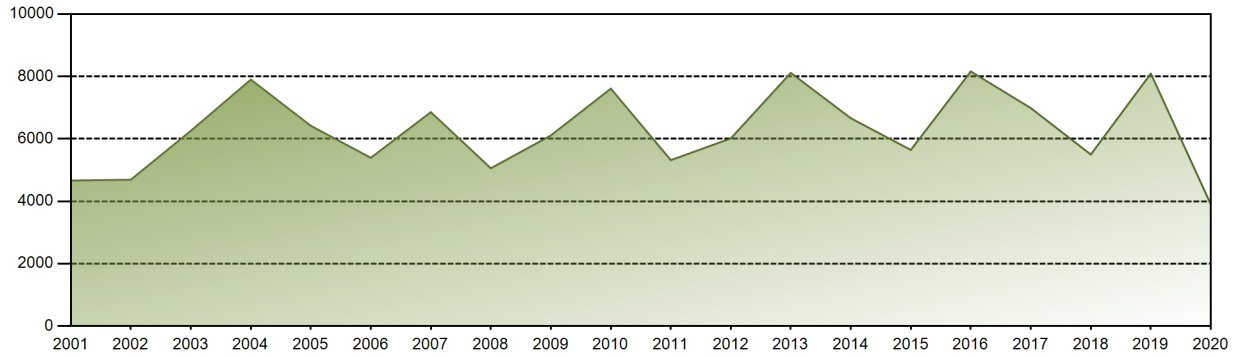
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	690.72	641.52	595.83	51.88	0.00	0.00	267.54	127.10	0.00	171.96	661.47	688.21	3896.22
EAF [%]	100.00	99.14	86.13	7.75	0.00	0.00	38.67	18.45	0.00	24.84	98.78	99.46	47.72
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	91.38	32.62	0.00	24.84	98.78	99.46	78.86
LF [%]	99.83	99.11	86.11	7.75	0.00	0.00	38.67	18.37	0.00	24.85	98.79	99.46	47.69
OF [%]	100.00	100.00	100.00	10.28	0.00	0.00	59.27	32.66	0.00	35.08	100.00	100.00	53.13
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	8.62	0.00	0.00	5.61	1.22	0.54	1.25
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	8.62	0.00	0.00	49.85	1.22	0.54	5.10
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	67.38	100.00	25.30	0.00	0.00	16.05
XUF [%]	0.00	0.86	13.87	92.25	100.00	100.00	52.71	14.17	0.00	0.00	0.00	0.00	31.14

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Historical Summary

Lifetime energy generation	:	205566.15 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.72 %
Cumulative Energy Availability Factor (EAF)	:	73.47 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.72 %
Cumulative Unit Capability Factor (UCF)	:	79.51 %	Cumulative Planned Unavailability Factor (PUF)	:	14.77 %
Cumulative Load Factor (LF)	:	72.47 %	Cumulative Externally cause unavailability (XUF)	:	6.03 %
Cumulative Operating Factor (OF)	:	79.27 %			

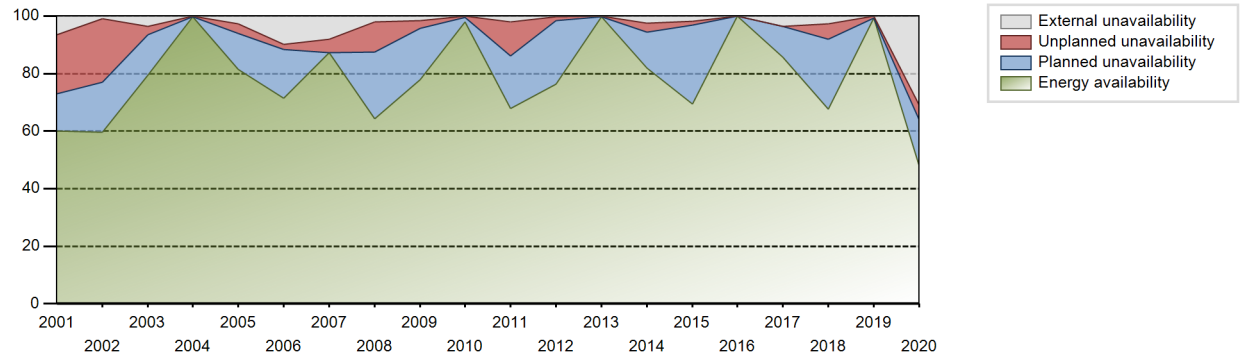
Electricity Production (net) [GWh]



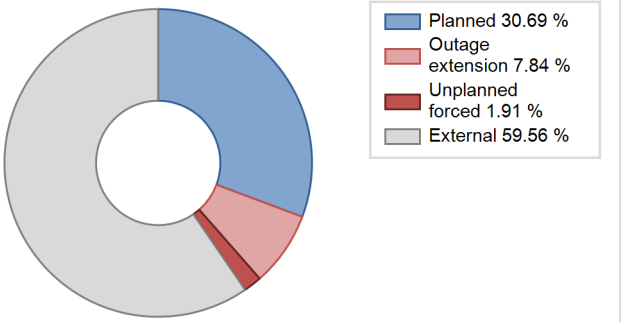
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	1389.80	2006	920	37.18	37.18	35.91	37.91	0.05	0.02	62.80	0.00
1986	5408.99	5969	922	67.32	67.38	66.97	68.14	32.00	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

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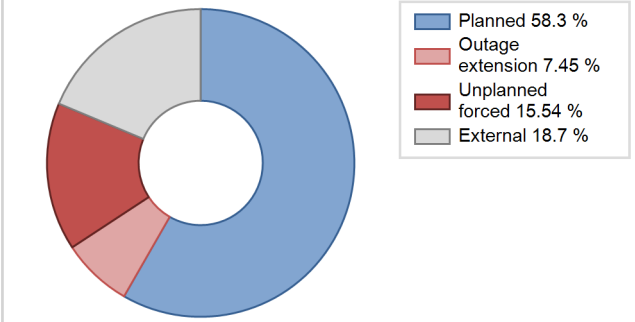
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		424			418	
C. Inspection, maintenance or repair combined with refuelling	1344			1174	28	
D. Inspection, maintenance or repair without refuelling				41		
E. Testing of plant systems or components				38	1	
H. Nuclear regulatory requirements					1	
J. Grid limitation, failure or grid unavailability						25
L. Human factor related					10	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						0
Z. Other			2348		36	70
Subtotal	1344	424	2348	1253	494	95
Total		**4116**			**1842**	

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Equipment Related Unplanned Full Outages, Analysis by System

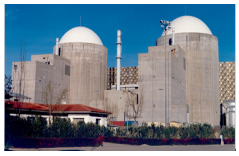
System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	360	27
12. Reactor I&C Systems		11
13. Reactor Auxiliary Systems		1
14. Safety Systems		54
15. Reactor Cooling Systems		12
16. Steam generation systems		40
31. Turbine and auxiliaries	64	28
32. Feedwater and Main Steam System		24
33. Circulating Water System		3
34. Miscellaneous Systems		37
35. All other I&C Systems		2
41. Main Generator Systems		67
42. Electrical Power Supply Systems		137
Total	**424**	**443**

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2020 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

Reactor type and model	:	PWR / WH 3LP
Thermal power	:	2947 MWth
Gross electrical power	:	1049 MWe
Reference unit power (net)	:	1011 MWe

Key Dates

Construction Date	:	1973-07-03
Grid Date	:	1981-05-01
Commercial Date	:	1983-09-01
Age at end of year	:	39 years

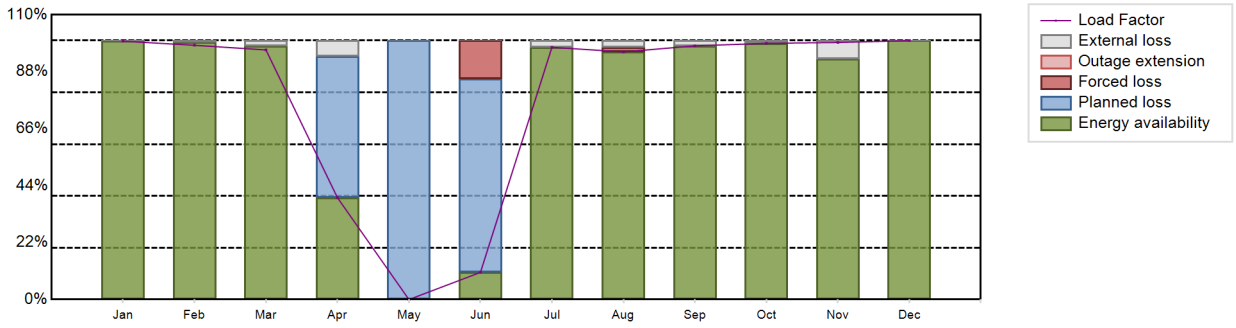
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	325
Fuel material	:	UO2	Number of SG	:	3
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	3.5
Average fuel enrichment [% of U235]	:	4.60	**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]	:	58000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	6.9
Active core height/length [m]	:	3.65	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]	:	17.3	Number of main condensate pumps	:	-
Number of control rod assemblies	:	48	Number of FW pumps for full power operation	:	-
Number of external reactor coolant loops	:	3	Number of on-site safety related diesel generators	:	NA
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	6913.12 GW(e).h	Forced Loss Rate (FLR)	:	1.66 %
Energy Availability Factor (EAF)	:	77.54 %	Unplanned Capability Loss Factor (UCL)	:	1.34 %
Unit Capability Factor (UCF)	:	79.58 %	Planned Unavailability Factor (PUF)	:	19.08 %
Load Factor (LF)	:	77.85 %	Externally cause unavailability (XUF)	:	2.04 %
Operating Factor (OF)	:	80.43 %	Total off-line time	:	1719 hours

Annual Summary



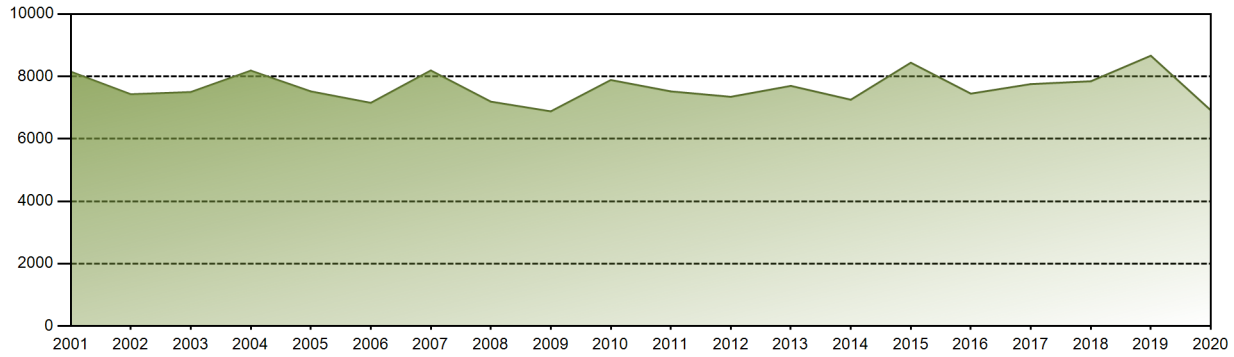
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	750.38	690.98	724.15	286.34	0.00	76.27	732.64	719.38	713.13	745.17	722.58	752.11	6913.13
EAF [%]	99.76	99.33	97.91	39.34	0.00	10.48	97.40	95.64	97.97	98.93	92.89	99.99	77.54
UCF [%]	100.00	100.00	100.00	45.42	0.00	10.48	100.00	98.38	100.00	100.00	99.98	100.00	79.58
LF [%]	99.76	98.20	96.40	39.34	0.00	10.48	97.40	95.64	97.97	98.93	99.27	99.99	77.85
OF [%]	100.00	100.00	100.00	46.11	0.00	18.47	100.00	100.00	100.00	100.00	100.00	100.00	80.43
FLR [%]	0.00	0.00	0.00	0.00	0.00	58.42	0.00	1.62	0.00	0.00	0.00	0.00	1.66
UCL [%]	0.00	0.00	0.00	0.00	0.00	14.72	0.00	1.62	0.00	0.00	0.00	0.00	1.34
PUF [%]	0.00	0.00	0.00	54.58	100.00	74.80	0.00	0.00	0.00	0.00	0.02	0.00	19.08
XUF [%]	0.24	0.67	2.09	6.09	0.00	0.00	2.60	2.74	2.03	1.07	7.09	0.01	2.04

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Historical Summary

Lifetime energy generation	:	271512.12 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.42 %
Cumulative Energy Availability Factor (EAF)	:	85.95 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.21 %
Cumulative Unit Capability Factor (UCF)	:	87 %	Cumulative Planned Unavailability Factor (PUF)	:	10.79 %
Cumulative Load Factor (LF)	:	86.01 %	Cumulative Externally cause unavailability (XUF)	:	1.05 %
Cumulative Operating Factor (OF)	:	88.51 %			

Electricity Production (net) [GWh]

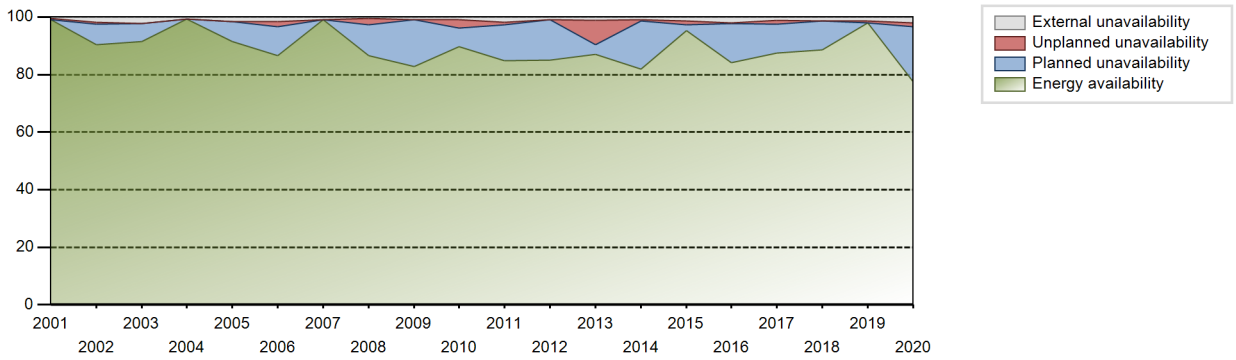


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	3713.90	5925	930	78.42	78.42	78.40	88.67	1.07	0.85	20.73	0.00
1984	4820.50	6062	893	65.03	65.03	61.45	69.01	6.16	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

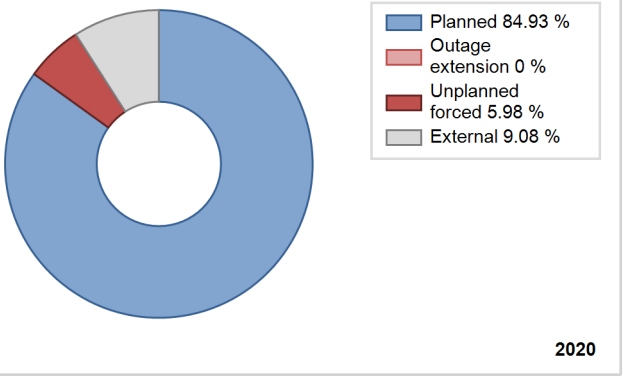
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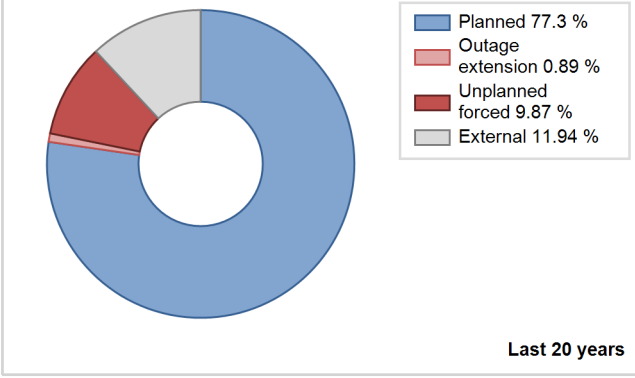
2020	6913.13	7065	1011	77.54	79.58	77.85	80.43	1.66	1.34	19.08	2.04

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1983 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		108			125	
C. Inspection, maintenance or repair combined with refuelling	1624			810		
D. Inspection, maintenance or repair without refuelling				159		
E. Testing of plant systems or components				45	0	
J. Grid limitation, failure or grid unavailability						4
L. Human factor related					3	
Z. Other					1	
Subtotal	1624	108		1014	129	4
Total	**1732**			**1147**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		28
15. Reactor Cooling Systems		10
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		18
33. Circulating Water System		1
41. Main Generator Systems	108	25
42. Electrical Power Supply Systems		20
Total	**108**	**123**

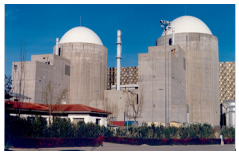
Highlights (2020)

Twenty-seventh refueling.

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2020 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	:	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]	:	4.60
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

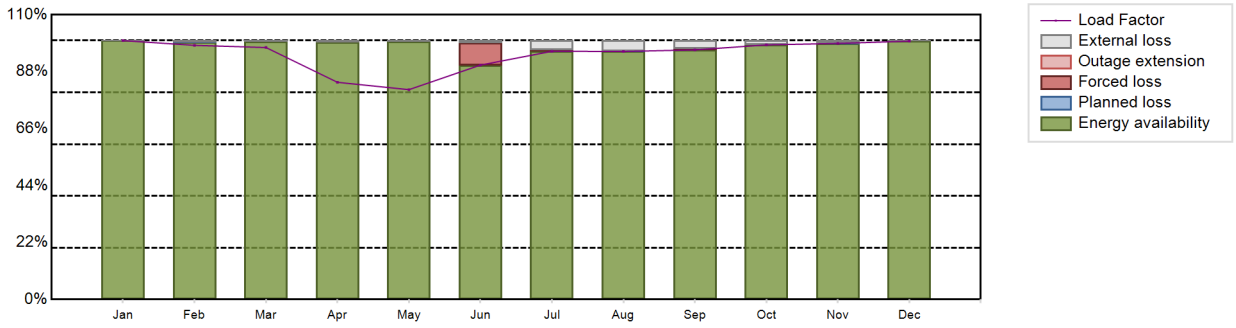
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	325
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	3.5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	8366.41 GW(e).h
Energy Availability Factor (EAF)	:	97.82 %
Unit Capability Factor (UCF)	:	99.22 %
Load Factor (LF)	:	94.68 %
Operating Factor (OF)	:	99.51 %

Forced Loss Rate (FLR)	:	0.77 %
Unplanned Capability Loss Factor (UCL)	:	0.77 %
Planned Unavailability Factor (PUF)	:	0.01 %
Externally cause unavailability (XUF)	:	1.4 %
Total off-line time	:	43 hours

Annual Summary



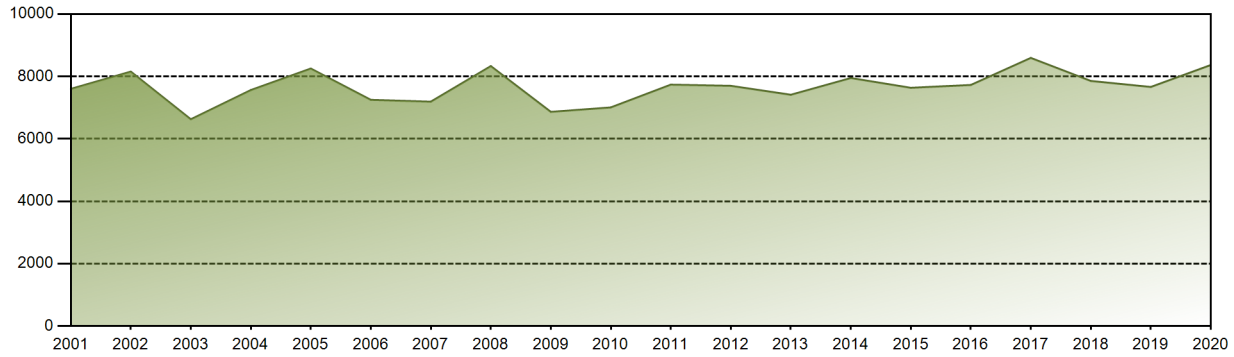
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	748.38	687.30	727.47	607.66	606.68	655.79	717.55	717.02	698.33	736.95	716.42	746.85	8366.41
EAF [%]	99.99	99.46	99.52	99.42	99.72	90.54	95.87	95.80	96.41	98.33	98.91	99.78	97.82
UCF [%]	100.00	99.98	100.00	100.00	100.00	91.41	99.52	99.96	99.63	100.00	99.97	100.00	99.22
LF [%]	99.99	98.16	97.33	83.89	81.06	90.54	95.87	95.80	96.41	98.33	98.91	99.78	94.68
OF [%]	100.00	100.00	100.00	100.00	100.00	94.03	100.00	100.00	100.00	100.00	100.00	100.00	99.51
FLR [%]	0.00	0.00	0.00	0.00	0.00	8.59	0.48	0.00	0.37	0.00	0.00	0.00	0.77
UCL [%]	0.00	0.00	0.00	0.00	0.00	8.59	0.48	0.00	0.37	0.00	0.00	0.00	0.77
PUF [%]	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.03	0.00	0.01
XUF [%]	0.01	0.51	0.48	0.58	0.28	0.87	3.65	4.16	3.22	1.67	1.06	0.22	1.40

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Historical Summary

Lifetime energy generation	:	268975.41 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.26 %
Cumulative Energy Availability Factor (EAF)	:	87.68 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.4 %
Cumulative Unit Capability Factor (UCF)	:	88.79 %	Cumulative Planned Unavailability Factor (PUF)	:	8.81 %
Cumulative Load Factor (LF)	:	87.75 %	Cumulative Externally cause unavailability (XUF)	:	1.11 %
Cumulative Operating Factor (OF)	:	90.28 %			

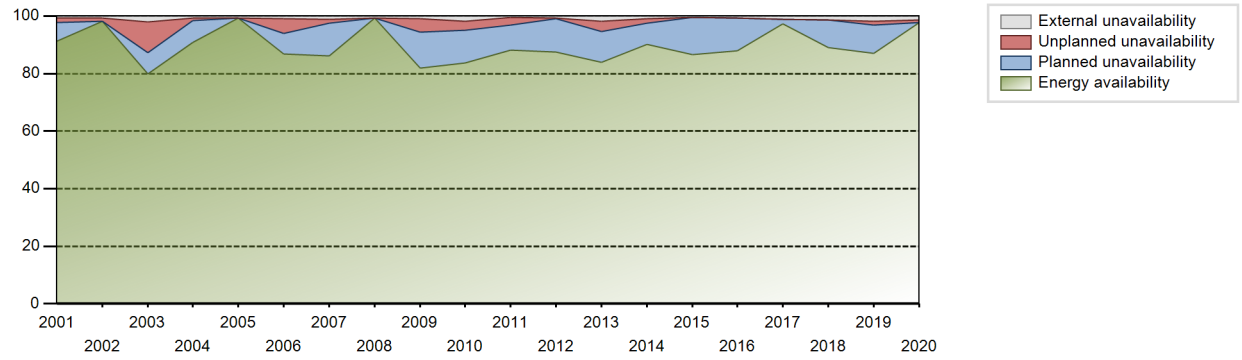
Electricity Production (net) [GWh]



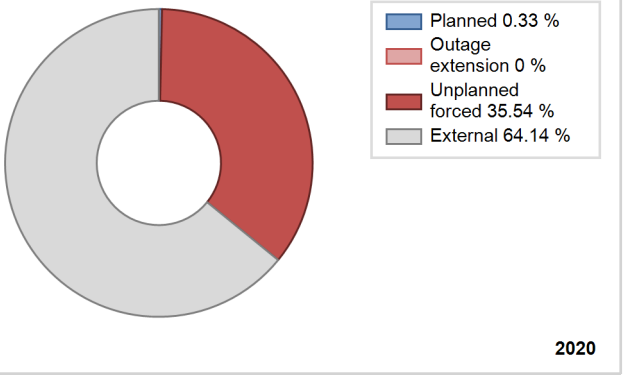
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	6012.94	7502	893	86.01	86.01	81.25	90.31	6.46	5.94	8.05	0.00
1985	6236.07	7297	900	79.84	79.84	79.10	83.30	2.74	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

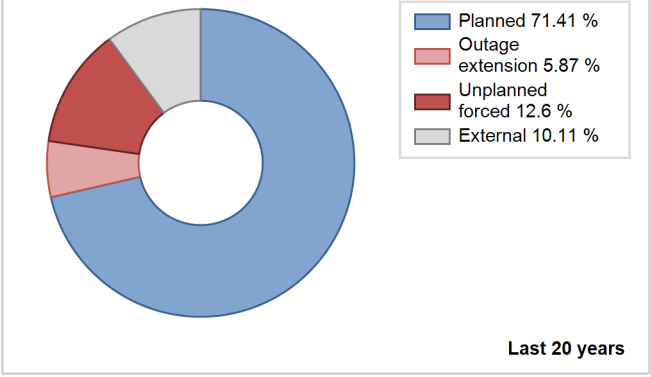
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		93			129	
C. Inspection, maintenance or repair combined with refuelling				689	5	
D. Inspection, maintenance or repair without refuelling				17		
E. Testing of plant systems or components				29		
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					7	
Z. Other					8	
Subtotal		93		735	149	2
Total		**93**			**886**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	93	2
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		3
14. Safety Systems		1
15. Reactor Cooling Systems		16
16. Steam generation systems		22
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		23
32. Feedwater and Main Steam System		22
35. All other I&C Systems		0
41. Main Generator Systems		16
42. Electrical Power Supply Systems		24
Total	**93**	**142**

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2020 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	:	37 years

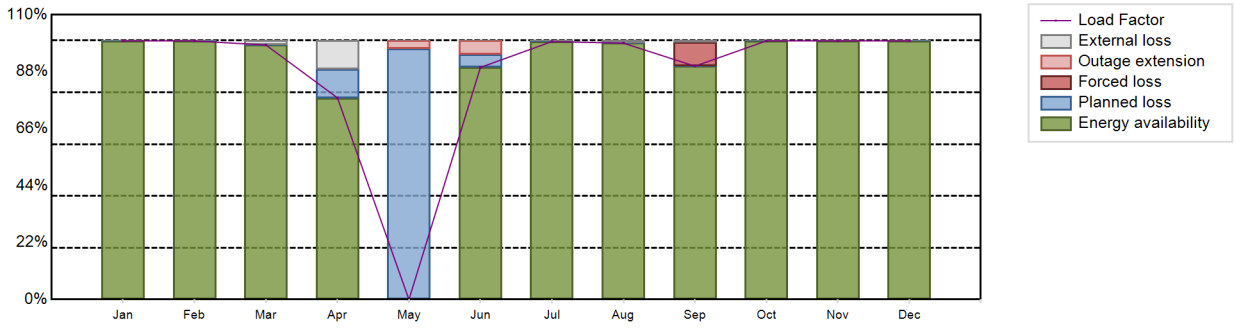
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.72
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	326.7
Fuel material	:	UO2	Number of SG	:	3
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	3.86
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	28	Turbine speed [rpm]	:	1500
Average discharge burnup [MWd/t]	:	50500	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.04	HP cylinder inlet steam pressure [MPa]	:	6.6
Active core height/length [m]	:	3.65	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	157	Primary means of condenser cooling	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	18.92	Number of main condensate pumps	:	4
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 (2020)

Net Energy Production	:	7669.03 GW(e).h	Forced Loss Rate (FLR)	:	0.84 %
Energy Availability Factor (EAF)	:	87.75 %	Unplanned Capability Loss Factor (UCL)	:	1.47 %
Unit Capability Factor (UCF)	:	88.92 %	Planned Unavailability Factor (PUF)	:	9.61 %
Load Factor (LF)	:	87.75 %	Externally cause unavailability (XUF)	:	1.18 %
Operating Factor (OF)	:	89.52 %	Total off-line time	:	921 hours

Annual Summary



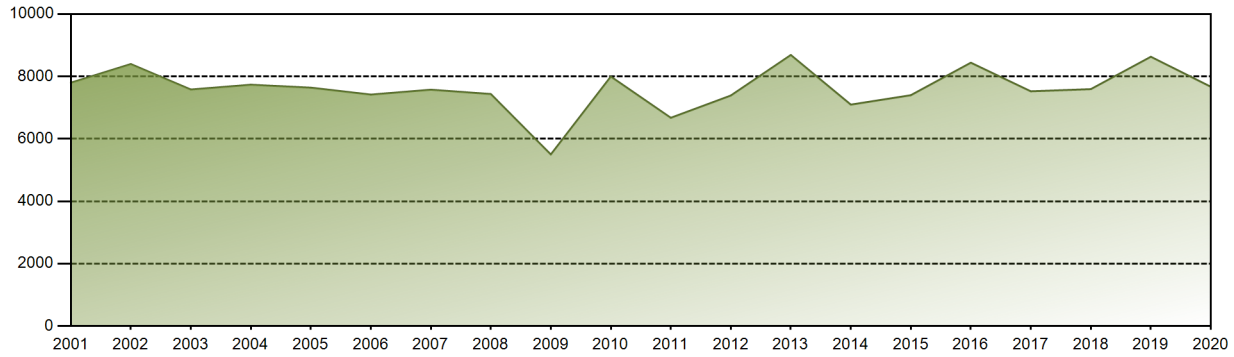
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	739.31	691.61	726.67	558.03	0.00	642.19	737.48	733.00	645.66	740.30	715.46	739.31	7669.03
EAF [%]	99.87	99.87	98.29	77.89	0.00	89.64	99.62	99.02	90.13	99.87	99.87	99.87	87.75
UCF [%]	99.87	99.87	99.87	88.91	0.00	89.64	99.87	99.87	90.71	99.87	99.87	99.87	88.92
LF [%]	99.87	99.87	98.29	77.89	0.00	89.64	99.62	99.02	90.13	99.87	99.87	99.87	87.75
OF [%]	100.00	100.00	100.00	90.00	0.00	94.58	100.00	100.00	90.83	100.00	100.00	100.00	89.52
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.18	0.00	0.00	0.00	0.84
UCL [%]	0.00	0.00	0.00	0.00	3.23	5.42	0.00	0.00	9.17	0.00	0.00	0.00	1.47
PUF [%]	0.13	0.13	0.13	11.09	96.77	4.94	0.13	0.13	0.12	0.13	0.13	0.13	9.61
XUF [%]	0.00	0.00	1.58	11.02	0.00	0.00	0.25	0.85	0.59	0.00	0.00	0.00	1.18

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Historical Summary

Lifetime energy generation	:	262735.03 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.55 %
Cumulative Energy Availability Factor (EAF)	:	85.57 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.22 %
Cumulative Unit Capability Factor (UCF)	:	86.24 %	Cumulative Planned Unavailability Factor (PUF)	:	10.54 %
Cumulative Load Factor (LF)	:	84.96 %	Cumulative Externally cause unavailability (XUF)	:	0.67 %
Cumulative Operating Factor (OF)	:	87.87 %			

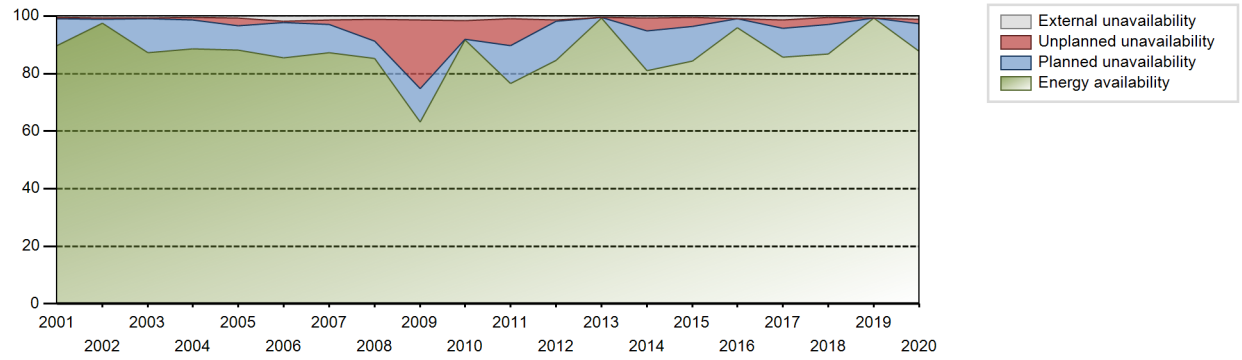
Electricity Production (net) [GWh]



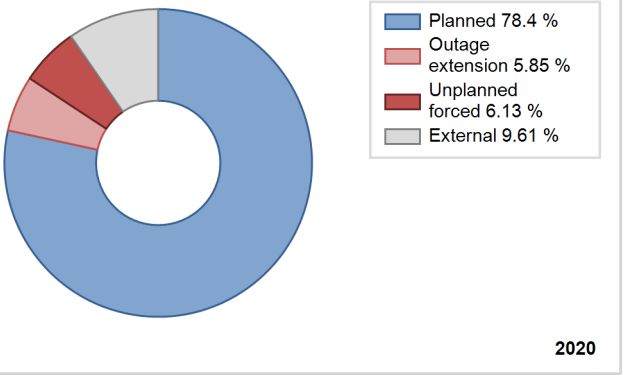
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	4038.42	5771	887	20.02	20.02	15.76	21.64	67.19	41.00	38.98	0.00
1985	4429.40	5342	898	60.32	60.32	56.31	60.98	6.75	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	7669.03	7863	995	87.75	88.92	87.75	89.52	0.84	1.47	9.61	1.18

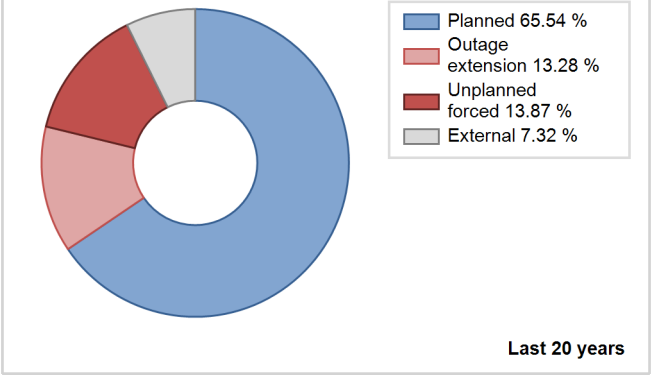
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		66			253	
C. Inspection, maintenance or repair combined with refuelling	792	24		791	39	
D. Inspection, maintenance or repair without refuelling				33		
E. Testing of plant systems or components		39		47	5	
J. Grid limitation, failure or grid unavailability						4
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					7	
Subtotal	792	129		871	308	12
Total		**921**			**1191**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		5
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems		0
14. Safety Systems		1
15. Reactor Cooling Systems	66	10
16. Steam generation systems		14
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities	63	47
31. Turbine and auxiliaries		51
32. Feedwater and Main Steam System		13
33. Circulating Water System		4
34. Miscellaneous Systems		3
35. All other I&C Systems		1
41. Main Generator Systems		75
42. Electrical Power Supply Systems		70
Total	**129**	**297**

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2020 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

Reactor type and model	:	PWR / WH 3LP
Thermal power	:	2941 MWth
Gross electrical power	:	1027 MWe
Reference unit power (net)	:	997 MWe

Key Dates

Construction Date	:	1975-03-07
Grid Date	:	1985-10-23
Commercial Date	:	1986-03-31
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 [%]	:	-
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

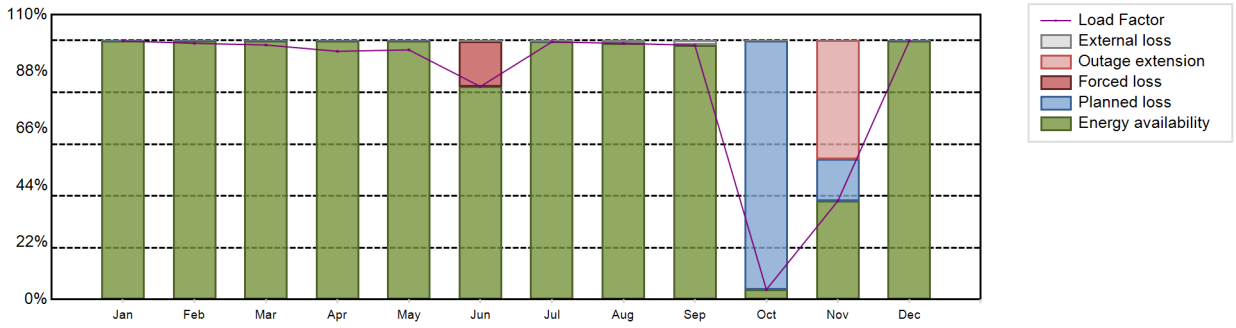
Operating coolant pressure [MPa]	:	15.72
Reactor outlet temperature [°C]	:	327
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	3.86
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7368.41 GW(e).h
Energy Availability Factor (EAF)	:	84.97 %
Unit Capability Factor (UCF)	:	85.25 %
Load Factor (LF)	:	84.14 %
Operating Factor (OF)	:	86.07 %

Forced Loss Rate (FLR)	:	1.64 %
Unplanned Capability Loss Factor (UCL)	:	5.18 %
Planned Unavailability Factor (PUF)	:	9.57 %
Externally cause unavailability (XUF)	:	0.28 %
Total off-line time	:	1224 hours

Annual Summary



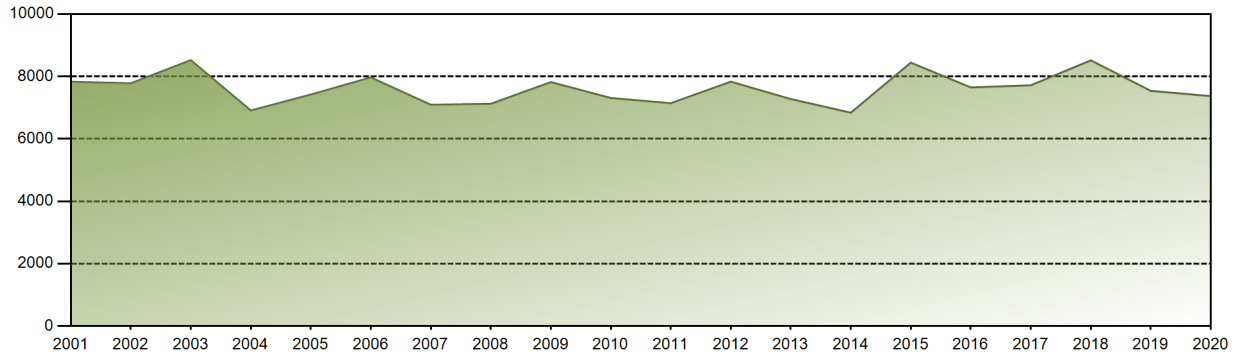
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	740.81	686.51	728.16	688.16	715.17	590.45	738.01	733.80	704.80	28.40	273.34	740.80	7368.41
EAF [%]	99.87	99.87	99.87	99.87	99.87	82.25	99.49	98.93	98.18	3.82	38.08	99.87	84.97
UCF [%]	99.87	99.87	99.87	99.87	99.87	82.53	99.87	99.87	99.82	4.00	38.08	99.87	85.25
LF [%]	99.87	98.93	98.30	95.87	96.41	82.25	99.49	98.93	98.18	3.82	38.08	99.87	84.14
OF [%]	100.00	100.00	100.00	100.00	100.00	82.64	100.00	100.00	100.00	6.44	44.17	100.00	86.07
FLR [%]	0.00	0.00	0.00	0.00	0.00	17.38	0.00	0.00	0.00	0.00	0.00	0.00	1.64
UCL [%]	0.00	0.00	0.00	0.00	0.00	17.36	0.00	0.00	0.00	0.00	45.83	0.00	5.18
PUF [%]	0.13	0.13	0.13	0.13	0.13	0.11	0.13	0.13	0.18	96.00	16.09	0.13	9.57
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.28	0.38	0.95	1.64	0.17	0.00	0.00	0.28

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Historical Summary

Lifetime energy generation	:	255810.41 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.7 %
Cumulative Energy Availability Factor (EAF)	:	87.27 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.21 %
Cumulative Unit Capability Factor (UCF)	:	88.23 %	Cumulative Planned Unavailability Factor (PUF)	:	8.56 %
Cumulative Load Factor (LF)	:	86.46 %	Cumulative Externally cause unavailability (XUF)	:	0.96 %
Cumulative Operating Factor (OF)	:	89.62 %			

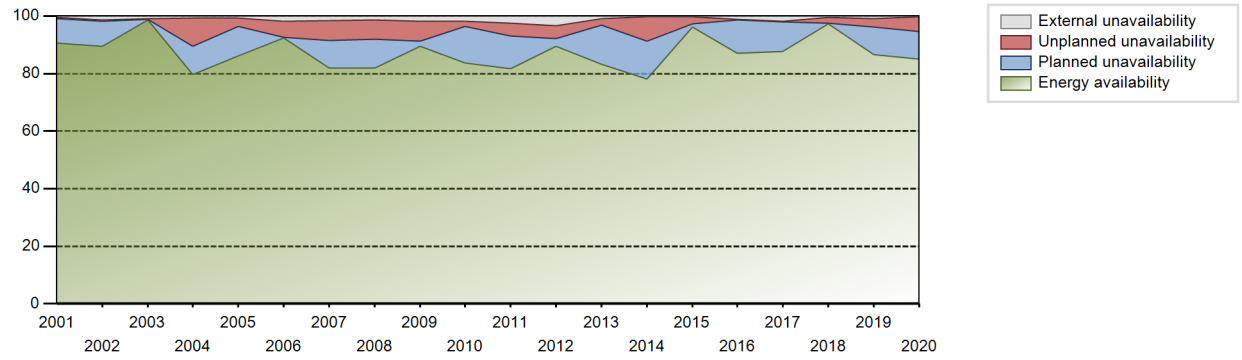
Electricity Production (net) [GWh]



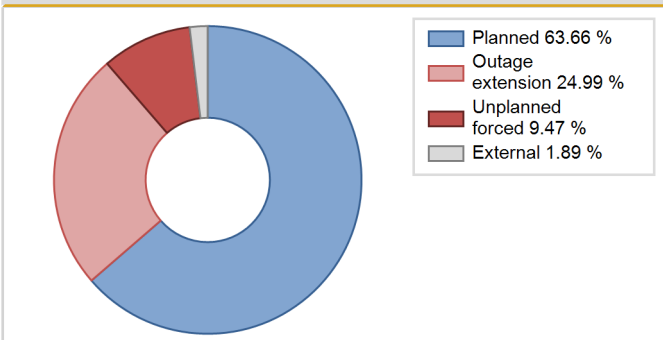
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	5368.00	6639	898	77.72	77.72	74.11	78.65	21.50	21.28	1.00	0.00
1987	5954.00	7035	898	77.27	78.13	75.69	80.31	3.63	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	7368.41	7560	997	84.97	85.25	84.14	86.07	1.64	5.18	9.57	0.28

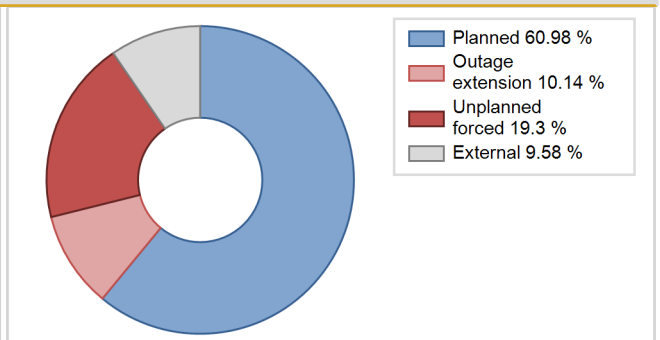
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		455			196	
C. Inspection, maintenance or repair combined with refuelling	769			658	42	
D. Inspection, maintenance or repair without refuelling				30		
E. Testing of plant systems or components				15	7	
F. Major backfitting, refurbishment or upgrading activities with refuelling				14		
J. Grid limitation, failure or grid unavailability						5
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	769	455		727	255	7
Total	**1224**			**989**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		5
13. Reactor Auxiliary Systems	125	23
14. Safety Systems		0
15. Reactor Cooling Systems	330	17
16. Steam generation systems		12
21. Fuel Handling and Storage Facilities		53
31. Turbine and auxiliaries		13
32. Feedwater and Main Steam System		56
33. Circulating Water System		7
34. Miscellaneous Systems		7
35. All other I&C Systems		1
41. Main Generator Systems		7
42. Electrical Power Supply Systems		51
Total	**455**	**255**

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2020 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

Reactor type and model	:	BWR / BWR-6 (Mark 3)
Thermal power	:	3237 MWth
Gross electrical power	:	1102 MWe
Reference unit power (net)	:	1064 MWe

Key Dates

Construction Date	:	1975-09-09
Grid Date	:	1984-10-14
Commercial Date	:	1985-03-11
Age at end of year	:	36 years

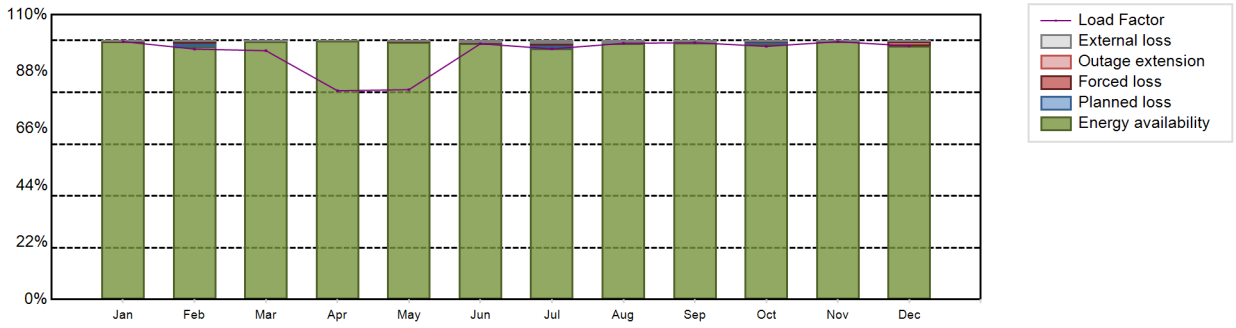
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4
Refuelling frequency [month]	:	24
Part of the core refuelled [%]	:	41
Average discharge burnup [MWd/t]	:	40000
Active core diameter [m]	:	4.29
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	624
Fuel linear heat generation rate [kW/m]	:	20.03
Number of control rod assemblies	:	145
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.26
Reactor outlet temperature [°C]	:	288
Number of SG	:	NA
Containment type	:	Single
Containment design pressure [MPa]	:	0.103
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]	:	7.115
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 (2020)

Net Energy Production	:	8902.95 GW(e).h	Forced Loss Rate (FLR)	:	0.34 %
Energy Availability Factor (EAF)	:	98.83 %	Unplanned Capability Loss Factor (UCL)	:	0.34 %
Unit Capability Factor (UCF)	:	99.38 %	Planned Unavailability Factor (PUF)	:	0.28 %
Load Factor (LF)	:	95.26 %	Externally cause unavailability (XUF)	:	0.55 %
Operating Factor (OF)	:	100 %	Total off-line time	:	0 hours

Annual Summary



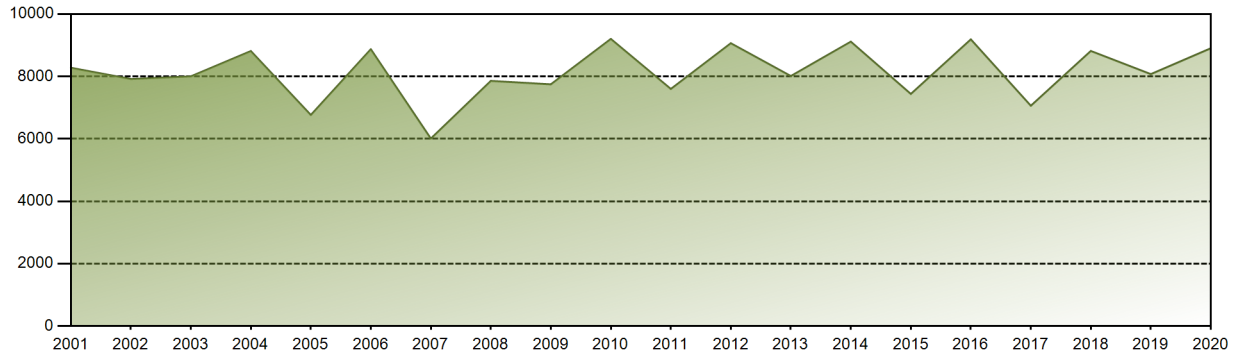
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	788.55	716.20	759.69	617.75	641.59	756.73	766.33	783.23	759.93	774.87	762.83	775.24	8902.95
EAF [%]	99.62	97.64	99.65	99.76	99.32	98.79	96.81	98.95	99.20	98.65	99.58	97.94	98.83
UCF [%]	99.93	97.98	100.00	100.00	99.68	99.63	97.89	100.00	100.00	99.15	100.00	98.27	99.38
LF [%]	99.61	96.71	96.10	80.64	81.05	98.78	96.81	98.94	99.20	97.75	99.58	97.93	95.26
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	0.73	0.00	0.00	0.32	0.37	0.81	0.00	0.00	0.04	0.00	1.73	0.34
UCL [%]	0.07	0.72	0.00	0.00	0.32	0.37	0.80	0.00	0.00	0.04	0.00	1.73	0.34
PUF [%]	0.00	1.30	0.00	0.00	0.00	0.00	1.31	0.00	0.00	0.81	0.00	0.00	0.28
XUF [%]	0.31	0.35	0.35	0.24	0.36	0.85	1.08	1.05	0.80	0.50	0.42	0.33	0.55

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Historical Summary

Lifetime energy generation	:	278659.62 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.83 %
Cumulative Energy Availability Factor (EAF)	:	87.42 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.05 %
Cumulative Unit Capability Factor (UCF)	:	88.39 %	Cumulative Planned Unavailability Factor (PUF)	:	8.57 %
Cumulative Load Factor (LF)	:	87.33 %	Cumulative Externally cause unavailability (XUF)	:	0.97 %
Cumulative Operating Factor (OF)	:	90.23 %			

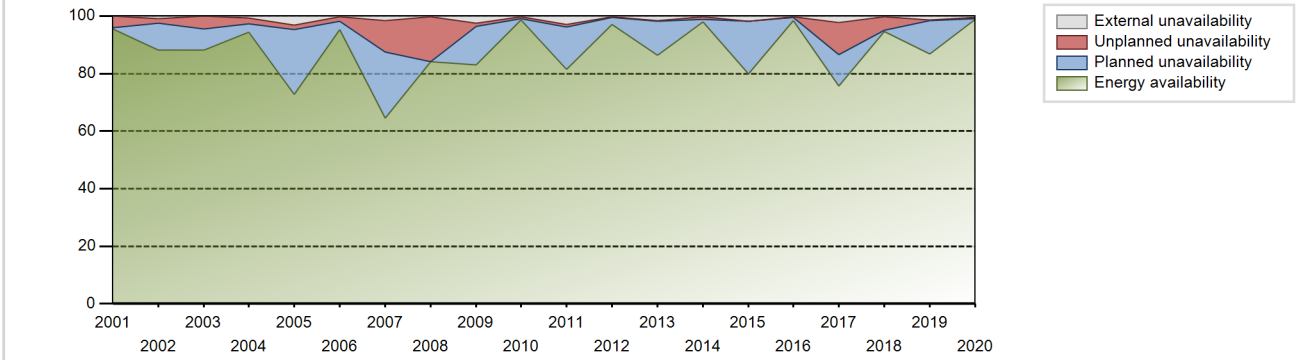
Electricity Production (net) [GWh]



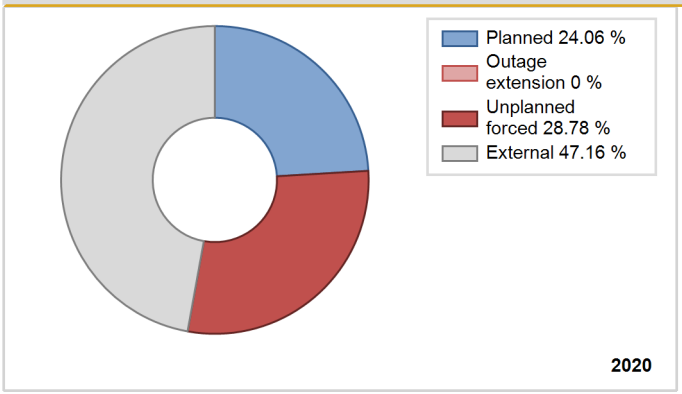
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	6142.48	7300	939	81.41	81.41	81.39	87.75	12.12	11.23	7.35	0.00
1986	6668.30	7487	939	81.07	81.96	81.07	85.47	2.10	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

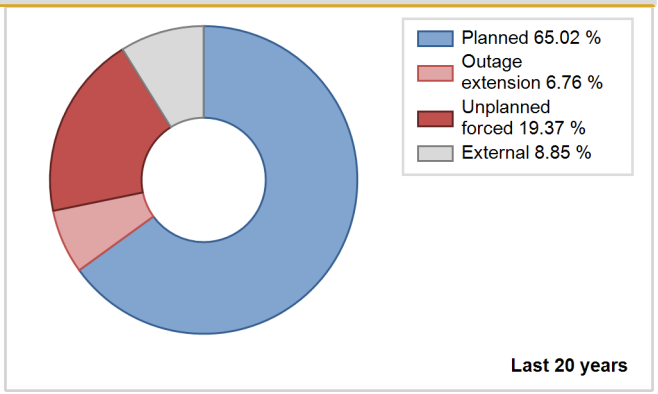
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					213	
B. Refuelling without maintenance				6		
C. Inspection, maintenance or repair combined with refuelling				591	2	
D. Inspection, maintenance or repair without refuelling				16		
E. Testing of plant systems or components				15		
J. Grid limitation, failure or grid unavailability						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
P. Fire					16	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				7		
Z. Other					9	
Subtotal				635	245	4
Total		**0**			**884**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		50
12. Reactor I&C Systems		43
13. Reactor Auxiliary Systems		3
15. Reactor Cooling Systems		6
16. Steam generation systems		1
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		54
32. Feedwater and Main Steam System		29
34. Miscellaneous Systems		1
41. Main Generator Systems		21
42. Electrical Power Supply Systems		24
Total		**234**

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2020 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	:	32 years

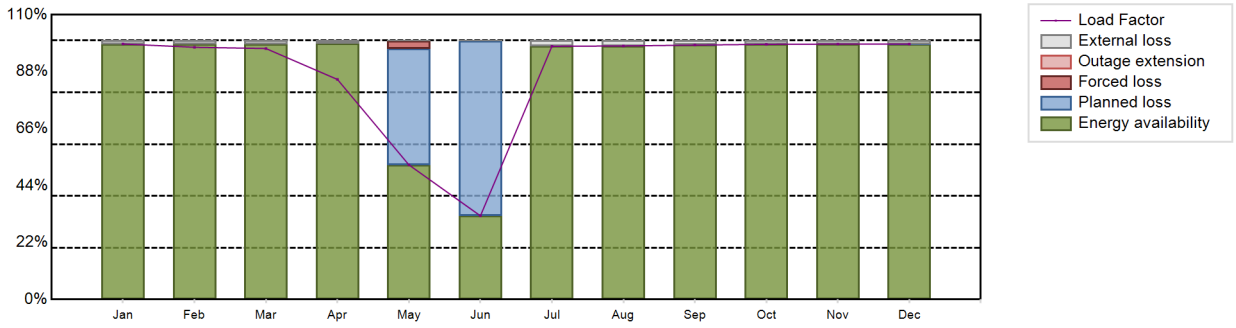
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	4.20
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	:	none

Annual Production Results (2020)

Net Energy Production	:	7729.61 GW(e).h	Forced Loss Rate (FLR)	:	0.29 %
Energy Availability Factor (EAF)	:	89.12 %	Unplanned Capability Loss Factor (UCL)	:	0.26 %
Unit Capability Factor (UCF)	:	90.39 %	Planned Unavailability Factor (PUF)	:	9.35 %
Load Factor (LF)	:	87.73 %	Externally cause unavailability (XUF)	:	1.26 %
Operating Factor (OF)	:	90.86 %	Total off-line time	:	803 hours

Annual Summary



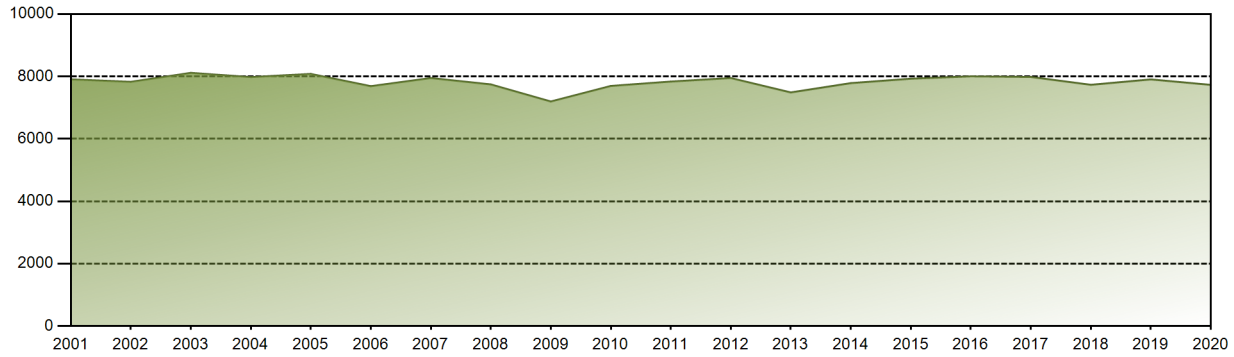
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	736.45	680.07	722.38	613.80	387.98	233.37	729.82	730.82	709.69	736.46	712.47	736.28	7729.61
EAF [%]	98.69	98.69	98.71	98.89	51.99	32.32	97.80	97.93	98.27	98.56	98.66	98.67	89.12
UCF [%]	100.00	100.00	100.00	100.00	52.02	32.42	100.00	100.00	99.94	100.00	100.00	99.95	90.39
LF [%]	98.69	97.42	96.93	85.00	51.99	32.32	97.80	97.93	98.27	98.56	98.66	98.67	87.73
OF [%]	100.00	100.00	100.00	100.00	55.11	34.86	100.00	100.00	100.00	100.00	100.00	100.00	90.86
FLR [%]	0.00	0.00	0.00	0.00	5.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
UCL [%]	0.00	0.00	0.00	0.00	3.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26
PUF [%]	0.00	0.00	0.00	0.00	44.89	67.58	0.00	0.00	0.06	0.00	0.00	0.05	9.35
XUF [%]	1.31	1.31	1.29	1.11	0.03	0.10	2.20	2.07	1.66	1.44	1.34	1.28	1.26

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Historical Summary

Lifetime energy generation	:	247166.63 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.42 %
Cumulative Energy Availability Factor (EAF)	:	87.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.6 %
Cumulative Unit Capability Factor (UCF)	:	87.82 %	Cumulative Planned Unavailability Factor (PUF)	:	9.58 %
Cumulative Load Factor (LF)	:	86.88 %	Cumulative Externally cause unavailability (XUF)	:	0.49 %
Cumulative Operating Factor (OF)	:	88.72 %			

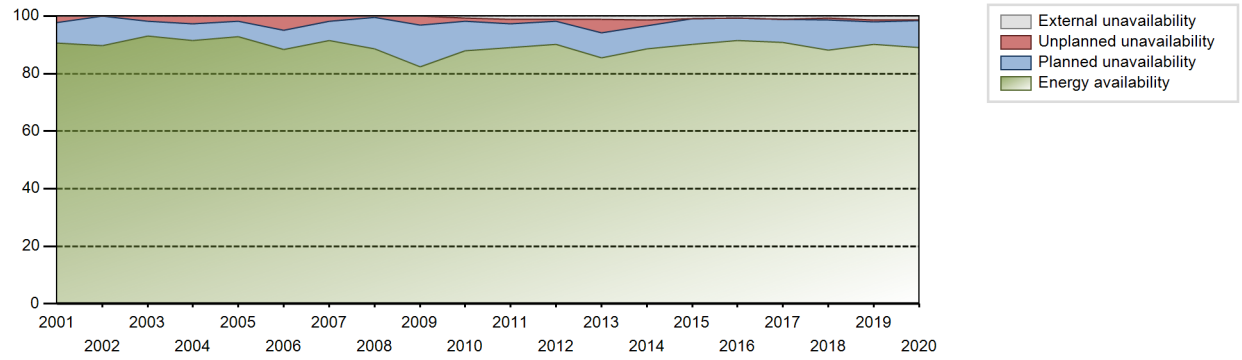
Electricity Production (net) [GWh]



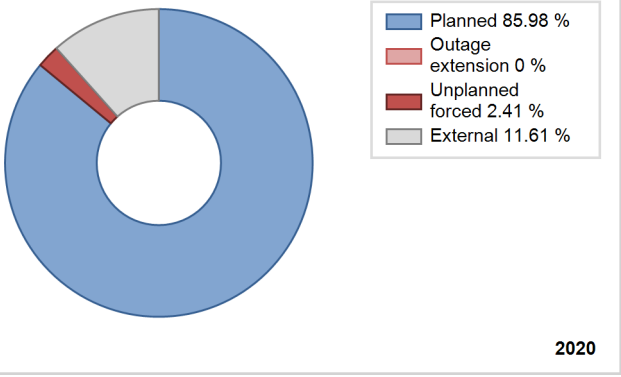
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	2896.23	3511	997	72.66	72.66	66.29	72.11	16.08	13.93	13.41	0.00
1989	7147.79	7665	974	83.77	83.79	83.77	87.50	1.38	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

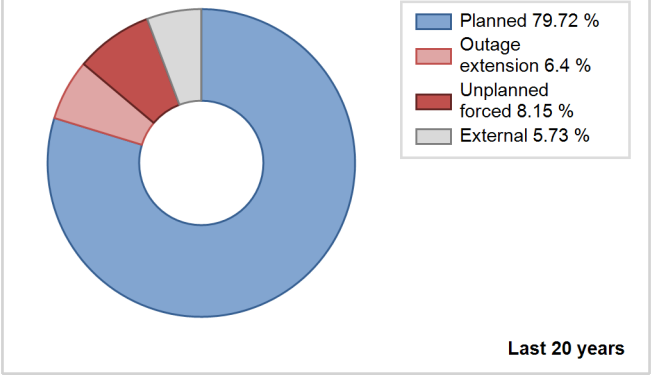
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					118	
C. Inspection, maintenance or repair combined with refuelling	803			790	6	
D. Inspection, maintenance or repair without refuelling				3		
Subtotal	803			793	124	
Total	**803**			**917**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		6
15. Reactor Cooling Systems		30
16. Steam generation systems		9
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		32
32. Feedwater and Main Steam System		14
34. Miscellaneous Systems		3
41. Main Generator Systems		8
42. Electrical Power Supply Systems		8
Total		**119**

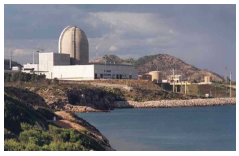
Highlights (2020)

Operation at 100% power, except during periods reported in outages

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2020 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

Reactor type and model	:	PWR / WH 3LP
Thermal power	:	2941 MWth
Gross electrical power	:	1087 MWe
Reference unit power (net)	:	1045 MWe

Key Dates

Construction Date	:	1980-12-29
Grid Date	:	1987-12-12
Commercial Date	:	1988-03-08
Age at end of year	:	33 years

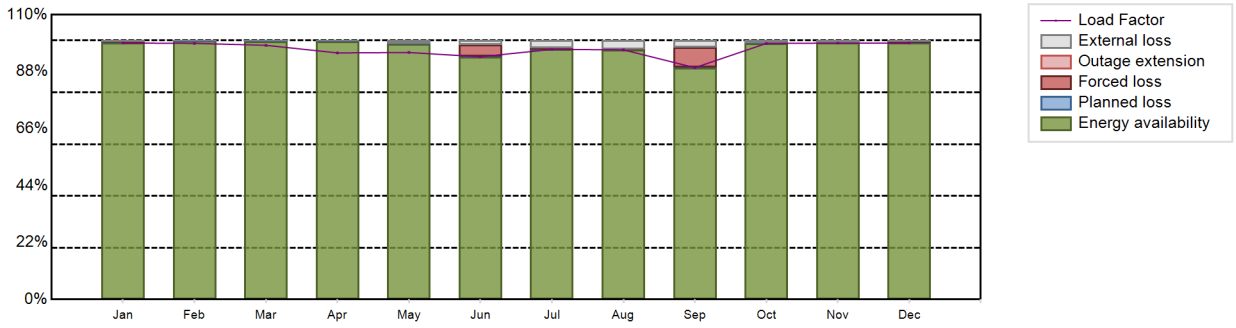
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	328.3
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 (2020)

Net Energy Production	:	8875.72 GW(e).h	Forced Loss Rate (FLR)	:	1.12 %
Energy Availability Factor (EAF)	:	97.53 %	Unplanned Capability Loss Factor (UCL)	:	1.12 %
Unit Capability Factor (UCF)	:	98.73 %	Planned Unavailability Factor (PUF)	:	0.15 %
Load Factor (LF)	:	96.69 %	Externally cause unavailability (XUF)	:	1.21 %
Operating Factor (OF)	:	100 %	Total off-line time	:	0 hours

Annual Summary



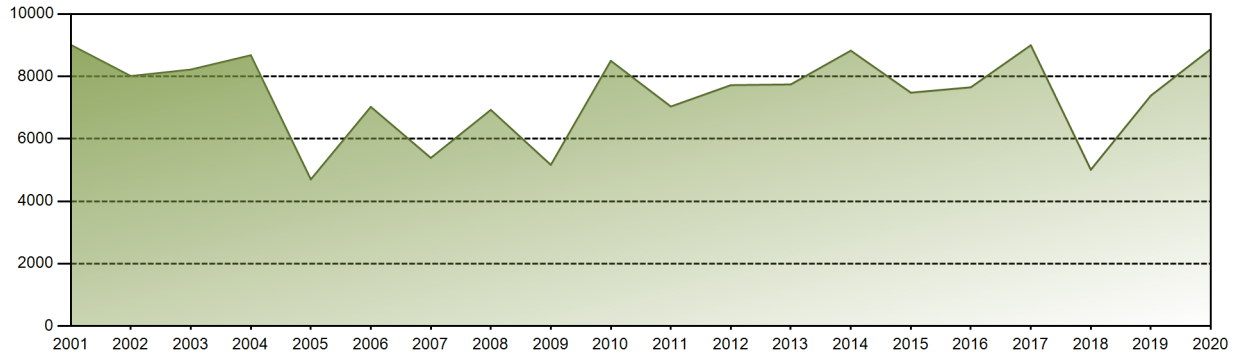
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	770.15	719.54	762.25	716.63	741.77	705.27	751.14	749.81	673.74	770.01	745.20	770.21	8875.72
EAF [%]	99.06	99.75	99.73	99.60	98.71	93.74	96.61	96.44	89.55	98.91	99.04	99.06	97.53
UCF [%]	99.36	99.87	99.86	99.86	99.86	95.34	99.46	99.77	92.29	99.87	99.76	99.33	98.73
LF [%]	99.06	98.93	98.17	95.25	95.41	93.74	96.61	96.44	89.55	98.91	99.04	99.06	96.69
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 [%]	0.45	0.00	0.00	0.00	0.00	4.52	0.39	0.06	7.57	0.00	0.09	0.54	1.12
UCL [%]	0.45	0.00	0.00	0.00	0.00	4.51	0.39	0.06	7.56	0.00	0.09	0.54	1.12
PUF [%]	0.19	0.13	0.14	0.14	0.14	0.15	0.14	0.17	0.15	0.13	0.16	0.13	0.15
XUF [%]	0.30	0.12	0.12	0.25	1.15	1.61	2.85	3.33	2.74	0.96	0.72	0.26	1.21

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Historical Summary

Lifetime energy generation	:	240003.42 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.05 %
Cumulative Energy Availability Factor (EAF)	:	82.32 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.14 %
Cumulative Unit Capability Factor (UCF)	:	83.28 %	Cumulative Planned Unavailability Factor (PUF)	:	9.57 %
Cumulative Load Factor (LF)	:	82.25 %	Cumulative Externally cause unavailability (XUF)	:	0.97 %
Cumulative Operating Factor (OF)	:	84.55 %			

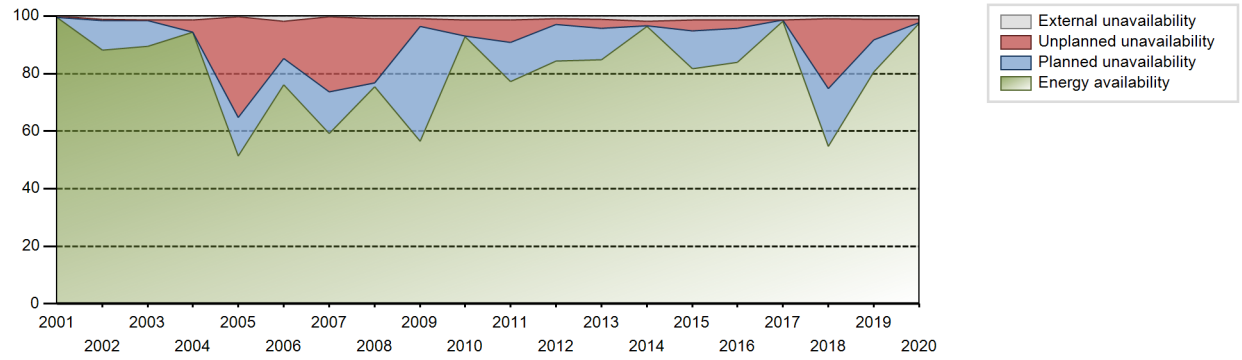
Electricity Production (net) [GWh]



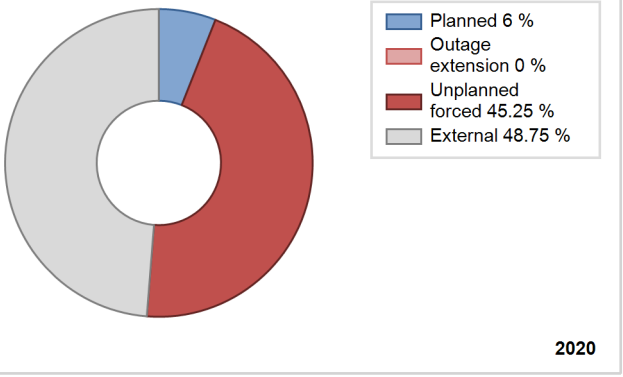
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	5101.90	6262	930	67.36	68.34	67.51	70.53	26.77	24.98	6.68	0.99
1989	5868.79	6357	943	70.58	70.62	71.04	72.57	22.13	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

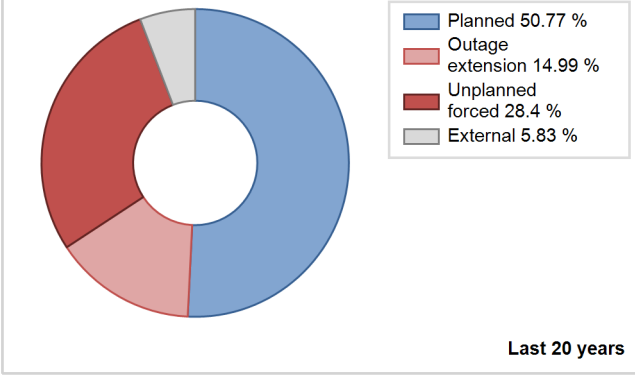
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					445	
C. Inspection, maintenance or repair combined with refuelling				699	16	
D. Inspection, maintenance or repair without refuelling				47		
E. Testing of plant systems or components				3	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling					55	
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					11	
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
Subtotal				749	528	14
Total		**0**			**1291**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1988 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		18
12. Reactor I&C Systems		57
13. Reactor Auxiliary Systems		96
15. Reactor Cooling Systems		99
16. Steam generation systems		1
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		15
32. Feedwater and Main Steam System		64
33. Circulating Water System		7
34. Miscellaneous Systems		4
41. Main Generator Systems		57
42. Electrical Power Supply Systems		89
Total		**508**

Highlights (2020)

In 2020, Vandellos II NPP produced 9234.81 gross GWh, slightly lower than expected gross 9374 GWh. These were the main events affecting the operation:
- On January 20th, load reduction due unavailability of sea water cleaning grids. Power reduced to 70%.
- On February 29th, load reduction to 70% due to load dispatching (grid operator)
- On April, two load reductions to 70% due to load dispatching (grid operator)
- On May, load reduction to 70% due to load dispatching (grid operator).
- On June, load reduction to 81% in order to investigate and repair a water leak on main condenser.
- On July, load reduction to 95% to further investigate water leak on condenser.
- On September 1st, load reduction to 8% and main turbine shutdown due to corrective maintenance on stator cooling water system.
- On November and December corrective maintenance on AF-P01B condensate drainage pump.

Due to these incidents, the load factor was 96.71%. The net production was 8865.41 GWh, versus expected 8997.44 GWh, resulting in a measured/expected ratio of 98.53%.

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2020 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	:	2927 MWth
Gross electrical power	:	1027 MWe
Reference unit power (net)	:	990 MWe

Key Dates

Construction Date	:	1973-06-01
Grid Date	:	1980-06-06
Commercial Date	:	1980-12-10
Age at end of year	:	40 years

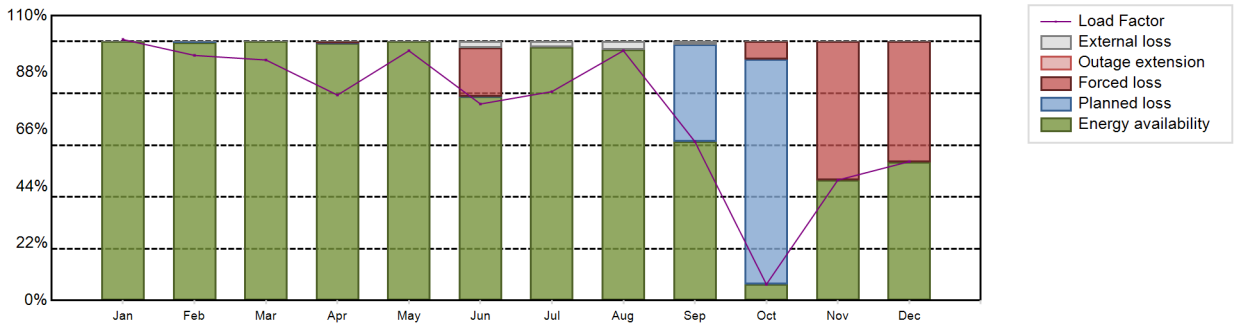
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7
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]	:	0.55
Average fuel enrichment [% of U235]	:	3.60	**Secondary systems**		
Refuelling frequency [month]	:	12	Number of turbine-generators per unit/reactor	:	2
Part of the core refuelled [%]	:	17	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	48000	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	4.51	HP cylinder inlet steam pressure [MPa]	:	6.51
Active core height/length [m]	:	3.68	Output voltage [kV]	:	21.5
Number of fissile fuel assemblies/bundles	:	676	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	1.8	Number of main condensate pumps	:	4
Number of control rod assemblies	:	161	Number of FW pumps for full power operation	:	2
Number of external reactor coolant loops	:	NA	Number of on-site safety related diesel generators	:	4
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	6410.36 GW(e).h	Forced Loss Rate (FLR)	:	11.72 %
Energy Availability Factor (EAF)	:	78.29 %	Unplanned Capability Loss Factor (UCL)	:	10.49 %
Unit Capability Factor (UCF)	:	79.04 %	Planned Unavailability Factor (PUF)	:	10.46 %
Load Factor (LF)	:	73.71 %	Externally cause unavailability (XUF)	:	0.76 %
Operating Factor (OF)	:	87.11 %	Total off-line time	:	1132 hours

Annual Summary



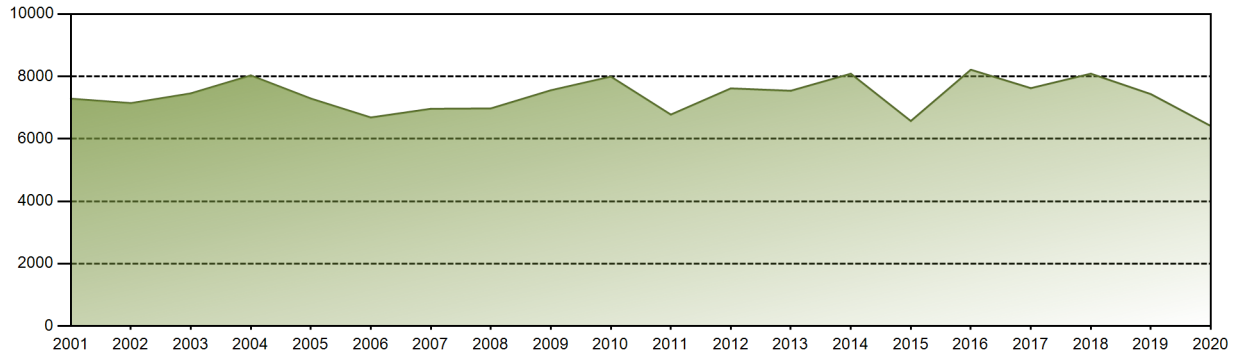
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	742.42	652.25	683.30	565.58	710.49	541.03	594.27	710.69	437.46	46.00	331.67	395.19	6410.35
EAF [%]	100.00	99.73	100.00	99.38	100.00	78.66	97.79	96.83	61.51	6.25	46.53	53.42	78.29
UCF [%]	100.00	99.73	100.00	99.38	100.00	81.10	100.00	100.00	62.73	6.25	46.53	53.42	79.04
LF [%]	100.80	94.66	92.89	79.35	96.46	75.90	80.68	96.49	61.37	6.24	46.53	53.65	73.71
OF [%]	100.00	100.00	100.00	100.00	100.00	83.47	100.00	100.00	65.14	13.42	93.47	90.59	87.11
FLR [%]	0.00	0.00	0.00	0.59	0.00	18.83	0.00	0.00	0.00	52.05	53.47	46.58	11.72
UCL [%]	0.00	0.00	0.00	0.59	0.00	18.81	0.00	0.00	0.00	6.78	53.47	46.58	10.49
PUF [%]	0.00	0.27	0.00	0.03	0.00	0.08	0.00	0.00	37.27	86.97	0.00	0.00	10.46
XUF [%]	0.00	0.00	0.00	0.00	0.00	2.44	2.21	3.17	1.21	0.00	0.00	0.00	0.76

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Historical Summary

Lifetime energy generation	:	280245.92 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.81 %
Cumulative Energy Availability Factor (EAF)	:	84.38 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.63 %
Cumulative Unit Capability Factor (UCF)	:	86.43 %	Cumulative Planned Unavailability Factor (PUF)	:	9.94 %
Cumulative Load Factor (LF)	:	82.66 %	Cumulative Externally cause unavailability (XUF)	:	2.05 %
Cumulative Operating Factor (OF)	:	89.76 %			

Electricity Production (net) [GWh]

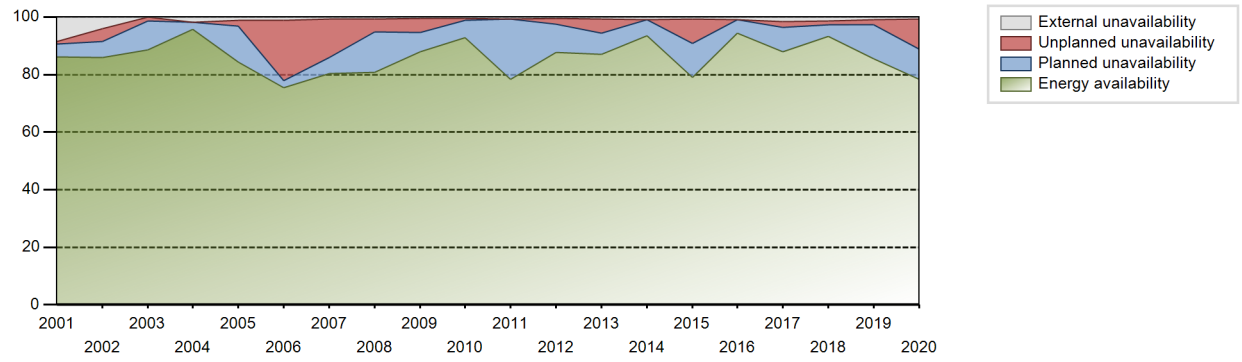


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	2200.90	5016	928	100.00	100.00	100.00	100.00	0.00	0.00	0.00	0.00
1981	6063.70	7305	900	76.91	76.91	76.91	83.39	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

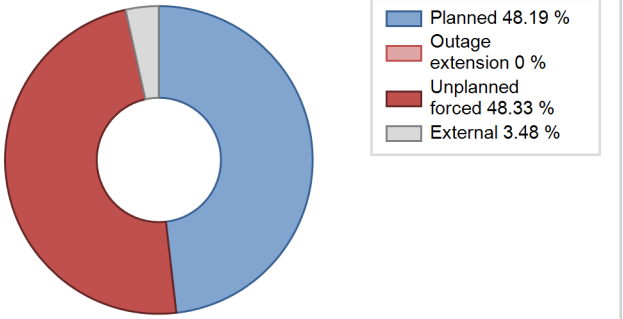
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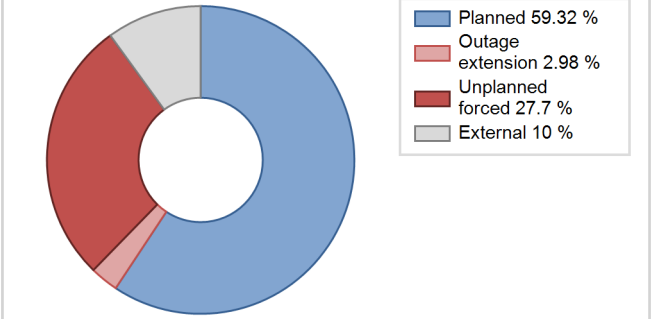
2017	7623.46	7994	984	87.85	89.45	88.44	91.26	1.34	2.03	8.52	1.60
2018	8087.58	8448	986	93.30	94.76	93.70	96.44	1.36	1.30	3.94	1.46
2019	7432.93	7699	990	85.54	86.35	85.87	87.89	2.06	1.81	11.83	0.81
2020	6410.35	7652	990	78.29	79.04	73.71	87.11	11.72	10.49	10.46	0.76

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		235			147	
B. Refuelling without maintenance				9		
C. Inspection, maintenance or repair combined with refuelling	894			670		
D. Inspection, maintenance or repair without refuelling				2		
E. Testing of plant systems or components				3		
F. Major backfitting, refurbishment or upgrading activities with refuelling				25		
H. Nuclear regulatory requirements					7	
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		2			28	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					5	
Subtotal	894	237		709	187	12
Total	**1131**			**908**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	68	48
12. Reactor I&C Systems	120	14
13. Reactor Auxiliary Systems		18
14. Safety Systems		28
15. Reactor Cooling Systems		10
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		9
32. Feedwater and Main Steam System		2
34. Miscellaneous Systems		1
41. Main Generator Systems		4
42. Electrical Power Supply Systems	47	44
Total	**235**	**180**

Highlights (2020)

Commissioning of a new diverse system for independent core cooling.

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2020 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	:	1157 MWe
Reference unit power (net)	:	1118 MWe

Key Dates

Construction Date	:	1975-01-01
Grid Date	:	1981-01-26
Commercial Date	:	1981-07-07
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]	:	3.60
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	20
Average discharge burnup [MWd/t]	:	4800
Active core diameter [m]	:	4.51
Active core height/length [m]	:	3.75
Number of fissile fuel assemblies/bundles	:	676
Fuel linear heat generation rate [kW/m]	:	2.1
Number of control rod assemblies	:	161
Number of external reactor coolant loops	:	NA
Coolant type	:	H2O

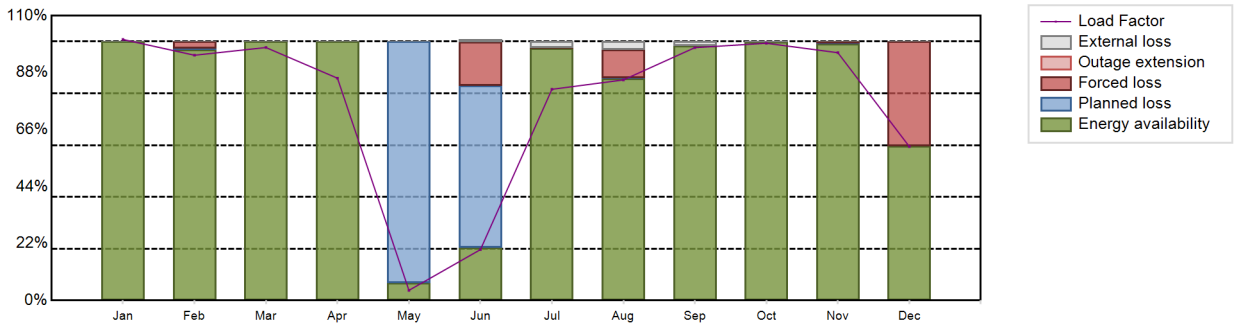
Operating coolant pressure [MPa]	:	7
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.55
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
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	:	none

Annual Production Results (2020)

Net Energy Production	:	7535.29 GW(e).h
Energy Availability Factor (EAF)	:	80.28 %
Unit Capability Factor (UCF)	:	80.9 %
Load Factor (LF)	:	76.73 %
Operating Factor (OF)	:	83.74 %

Forced Loss Rate (FLR)	:	6.91 %
Unplanned Capability Loss Factor (UCL)	:	6 %
Planned Unavailability Factor (PUF)	:	13.1 %
Externally cause unavailability (XUF)	:	0.69 %
Total off-line time	:	1428 hours

Annual Summary



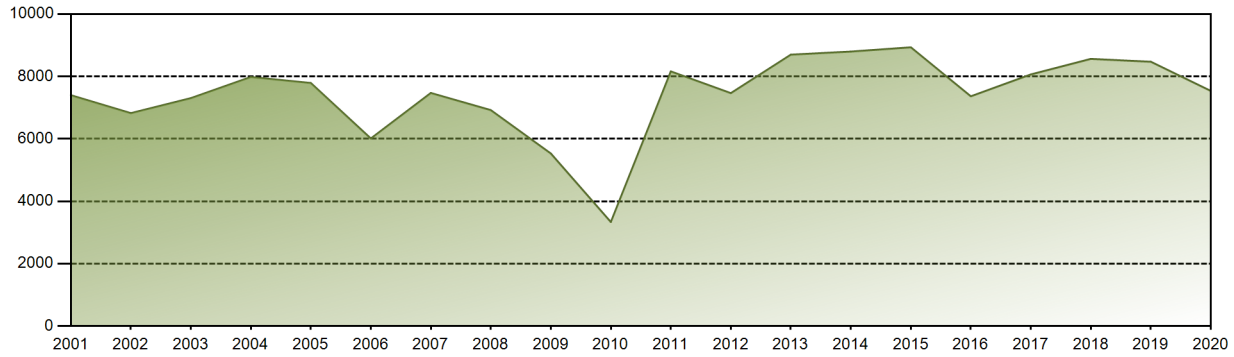
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	838.56	737.15	811.64	691.15	32.77	158.26	678.53	708.67	786.20	827.53	770.42	494.40	7535.29
EAF [%]	100.00	96.95	100.00	100.00	6.77	20.44	97.43	85.83	98.35	99.97	99.02	59.56	80.28
UCF [%]	100.00	96.95	100.00	100.00	6.77	20.54	99.82	89.07	100.00	100.00	99.02	59.56	80.90
LF [%]	100.81	94.73	97.71	85.86	3.94	19.66	81.57	85.20	97.67	99.35	95.71	59.44	76.73
OF [%]	100.00	100.00	100.00	100.00	7.66	37.50	100.00	94.22	100.00	100.00	100.00	66.67	83.74
FLR [%]	0.00	2.67	0.00	0.00	0.00	45.23	0.18	10.78	0.00	0.00	0.61	40.44	6.91
UCL [%]	0.00	2.66	0.00	0.00	0.00	16.96	0.18	10.76	0.00	0.00	0.61	40.44	6.00
PUF [%]	0.00	0.39	0.00	0.00	93.23	62.50	0.00	0.17	0.00	0.00	0.37	0.00	13.10
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.88	2.39	3.24	1.65	0.03	0.00	0.00	0.69

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Historical Summary

Lifetime energy generation	:	276782.26 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.56 %
Cumulative Energy Availability Factor (EAF)	:	82.62 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.07 %
Cumulative Unit Capability Factor (UCF)	:	84.51 %	Cumulative Planned Unavailability Factor (PUF)	:	9.42 %
Cumulative Load Factor (LF)	:	80.67 %	Cumulative Externally cause unavailability (XUF)	:	1.9 %
Cumulative Operating Factor (OF)	:	89.14 %			

Electricity Production (net) [GWh]

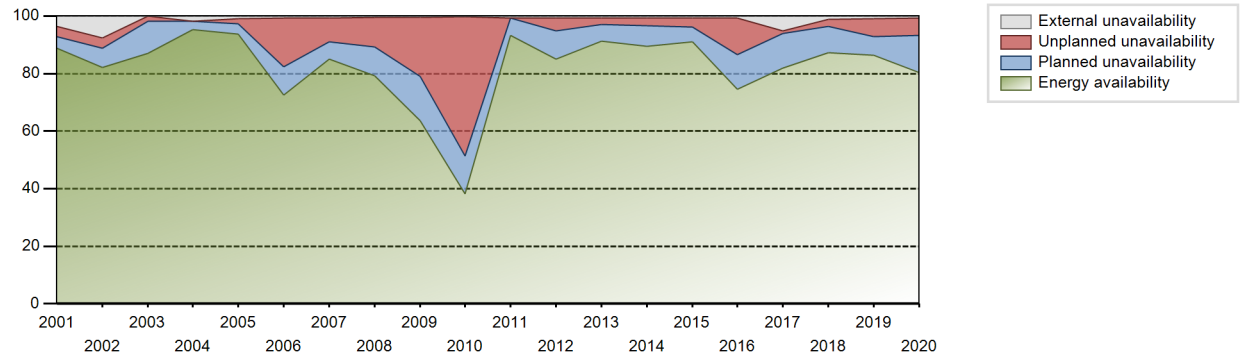


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	2870.70	3977	900	72.23	72.23	72.23	90.06	22.48	20.94	6.83	0.00
1982	5316.40	6076	900	67.40	67.40	67.43	69.36	24.62	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

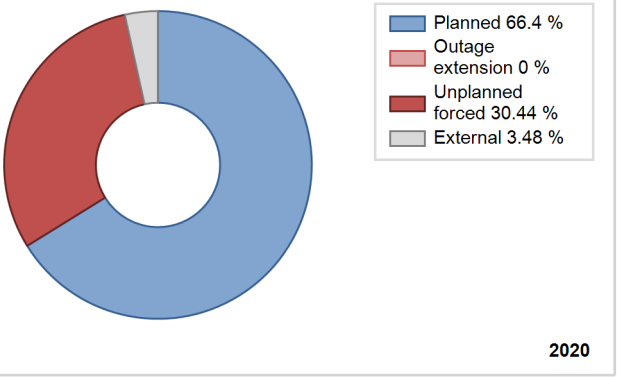
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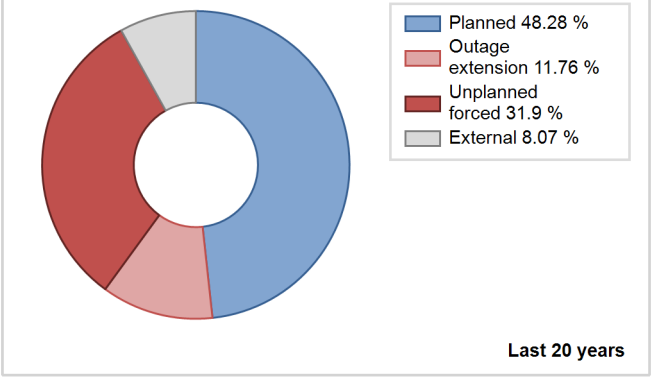
2018	8562.30	7890	1116	87.17	88.38	87.48	90.07	2.05	2.36	9.26	1.21
2019	8470.86	8183	1118	86.33	87.28	86.49	93.41	5.94	6.11	6.61	0.95
2020	7535.29	7356	1118	80.28	80.90	76.73	83.74	6.91	6.00	13.10	0.69

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		43			217	
B. Refuelling without maintenance				5		
C. Inspection, maintenance or repair combined with refuelling	1137			591	9	
D. Inspection, maintenance or repair without refuelling				50		
F. Major backfitting, refurbishment or upgrading activities with refuelling				35		
H. Nuclear regulatory requirements					20	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						13
L. Human factor related					17	
P. Fire					3	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)		248		3	7	
Subtotal	1137	291		684	273	13
Total	**1428**			**970**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	248	84
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		7
14. Safety Systems		40
15. Reactor Cooling Systems	43	14
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		54
32. Feedwater and Main Steam System		5
34. Miscellaneous Systems		14
41. Main Generator Systems		0
42. Electrical Power Supply Systems		46
Total	**291**	**268**

Highlights (2020)

Commissioning of a new diverse system for independent core cooling.

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2020 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	:	1195 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	:	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]	:	3.65
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]	:	1.9
Number of control rod assemblies	:	169
Number of external reactor coolant loops	:	NA
Coolant type	:	H2O

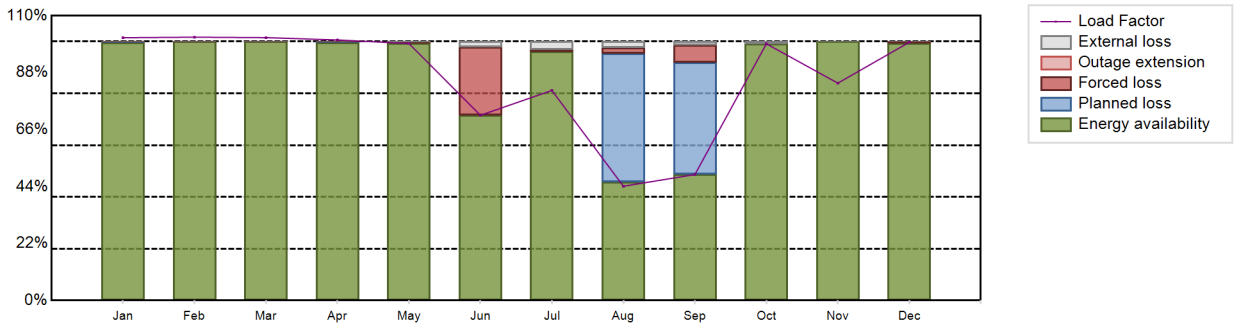
Operating coolant pressure [MPa]	:	7
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.6
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	8864.05 GW(e).h
Energy Availability Factor (EAF)	:	88.29 %
Unit Capability Factor (UCF)	:	89.12 %
Load Factor (LF)	:	86.1 %
Operating Factor (OF)	:	90.13 %

Forced Loss Rate (FLR)	:	3.36 %
Unplanned Capability Loss Factor (UCL)	:	3.1 %
Planned Unavailability Factor (PUF)	:	7.78 %
Externally cause unavailability (XUF)	:	0.83 %
Total off-line time	:	867 hours

Annual Summary



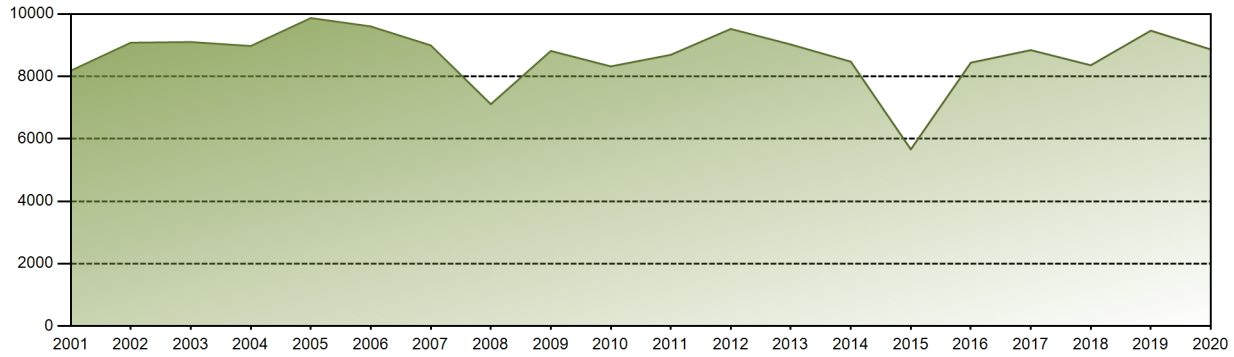
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	885.01	829.68	884.15	849.12	865.51	603.72	707.42	384.88	410.49	865.65	708.49	869.93	8864.05
EAF [%]	99.70	100.00	100.00	99.68	99.31	71.54	96.13	45.66	48.65	99.16	100.00	99.37	88.29
UCF [%]	99.70	100.00	100.00	99.68	99.49	73.61	99.27	48.10	49.93	100.00	100.00	99.37	89.12
LF [%]	101.50	101.71	101.53	100.63	99.26	71.54	81.13	44.14	48.65	99.14	83.96	99.77	86.10
OF [%]	100.00	100.00	100.00	100.00	100.00	78.89	100.00	48.39	54.03	100.00	100.00	100.00	90.13
FLR [%]	0.13	0.00	0.00	0.15	0.51	26.39	0.73	4.28	12.18	0.00	0.00	0.63	3.36
UCL [%]	0.13	0.00	0.00	0.15	0.51	26.39	0.73	2.15	6.92	0.00	0.00	0.63	3.10
PUF [%]	0.17	0.00	0.00	0.18	0.00	0.00	0.00	49.75	43.15	0.00	0.00	0.00	7.78
XUF [%]	0.00	0.00	0.00	0.00	0.18	2.06	3.14	2.44	1.28	0.84	0.00	0.00	0.83

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Historical Summary

Lifetime energy generation	:	302384.14 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.42 %
Cumulative Energy Availability Factor (EAF)	:	85.35 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.44 %
Cumulative Unit Capability Factor (UCF)	:	87.47 %	Cumulative Planned Unavailability Factor (PUF)	:	9.09 %
Cumulative Load Factor (LF)	:	84.11 %	Cumulative Externally cause unavailability (XUF)	:	2.12 %
Cumulative Operating Factor (OF)	:	89.31 %			

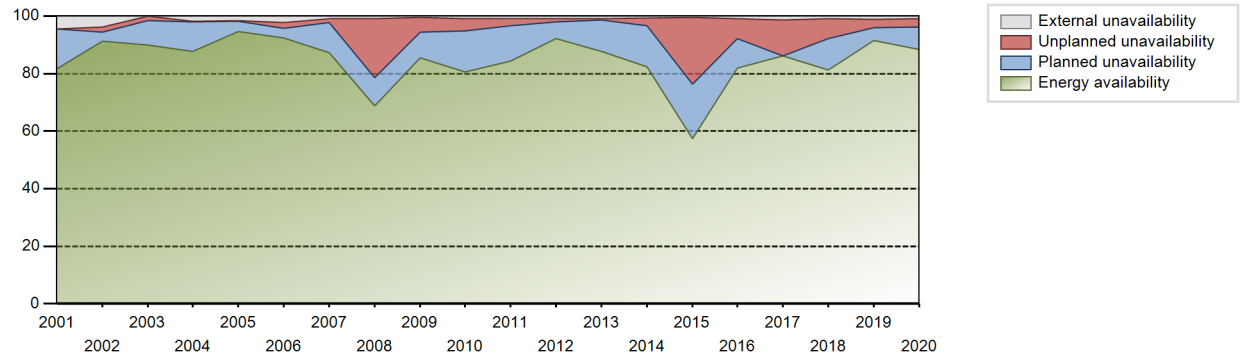
Electricity Production (net) [GWh]



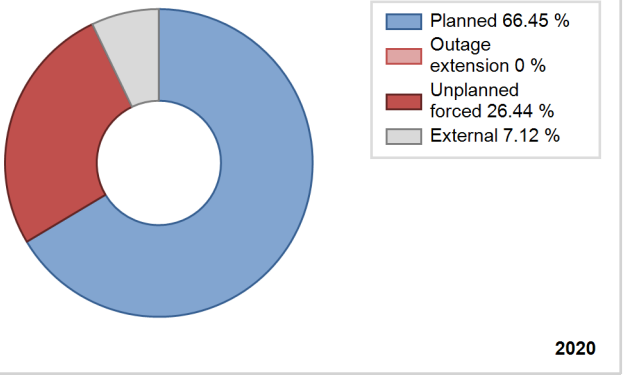
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	4155.51	4803	1068	95.52	95.52	86.55	96.82	4.15	4.14	0.35	0.00
1986	8069.60	7983	1060	88.36	88.36	86.90	91.13	3.39	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

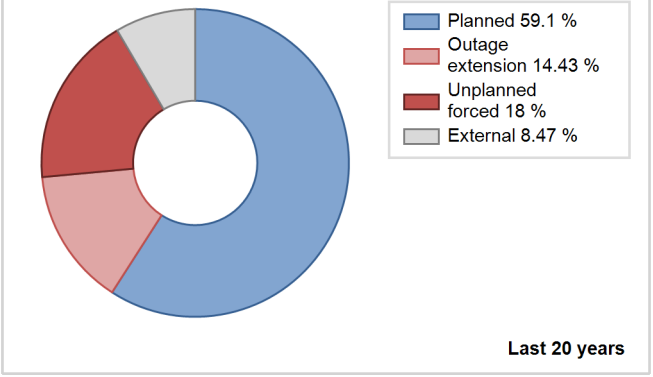
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		179			217	
C. Inspection, maintenance or repair combined with refuelling	672			674		
D. Inspection, maintenance or repair without refuelling				2		
E. Testing of plant systems or components				3	2	
F. Major backfitting, refurbishment or upgrading activities with refuelling				8		
H. Nuclear regulatory requirements					8	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						5
L. Human factor related					19	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					2	
Z. Other		16			0	1
Subtotal	672	195		687	248	6
Total		**867**			**941**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	168	56
12. Reactor I&C Systems		64
13. Reactor Auxiliary Systems		3
15. Reactor Cooling Systems		10
17. Safety I&C Systems (excluding reactor I&C)		5
31. Turbine and auxiliaries	27	21
32. Feedwater and Main Steam System		2
41. Main Generator Systems		57
42. Electrical Power Supply Systems		26
Total	**195**	**244**

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Highlights (2020)

Commissioning of a new diverse system for independent core cooling.

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2020 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	:	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
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

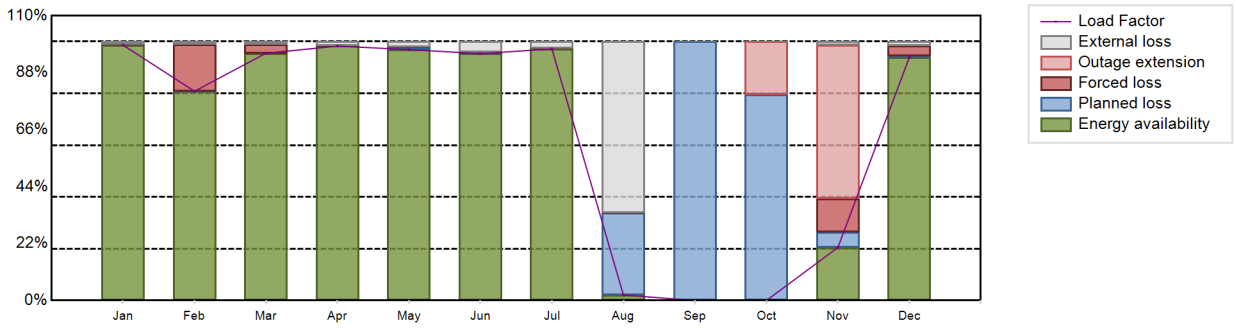
Operating coolant pressure [MPa]	:	7
Reactor outlet temperature [°C]	:	288
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	6
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	3
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7988.94 GW(e).h
Energy Availability Factor (EAF)	:	64.97 %
Unit Capability Factor (UCF)	:	71.99 %
Load Factor (LF)	:	64.97 %
Operating Factor (OF)	:	69.24 %

Forced Loss Rate (FLR)	:	4.23 %
Unplanned Capability Loss Factor (UCL)	:	9.78 %
Planned Unavailability Factor (PUF)	:	18.23 %
Externally cause unavailability (XUF)	:	7.02 %
Total off-line time	:	2702 hours

Annual Summary



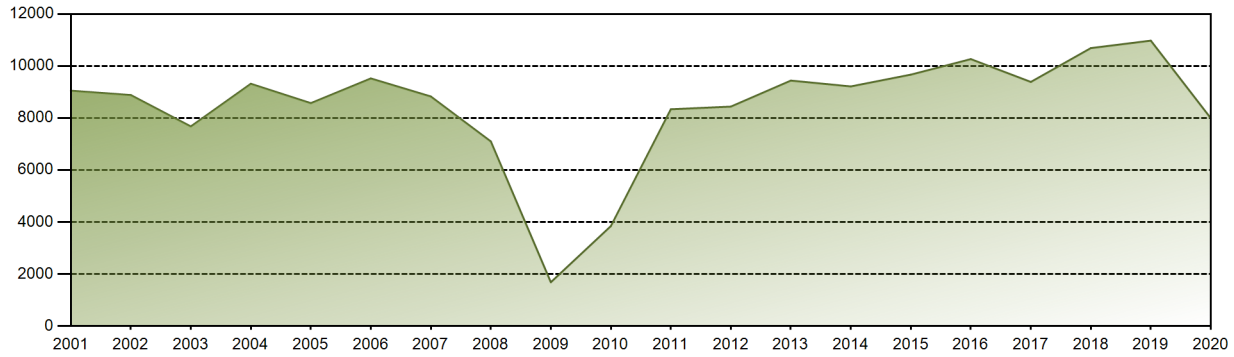
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	1027.69	787.57	993.47	990.41	1009.40	961.24	1011.90	22.27	0.00	0.00	206.46	978.53	7988.94
EAF [%]	98.66	80.83	95.51	98.25	96.91	95.36	97.15	2.14	0.00	0.00	20.48	93.94	64.97
UCF [%]	99.82	82.06	96.72	99.82	99.00	99.44	99.87	68.26	0.00	0.00	21.82	95.57	71.99
LF [%]	98.66	80.83	95.51	98.25	96.91	95.36	97.15	2.14	0.00	0.00	20.48	93.94	64.97
OF [%]	100.00	90.66	100.00	100.00	100.00	100.00	100.00	2.96	0.00	0.00	37.36	100.00	69.24
FLR [%]	0.18	17.94	3.28	0.18	0.02	0.50	0.13	0.00	0.00	0.00	37.19	4.03	4.23
UCL [%]	0.18	17.94	3.28	0.18	0.02	0.50	0.13	0.00	0.00	20.56	72.16	4.02	9.78
PUF [%]	0.00	0.00	0.00	0.00	0.98	0.07	0.00	31.74	100.00	79.44	6.02	0.42	18.23
XUF [%]	1.15	1.23	1.21	1.57	2.09	4.08	2.72	66.12	0.00	0.00	1.34	1.62	7.02

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Historical Summary

Lifetime energy generation	:	295036.97 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.01 %
Cumulative Energy Availability Factor (EAF)	:	80.78 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.83 %
Cumulative Unit Capability Factor (UCF)	:	81.99 %	Cumulative Planned Unavailability Factor (PUF)	:	9.18 %
Cumulative Load Factor (LF)	:	77.94 %	Cumulative Externally cause unavailability (XUF)	:	1.21 %
Cumulative Operating Factor (OF)	:	84.83 %			

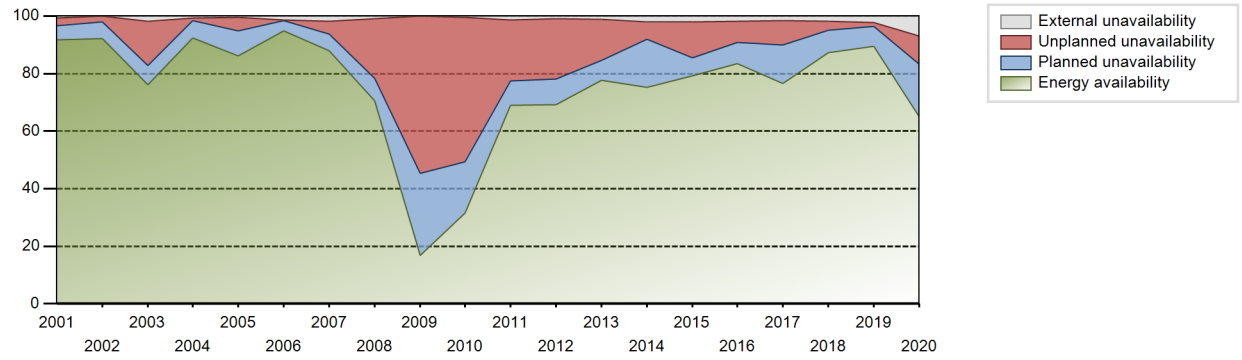
Electricity Production (net) [GWh]



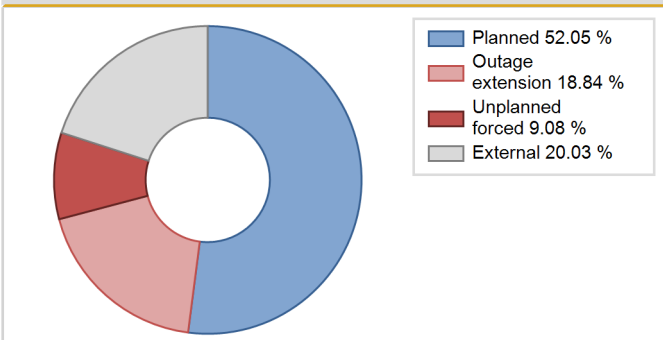
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	3848.48	4706	1055	92.98	92.98	79.25	93.38	7.02	7.02	0.00	0.00
1986	8386.93	8111	1060	91.91	91.91	90.39	92.59	2.32	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

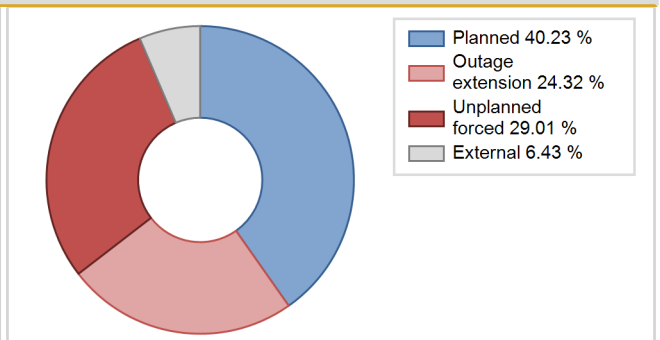
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		669			485	
C. Inspection, maintenance or repair combined with refuelling	1543			646	18	
D. Inspection, maintenance or repair without refuelling				24	0	
E. Testing of plant systems or components				1		
F. Major backfitting, refurbishment or upgrading activities with refuelling				62		
H. Nuclear regulatory requirements					34	
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.)					16	
Z. Other			490		16	14
Subtotal	1543	669	490	733	588	14
Total	**2702**			**1335**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		121
12. Reactor I&C Systems		10
13. Reactor Auxiliary Systems		8
14. Safety Systems		23
15. Reactor Cooling Systems		23
31. Turbine and auxiliaries	604	243
32. Feedwater and Main Steam System	65	76
33. Circulating Water System		2
34. Miscellaneous Systems		2
35. All other I&C Systems		0
41. Main Generator Systems		12
42. Electrical Power Supply Systems		8
Total	**669**	**528**

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2020 Operating Experience

SE-4 RINGHALS-1 SWEDEN



Status at end of year	:	**Permanent Shutdown**
Operator	:	RAB (Ringhals AB)
Owner	:	RAB (Ringhals AB)
Reactor Supplier	:	ABB ATOM (ABB ATOM (formerly ASEA-ATOM))
Turbine Supplier	:	GEC (GENERAL ELECTRIC COMPANY (UK))

Reactor Unit Details

Reactor type and model	:	BWR / AA-I
Thermal power	:	2540 MWth
Gross electrical power	:	910 MWe
Reference unit power (net)	:	881 MWe

Key Dates

Construction Date	:	1969-02-01
Grid Date	:	1974-10-14
Commercial Date	:	1976-01-01
Age at end of year	:	46 years

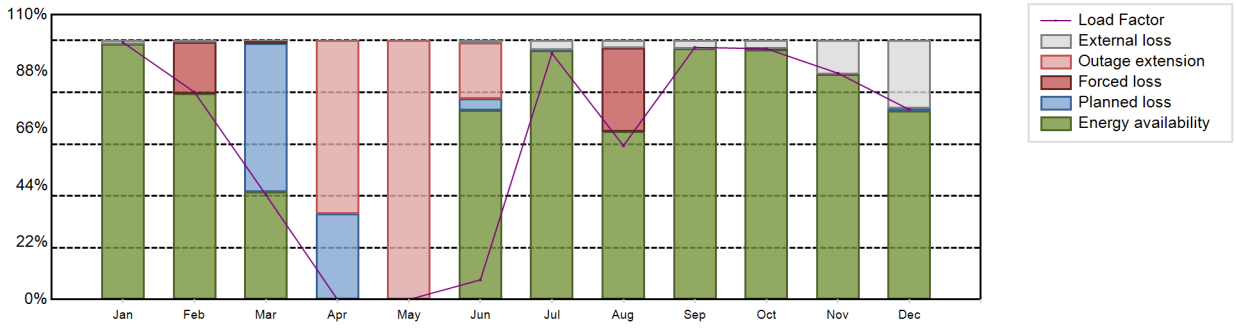
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7
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]	:	5
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	12	Number of turbine-generators per unit/reactor	:	2
Part of the core refuelled [%]	:	15	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	41000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	4.39	HP cylinder inlet steam pressure [MPa]	:	6.66
Active core height/length [m]	:	3.68	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	648	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	28	Number of main condensate pumps	:	-
Number of control rod assemblies	:	157	Number of FW pumps for full power operation	:	-
Number of external reactor coolant loops	:	6	Number of on-site safety related diesel generators	:	-
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	4755.22 GW(e).h	Forced Loss Rate (FLR)	:	5.75 %
Energy Availability Factor (EAF)	:	67.17 %	Unplanned Capability Loss Factor (UCL)	:	20.11 %
Unit Capability Factor (UCF)	:	71.77 %	Planned Unavailability Factor (PUF)	:	8.12 %
Load Factor (LF)	:	61.45 %	Externally cause unavailability (XUF)	:	4.6 %
Operating Factor (OF)	:	68.09 %	Total off-line time	:	2803 hours

Annual Summary



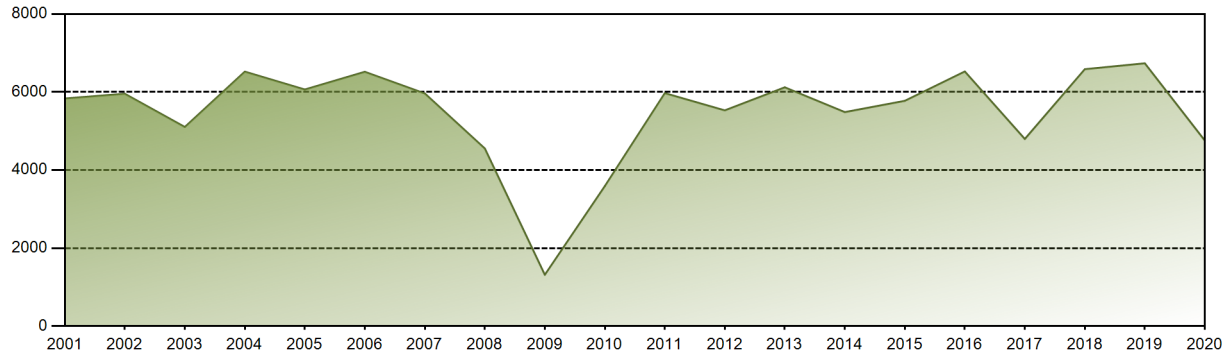
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	650.88	491.03	264.86	0.00	0.00	48.21	623.14	389.36	617.59	634.98	554.44	480.73	4755.22
EAF [%]	98.73	79.51	41.56	0.09	0.00	72.95	96.06	64.86	96.79	96.30	86.85	72.77	67.17
UCF [%]	100.00	80.23	41.79	0.09	0.00	73.75	99.58	67.76	100.00	99.37	99.94	98.85	71.77
LF [%]	99.30	80.08	40.41	0.00	0.00	7.60	95.07	59.40	97.36	96.88	87.41	73.34	61.45
OF [%]	100.00	83.33	45.56	0.00	0.00	12.64	100.00	74.60	100.00	100.00	100.00	100.00	68.09
FLR [%]	0.00	19.77	2.00	0.00	0.00	0.00	0.00	32.24	0.00	0.08	0.06	0.00	5.75
UCL [%]	0.00	19.77	0.85	66.81	100.00	21.79	0.00	32.24	0.00	0.08	0.06	0.00	20.11
PUF [%]	0.00	0.00	57.35	33.10	0.00	4.46	0.42	0.00	0.00	0.55	0.00	1.15	8.12
XUF [%]	1.27	0.72	0.23	0.00	0.00	0.80	3.52	2.90	3.21	3.07	13.09	26.08	4.60

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Historical Summary

Lifetime energy generation	:	221148.22 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	11.66 %
Cumulative Energy Availability Factor (EAF)	:	70 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.78 %
Cumulative Unit Capability Factor (UCF)	:	71.2 %	Cumulative Planned Unavailability Factor (PUF)	:	15.01 %
Cumulative Load Factor (LF)	:	68.49 %	Cumulative Externally cause unavailability (XUF)	:	1.2 %
Cumulative Operating Factor (OF)	:	76.27 %			

Electricity Production (net) [GWh]

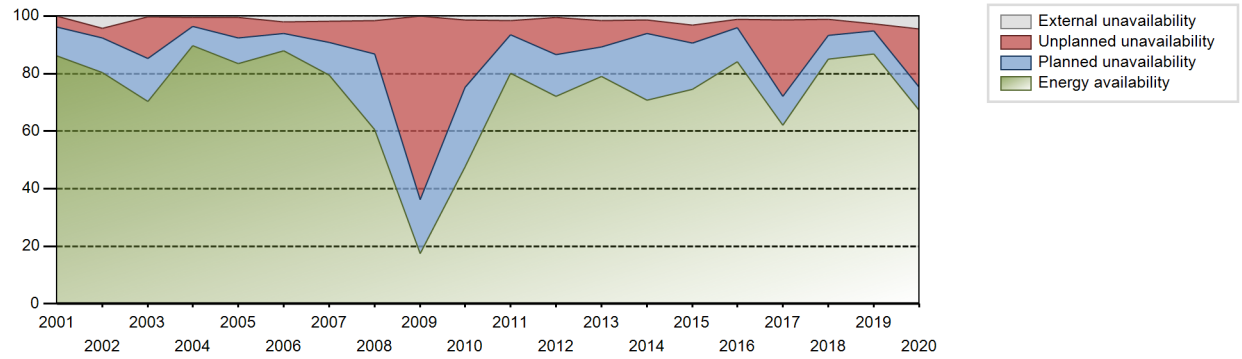


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	2164.60	4269	760	32.41	32.41	32.42	48.60	56.63	42.33	25.26	0.00
1977	3531.20	6095	760	53.04	53.04	53.04	69.58	28.55	21.20	25.77	0.00
1978	4153.10	6099	750	63.22	63.22	63.21	69.62	19.84	15.65	21.14	0.00
1979	3868.20	6070	750	58.85	58.85	58.88	69.29	24.84	19.45	21.70	0.00
1980	4433.80	6362	750	68.15	68.76	67.30	72.43	16.57	13.66	17.58	0.61
1981	4059.40	6285	750	61.79	61.79	61.79	71.75	10.01	6.87	31.34	0.00
1982	4687.50	7162	750	74.95	74.95	71.35	81.76	10.25	8.56	16.50	0.00
1983	3265.00	5372	750	49.67	49.67	49.70	61.32	16.77	10.00	40.33	0.00
1984	4917.65	7382	750	79.73	79.79	74.65	84.04	10.31	9.17	11.03	0.07
1985	5168.85	7832	750	86.00	86.00	78.67	89.41	6.11	5.60	8.40	0.00
1986	4470.50	7203	750	69.88	69.88	68.04	82.23	14.02	11.40	18.73	0.00
1987	4872.69	7878	750	77.68	77.68	74.17	89.93	7.79	6.56	15.76	0.00
1988	4694.74	7338	750	74.75	75.09	71.26	83.54	7.09	5.73	19.18	0.35
1989	4855.30	7963	755	81.81	81.81	73.43	90.90	4.63	3.98	14.21	0.00
1990	4525.62	7918	795	71.44	71.60	64.98	90.39	16.35	14.00	14.39	0.16
1991	5638.95	8034	795	82.54	82.60	80.97	91.71	8.36	7.53	9.86	0.07
1992	3383.79	4938	795	51.15	51.15	48.46	56.22	41.66	36.52	12.33	0.00
1993	3996.35	6575	795	68.51	68.51	57.38	75.06	25.97	24.04	7.45	0.00
1994	5389.23	7189	795	76.35	78.05	77.38	82.07	7.45	6.28	15.67	1.69
1995	5666.97	7697	826	78.19	78.28	78.32	87.87	10.74	9.41	12.30	0.10
1996	6490.90	8008	832	90.08	90.34	88.73	91.17	2.05	1.89	7.77	0.26
1997	2236.34	3022	830	30.54	32.90	30.75	34.49	18.81	42.37	24.73	2.36
1998	5601.63	7605	830	80.66	84.77	77.04	86.82	8.52	7.90	7.33	4.11
1999	4930.37	6500	825	68.41	73.27	68.22	74.20	19.25	17.46	9.26	4.87
2000	3239.66	4659	825	50.84	57.21	44.70	53.04	38.00	35.07	7.72	6.37
2001	5835.00	7814	825	86.09	86.09	80.74	89.20	4.29	3.86	10.05	0.00
2002	5956.16	7667	830	80.42	84.72	81.92	87.52	3.81	3.36	11.92	4.30
2003	5104.28	6269	830	70.22	70.42	70.20	71.56	17.16	14.59	14.99	0.20
2004	6523.07	7974	830	89.72	90.11	89.47	90.78	1.25	3.18	6.71	0.38
2005	6064.85	7452	830	83.53	83.92	83.41	85.07	3.28	7.12	8.95	0.40
2006	6518.82	7982	843	87.86	89.94	88.27	91.12	1.70	4.01	6.05	2.08
2007	5963.38	7275	843	79.42	81.15	80.75	83.05	5.90	7.36	11.50	1.72
2008	4552.73	5480	856	60.56	62.08	60.55	62.39	6.09	11.68	26.23	1.52
2009	1314.31	1639	856	17.41	17.41	17.53	18.71	7.24	63.69	18.90	0.00
2010	3587.63	4518	855	47.49	48.80	47.90	51.58	0.98	23.50	27.70	1.31
2011	5971.23	7377	854	80.03	81.67	79.82	84.21	2.71	4.87	13.45	1.65
2012	5529.58	7322	865	72.09	72.51	72.78	83.36	15.10	12.89	14.60	0.42

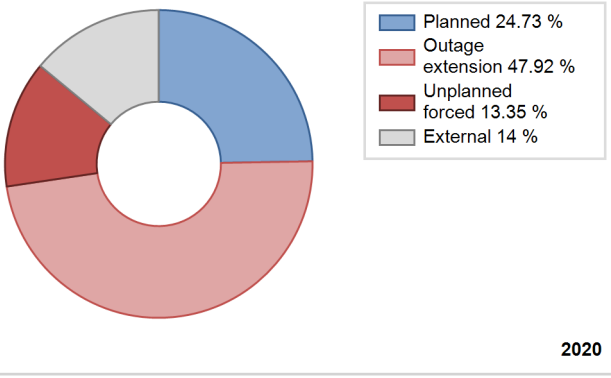
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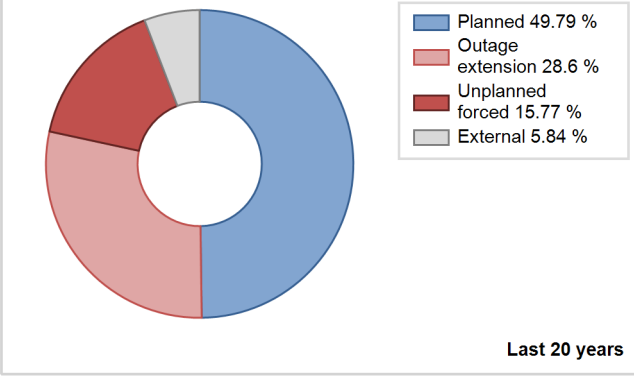
2013	6120.55	7842	878	79.00	80.58	79.58	89.52	10.10	9.11	10.31	1.59
2014	5485.09	6449	878	70.72	72.10	71.32	73.62	2.39	4.76	23.14	1.38
2015	5774.14	7248	881	74.46	77.66	74.82	82.74	7.30	6.11	16.23	3.19
2016	6526.79	7802	883	84.07	85.25	84.32	88.82	3.22	2.86	11.89	1.18
2017	4796.19	5603	883	62.02	63.32	62.01	63.96	0.00	26.60	10.08	1.30
2018	6585.78	7753	881	84.95	86.21	85.33	88.50	5.86	5.41	8.38	1.26
2019	6736.43	7968	881	86.88	89.56	87.29	90.96	1.93	2.53	7.91	2.68
2020	4755.22	5981	881	67.17	71.77	61.45	68.09	5.75	20.11	8.12	4.60

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1976 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		1685			859	1
C.	Inspection, maintenance or repair combined with refuelling	644			1101	30	
D.	Inspection, maintenance or repair without refuelling				24		
E.	Testing of plant systems or components		15			5	
H.	Nuclear regulatory requirements					11	
J.	Grid limitation, failure or grid unavailability						3
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			472			10
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
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					9	
Z.	Other					24	8
Subtotal		644	1700	472	1125	943	23
Total		**2816**			**2091**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1976 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		277
12. Reactor I&C Systems	1382	101
13. Reactor Auxiliary Systems		23
14. Safety Systems	116	241
15. Reactor Cooling Systems	15	95
17. Safety I&C Systems (excluding reactor I&C)	187	4
21. Fuel Handling and Storage Facilities		0
31. Turbine and auxiliaries		42
32. Feedwater and Main Steam System		45
34. Miscellaneous Systems		33
35. All other I&C Systems		4
41. Main Generator Systems		0
42. Electrical Power Supply Systems	472	20
Total	**2172**	**885**

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2020 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

Reactor type and model	:	PWR / WH 3LP
Thermal power	:	3135 MWth
Gross electrical power	:	1117 MWe
Reference unit power (net)	:	1072 MWe

Key Dates

Construction Date	:	1972-09-01
Grid Date	:	1980-09-07
Commercial Date	:	1981-09-09
Age at end of year	:	40 years

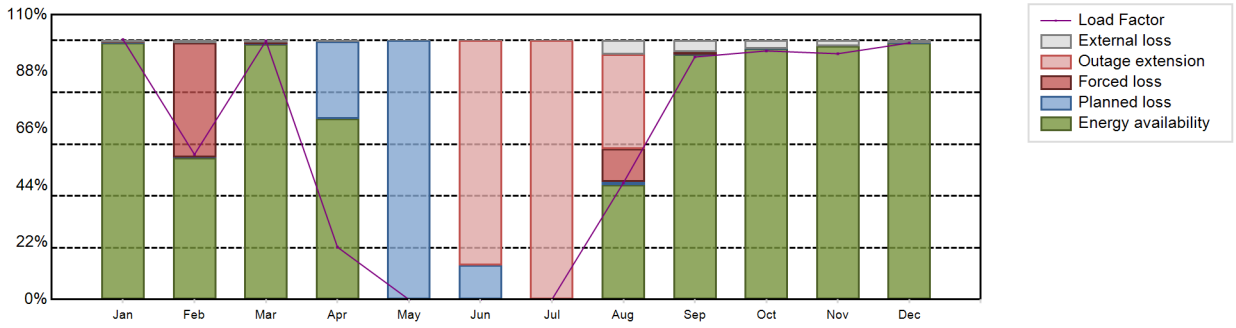
Design Characteristics

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 (2020)

Net Energy Production	:	5522.53 GW(e).h	Forced Loss Rate (FLR)	:	6.8 %
Energy Availability Factor (EAF)	:	63.08 %	Unplanned Capability Loss Factor (UCL)	:	23.32 %
Unit Capability Factor (UCF)	:	64.61 %	Planned Unavailability Factor (PUF)	:	12.07 %
Load Factor (LF)	:	58.97 %	Externally cause unavailability (XUF)	:	1.53 %
Operating Factor (OF)	:	62.07 %	Total off-line time	:	3332 hours

Annual Summary



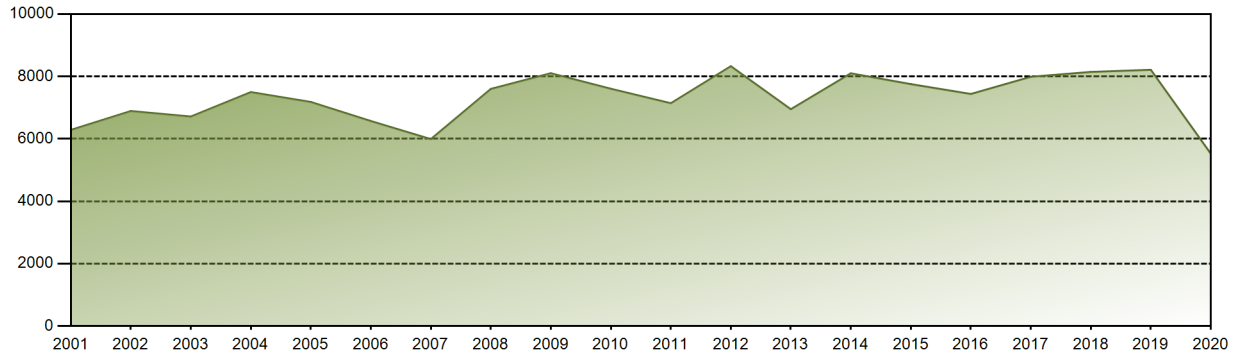
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	793.43	414.16	789.28	154.73	0.00	0.00	0.00	359.34	722.91	765.67	732.70	790.30	5522.53
EAF [%]	99.19	54.81	98.68	69.93	0.00	0.00	0.00	44.23	94.64	96.97	97.99	99.20	63.08
UCF [%]	99.95	55.66	99.34	70.23	0.00	0.00	0.00	49.70	99.03	99.99	100.00	99.99	64.61
LF [%]	100.42	56.03	99.89	20.24	0.00	0.00	0.00	45.05	93.66	96.00	94.93	99.09	58.97
OF [%]	100.00	59.20	100.00	20.69	0.00	0.00	0.00	63.84	100.00	100.00	100.00	100.00	62.07
FLR [%]	0.03	44.34	0.65	0.00	0.00	0.00	0.00	20.29	0.96	0.00	0.00	0.00	6.80
UCL [%]	0.03	44.33	0.65	0.00	0.00	86.81	100.00	48.91	0.96	0.00	0.00	0.00	23.32
PUF [%]	0.02	0.01	0.01	29.77	100.00	13.19	0.00	1.39	0.01	0.01	0.00	0.01	12.07
XUF [%]	0.75	0.85	0.66	0.30	0.00	0.00	0.00	5.47	4.40	3.02	2.01	0.79	1.53

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Historical Summary

Lifetime energy generation	:	258017.53 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.3 %
Cumulative Energy Availability Factor (EAF)	:	78.53 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.53 %
Cumulative Unit Capability Factor (UCF)	:	80.52 %	Cumulative Planned Unavailability Factor (PUF)	:	11.96 %
Cumulative Load Factor (LF)	:	76.86 %	Cumulative Externally cause unavailability (XUF)	:	1.98 %
Cumulative Operating Factor (OF)	:	84.64 %			

Electricity Production (net) [GWh]

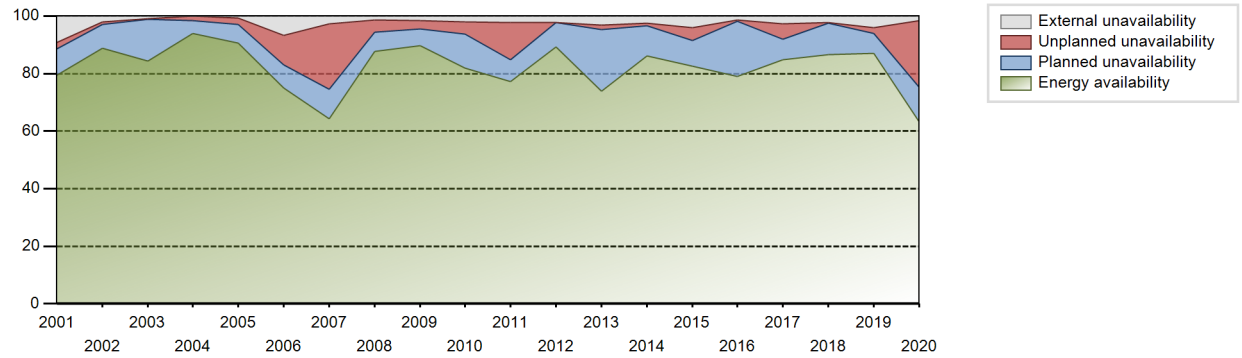


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	2859.20	4560	920	26.75	26.75	26.77	29.51	73.25	73.25	0.00	0.00
1982	1251.60	3680	915	15.62	15.62	15.61	42.01	73.78	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

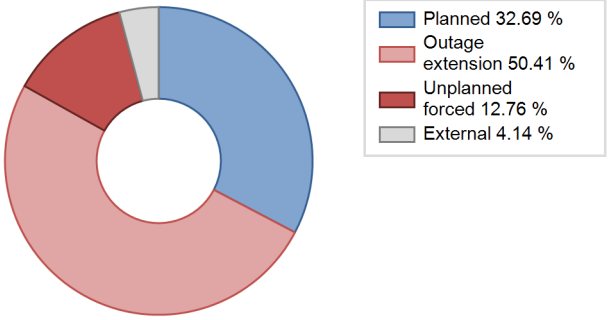
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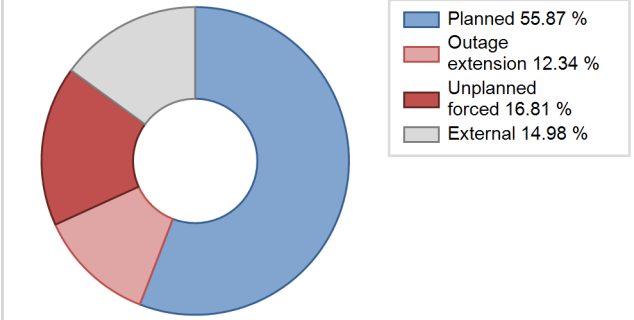
2018	8144.41	7821	1062	86.48	88.80	87.54	89.28	0.09	0.08	11.12	2.32
2019	8212.36	8107	1062	87.05	91.10	88.28	92.55	2.20	2.05	6.85	4.05
2020	5522.53	5452	1072	63.08	64.61	58.97	62.07	6.80	23.32	12.07	1.53

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		1532			334	
C.	Inspection, maintenance or repair combined with refuelling	1050			757	16	
D.	Inspection, maintenance or repair without refuelling				193		
E.	Testing of plant systems or components				5	1	
J.	Grid limitation, failure or grid unavailability						2
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			365			13
L.	Human factor related		384			14	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
Z.	Other					2	
Subtotal		1050	1916	365	955	367	16
Total			**3331**			**1338**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	72	29
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems	280	8
14. Safety Systems	862	47
15. Reactor Cooling Systems		40
16. Steam generation systems		115
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		2
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System	382	27
35. All other I&C Systems		0
41. Main Generator Systems	8	15
42. Electrical Power Supply Systems	365	26
Total	**1969**	**347**

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2020 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

Reactor type and model	:	PWR / WH 3LP
Thermal power	:	3300 MWth
Gross electrical power	:	1171 MWe
Reference unit power (net)	:	1130 MWe

Key Dates

Construction Date	:	1973-11-01
Grid Date	:	1982-06-23
Commercial Date	:	1983-11-21
Age at end of year	:	38 years

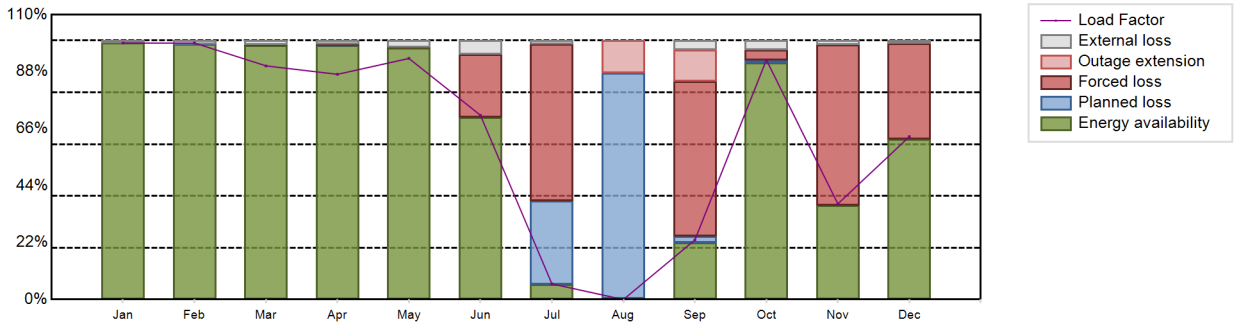
Design Characteristics

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 (2020)

Net Energy Production	:	6285.45 GW(e).h	Forced Loss Rate (FLR)	:	23.55 %
Energy Availability Factor (EAF)	:	64.86 %	Unplanned Capability Loss Factor (UCL)	:	22.69 %
Unit Capability Factor (UCF)	:	66.92 %	Planned Unavailability Factor (PUF)	:	10.39 %
Load Factor (LF)	:	63.32 %	Externally cause unavailability (XUF)	:	2.06 %
Operating Factor (OF)	:	76.72 %	Total off-line time	:	2045 hours

Annual Summary



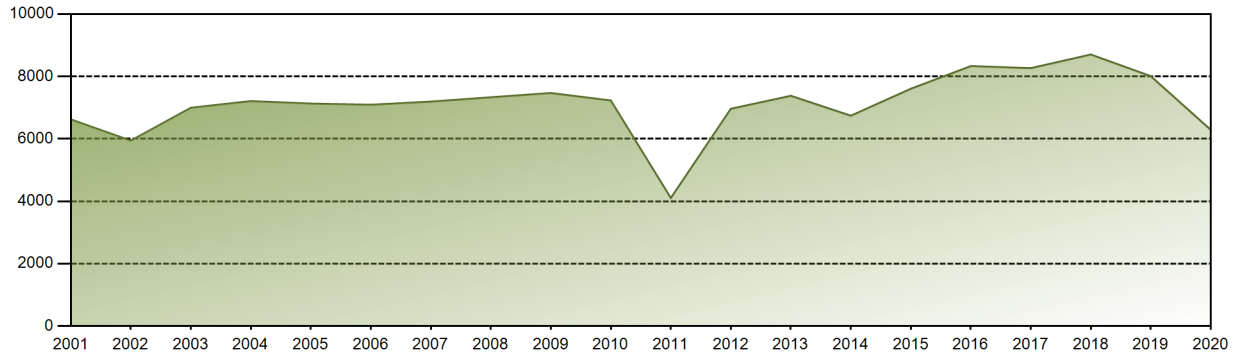
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	832.32	779.10	758.69	707.65	782.76	579.20	50.83	0.00	187.22	777.97	300.68	529.04	6285.45
EAF [%]	99.03	98.56	98.22	98.18	97.19	70.43	5.87	0.28	21.94	91.47	36.30	61.96	64.86
UCF [%]	99.99	99.97	99.94	99.67	99.70	75.86	7.13	0.28	25.52	95.07	37.92	63.16	66.92
LF [%]	99.00	99.06	90.24	86.98	93.11	71.19	6.05	0.00	23.01	92.54	36.96	62.93	63.32
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	13.31	0.00	53.75	100.00	65.00	90.46	76.72
FLR [%]	0.00	0.00	0.06	0.32	0.30	24.14	89.49	0.00	70.02	4.04	62.08	36.84	23.55
UCL [%]	0.00	0.00	0.06	0.32	0.30	24.14	60.73	12.62	71.90	4.00	62.08	36.84	22.69
PUF [%]	0.01	0.03	0.00	0.01	0.00	0.00	32.14	87.10	2.58	0.93	0.00	0.00	10.39
XUF [%]	0.96	1.41	1.72	1.49	2.51	5.43	1.26	0.00	3.59	3.60	1.62	1.20	2.06

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Historical Summary

Lifetime energy generation	:	250041.45 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.78 %
Cumulative Energy Availability Factor (EAF)	:	83.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.27 %
Cumulative Unit Capability Factor (UCF)	:	85.37 %	Cumulative Planned Unavailability Factor (PUF)	:	10.36 %
Cumulative Load Factor (LF)	:	80.2 %	Cumulative Externally cause unavailability (XUF)	:	2.26 %
Cumulative Operating Factor (OF)	:	87.18 %			

Electricity Production (net) [GWh]

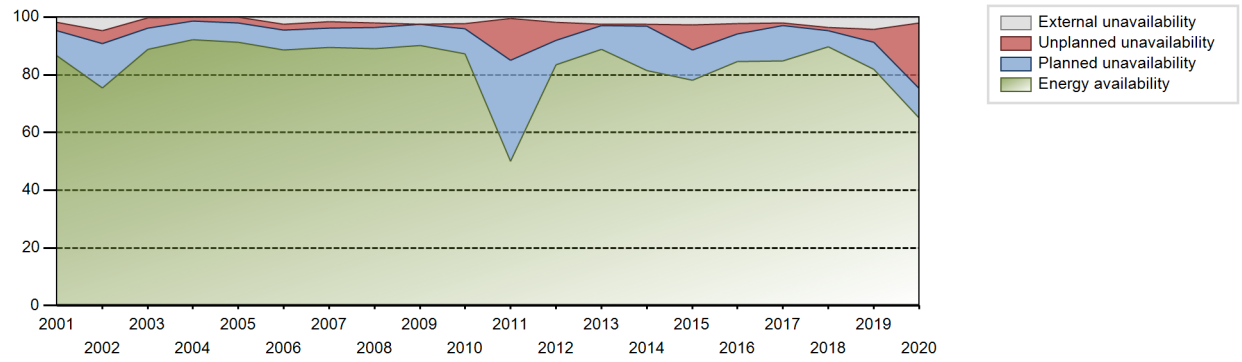


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	2653.10	4122	915	56.37	56.37	56.38	74.60	24.02	17.82	25.81	0.00
1984	5987.71	7517	915	82.17	82.26	74.50	85.58	9.40	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

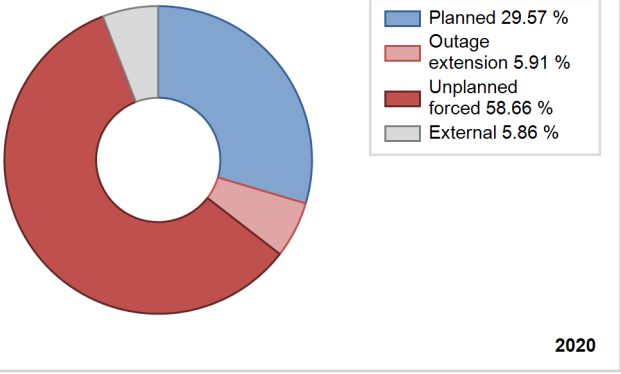
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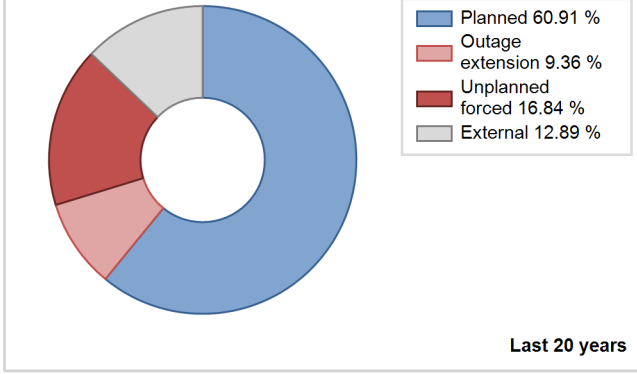
2020	6285.45	6739	1130	64.86	66.92	63.32	76.72	23.55	22.69	10.39	2.06

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1983 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		626			218	1
C. Inspection, maintenance or repair combined with refuelling	884			848	1	
D. Inspection, maintenance or repair without refuelling				162		
E. Testing of plant systems or components		31		30	14	
H. Nuclear regulatory requirements					2	
J. Grid limitation, failure or grid unavailability						0
L. Human factor related		495			18	
Z. Other				1	12	
Subtotal	884	1152		1041	265	1
Total	**2036**			**1307**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1983 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		71
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems	10	15
14. Safety Systems	268	19
15. Reactor Cooling Systems		59
16. Steam generation systems		31
21. Fuel Handling and Storage Facilities	43	1
31. Turbine and auxiliaries	257	9
32. Feedwater and Main Steam System	103	23
41. Main Generator Systems		2
42. Electrical Power Supply Systems		0
Total	**681**	**234**

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2020 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

Reactor type and model	:	PWR / WH 2LP
Thermal power	:	1130 MWth
Gross electrical power	:	380 MWe
Reference unit power (net)	:	365 MWe

Key Dates

Construction Date	:	1965-09-01
Grid Date	:	1969-07-17
Commercial Date	:	1969-12-09
Age at end of year	:	51 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]	:	4.68
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	17
Average discharge burnup [MWd/t]	:	42000
Active core diameter [m]	:	2.45
Active core height/length [m]	:	3.05
Number of fissile fuel assemblies/bundles	:	121
Fuel linear heat generation rate [kW/m]	:	16.7
Number of control rod assemblies	:	17
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

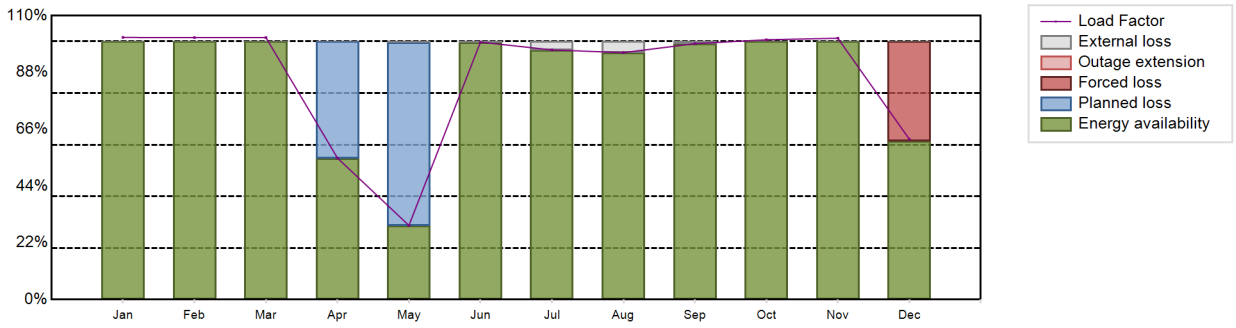
Operating coolant pressure [MPa]	:	15.3
Reactor outlet temperature [°C]	:	313
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.31
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	5.3
Output voltage [kV]	:	15
Primary means of condenser cooling	:	River (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	:	3
Non-electrical applications	:	DH

Annual Production Results (2020)

Net Energy Production	:	2784.66 GW(e).h
Energy Availability Factor (EAF)	:	86.25 %
Unit Capability Factor (UCF)	:	87.02 %
Load Factor (LF)	:	86.85 %
Operating Factor (OF)	:	87.22 %
Equivalent non-electrical energy generated (NEG)	:	41.44 GW(e).h

Forced Loss Rate (FLR)	:	3.61 %
Unplanned Capability Loss Factor (UCL)	:	3.26 %
Planned Unavailability Factor (PUF)	:	9.71 %
Externally cause unavailability (XUF)	:	0.78 %
Total off-line time	:	1123 hours

Annual Summary



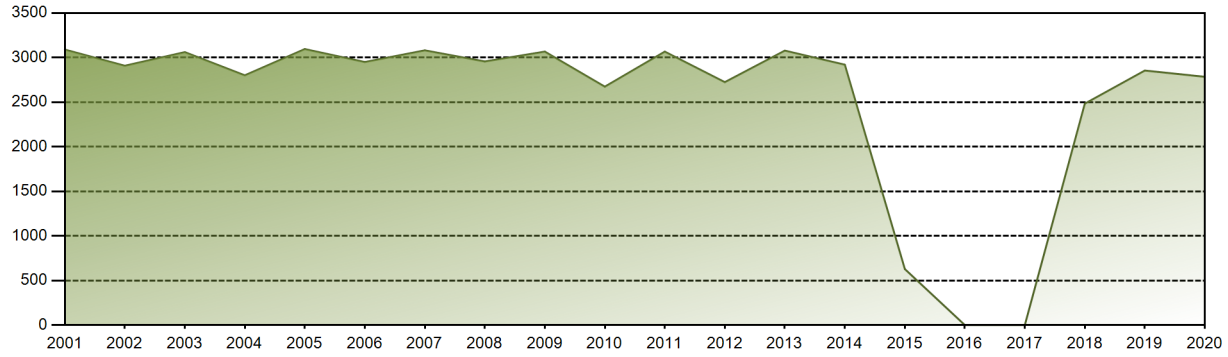
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	275.79	257.81	275.20	144.16	78.04	262.11	262.66	259.84	260.54	273.74	266.08	168.70	2784.66
EAF [%]	100.00	100.00	100.00	54.63	28.74	99.74	96.72	95.68	99.14	100.00	100.00	61.50	86.25
UCF [%]	100.00	100.00	100.00	54.63	29.21	100.00	100.00	100.00	100.00	100.00	100.00	61.50	87.02
LF [%]	101.56	101.48	101.48	54.86	28.74	99.74	96.72	95.68	99.14	100.67	101.25	62.12	86.85
OF [%]	100.00	100.00	100.00	54.86	30.65	100.00	100.00	100.00	100.00	100.00	100.00	62.10	87.22
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.50	3.61
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.50	3.26
PUF [%]	0.00	0.00	0.00	45.37	70.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.71
XUF [%]	0.00	0.00	0.00	0.00	0.47	0.26	3.28	4.32	0.86	0.00	0.00	0.00	0.78

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Historical Summary

Lifetime energy generation	:	127519.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.76 %
Cumulative Energy Availability Factor (EAF)	:	80.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.68 %
Cumulative Unit Capability Factor (UCF)	:	80.59 %	Cumulative Planned Unavailability Factor (PUF)	:	11.73 %
Cumulative Load Factor (LF)	:	79.9 %	Cumulative Externally cause unavailability (XUF)	:	0.25 %
Cumulative Operating Factor (OF)	:	81.85 %			

Electricity Production (net) [GWh]

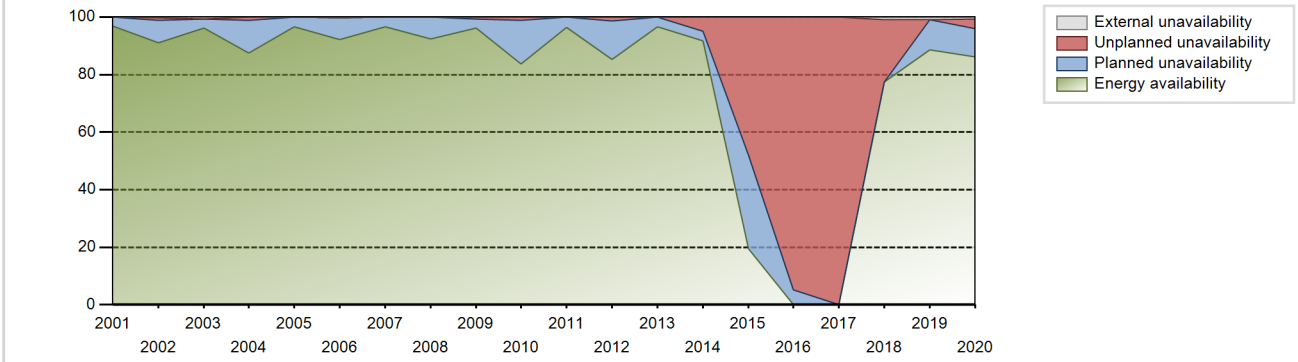


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1969	Data not provided										
1970	1947.00	5917	364	61.05	61.05	61.06	67.55	0.00	0.00	38.95	0.00
1971	1700.50	5123	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

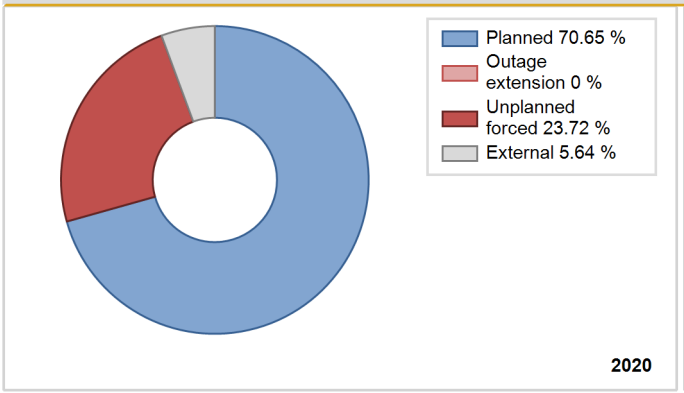
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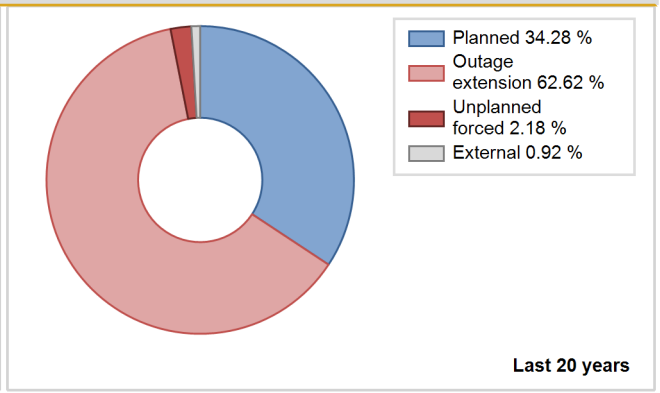
2006	2950.68	8114	365	92.19	92.35	92.28	92.63	0.01	0.01	7.65	0.15
2007	3081.34	8486	365	96.67	96.70	96.37	96.87	0.00	0.00	3.30	0.03
2008	2956.58	8143	365	92.45	92.45	92.22	92.70	0.11	0.10	7.44	0.00
2009	3067.33	8460	365	96.27	96.30	95.93	96.58	0.57	0.68	3.02	0.03
2010	2673.99	7347	365	83.66	83.66	83.63	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1969 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		282			197	
B.	Refuelling without maintenance				40		
C.	Inspection, maintenance or repair combined with refuelling	841			798		
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				66		
H.	Nuclear regulatory requirements					463	
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		841	282		917	660	2
Total		**1123**			**1579**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1969 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		480
12. Reactor I&C Systems		71
13. Reactor Auxiliary Systems		10
14. Safety Systems		3
15. Reactor Cooling Systems		9
16. Steam generation systems		70
21. Fuel Handling and Storage Facilities		0
31. Turbine and auxiliaries		2
32. Feedwater and Main Steam System		10
35. All other I&C Systems		0
42. Electrical Power Supply Systems	282	6
Total	**282**	**661**

Highlights (2020)

Full load operation
Exept shutdown for Emergency NS Diesel repair

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2020 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

Reactor type and model	:	PWR / WH 2LP
Thermal power	:	1130 MWth
Gross electrical power	:	380 MWe
Reference unit power (net)	:	365 MWe

Key Dates

Construction Date	:	1968-01-01
Grid Date	:	1971-10-23
Commercial Date	:	1972-03-04
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]	:	4.68
Refuelling frequency [month]	:	12
Part of the core refuelled [%]	:	17
Average discharge burnup [MWd/t]	:	42000
Active core diameter [m]	:	2.45
Active core height/length [m]	:	3.05
Number of fissile fuel assemblies/bundles	:	121
Fuel linear heat generation rate [kW/m]	:	16.7
Number of control rod assemblies	:	25
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

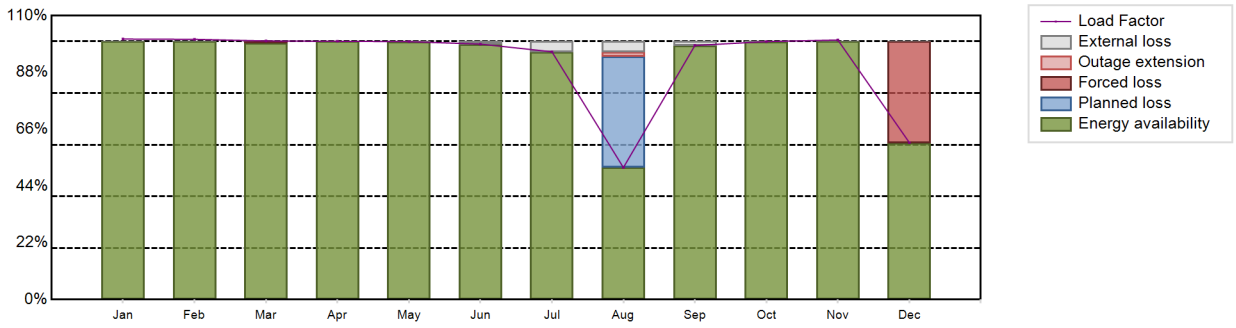
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	313
Number of SG	:	2
Containment type	:	Double
Containment design pressure [MPa]	:	0.31
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	2
HP cylinder inlet steam pressure [MPa]	:	5.3
Output voltage [kV]	:	-
Primary means of condenser cooling	:	River (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	:	3
Non-electrical applications	:	DH

Annual Production Results (2020)

Net Energy Production	:	2956.04 GW(e).h
Energy Availability Factor (EAF)	:	91.92 %
Unit Capability Factor (UCF)	:	92.83 %
Load Factor (LF)	:	92.2 %
Operating Factor (OF)	:	93.07 %
Equivalent non-electrical energy generated (NEG)	:	3.98 GW(e).h

Forced Loss Rate (FLR)	:	3.52 %
Unplanned Capability Loss Factor (UCL)	:	3.54 %
Planned Unavailability Factor (PUF)	:	3.63 %
Externally cause unavailability (XUF)	:	0.91 %
Total off-line time	:	609 hours

Annual Summary



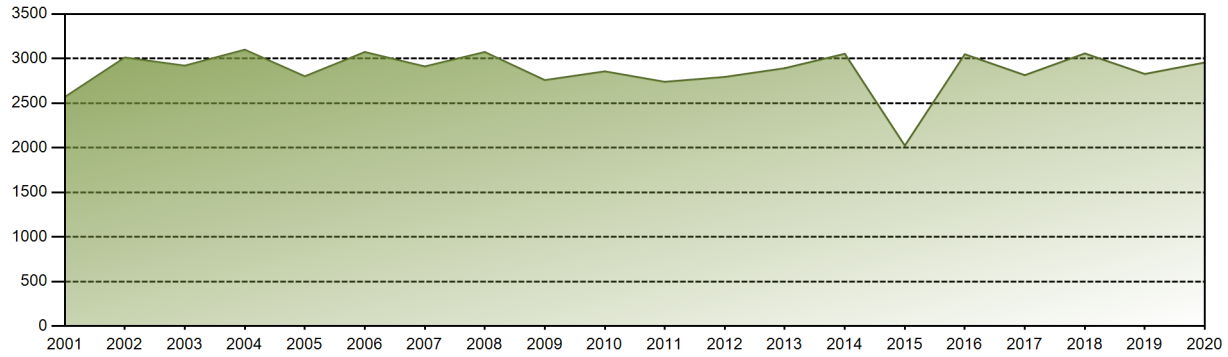
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	274.11	256.17	271.71	262.94	271.37	260.11	260.71	138.95	258.71	271.80	264.30	165.16	2956.04
EAF [%]	100.00	100.00	99.34	100.00	99.93	98.98	96.00	51.17	98.44	99.95	100.00	60.71	91.92
UCF [%]	100.00	100.00	99.34	100.00	100.00	100.00	100.00	55.25	100.00	100.00	100.00	60.71	92.83
LF [%]	100.94	100.84	100.19	100.05	99.93	98.98	96.00	51.17	98.44	99.95	100.57	60.82	92.20
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	56.85	100.00	100.00	100.00	61.29	93.07
FLR [%]	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.29	3.52
UCL [%]	0.00	0.00	0.66	0.00	0.00	0.00	0.00	1.88	0.00	0.00	0.00	39.29	3.54
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.86	0.00	0.00	0.00	0.00	3.63
XUF [%]	0.00	0.00	0.00	0.00	0.07	1.02	4.00	4.09	1.56	0.05	0.00	0.00	0.91

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Historical Summary

Lifetime energy generation	:	134581.04 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.18 %
Cumulative Energy Availability Factor (EAF)	:	87.45 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.2 %
Cumulative Unit Capability Factor (UCF)	:	87.62 %	Cumulative Planned Unavailability Factor (PUF)	:	11.18 %
Cumulative Load Factor (LF)	:	87.69 %	Cumulative Externally cause unavailability (XUF)	:	0.17 %
Cumulative Operating Factor (OF)	:	88.68 %			

Electricity Production (net) [GWh]

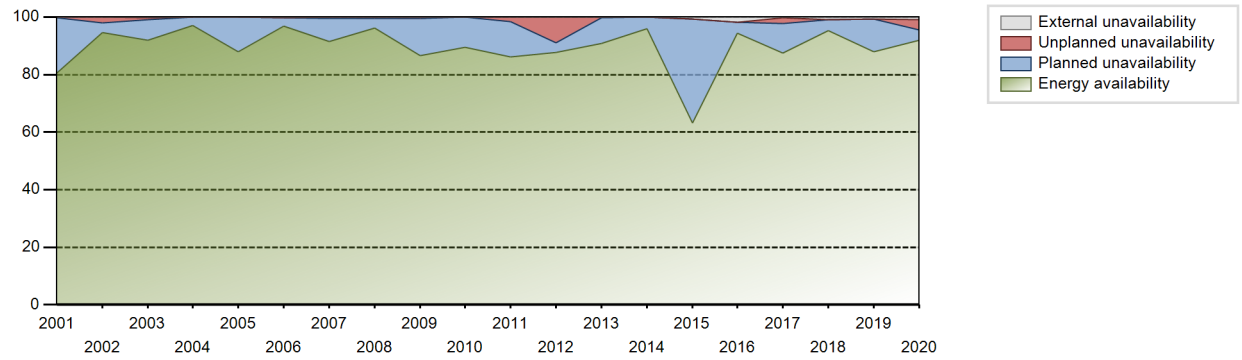


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1972	2618.50	7624	364	83.06	83.06	82.10	84.20	9.60	8.82	8.12	0.00
1973	2220.70	7042	350	78.45	78.45	72.43	80.39	1.91	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

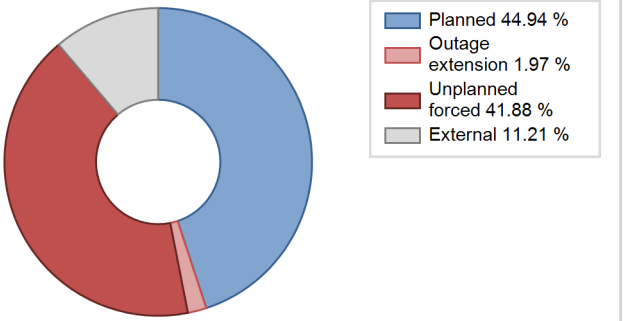
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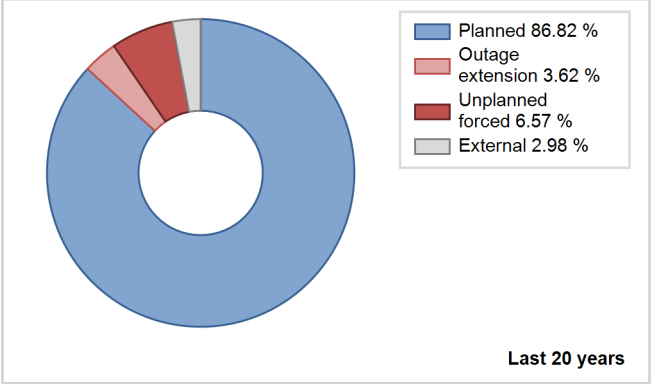
2009	2758.47	7615	365	86.56	86.67	86.27	86.93	0.52	0.45	12.88	0.10
2010	2856.53	7865	365	89.59	89.59	89.34	89.78	0.00	0.00	10.41	0.00
2011	2739.21	7564	365	86.11	86.11	85.67	86.35	0.00	1.68	12.21	0.00
2012	2793.97	7715	365	87.65	87.65	87.14	87.83	6.98	9.01	3.33	0.00
2013	2892.03	7968	365	90.82	90.82	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1972 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		302			95	
B. Refuelling without maintenance	307			55		
C. Inspection, maintenance or repair combined with refuelling				757		
D. Inspection, maintenance or repair without refuelling				29		
F. Major backfitting, refurbishment or upgrading activities with refuelling				64		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L. Human factor related					1	
Subtotal	307	302		905	96	0
Total	**609**			**1001**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1972 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	14	5
12. Reactor I&C Systems		7
13. Reactor Auxiliary Systems		1
14. Safety Systems		1
15. Reactor Cooling Systems		23
16. Steam generation systems		20
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		11
32. Feedwater and Main Steam System		3
33. Circulating Water System		3
34. Miscellaneous Systems		8
35. All other I&C Systems		2
42. Electrical Power Supply Systems	288	10
Total	**302**	**96**

Highlights (2020)

Full load opereation mode
Shut down for repair of emergency diesel

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2020 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	:	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 [%]	:	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

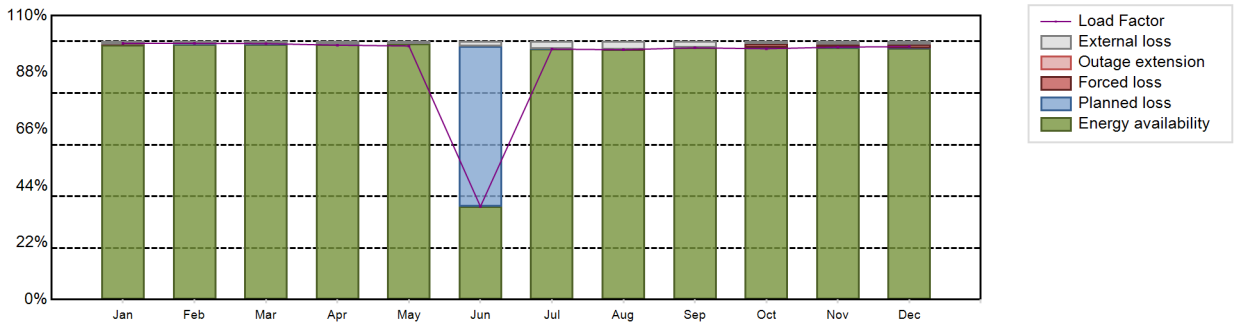
Operating coolant pressure [MPa]	:	15.3
Reactor outlet temperature [°C]	:	324.5
Number of SG	:	3
Containment type	:	Double
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP cylinder 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 (2020)

Net Energy Production	:	8249.56 GW(e).h
Energy Availability Factor (EAF)	:	92.94 %
Unit Capability Factor (UCF)	:	94.52 %
Load Factor (LF)	:	92.99 %
Operating Factor (OF)	:	95.17 %
Equivalent non-electrical energy generated (NEG)	:	24.76 GW(e).h

Forced Loss Rate (FLR)	:	0.4 %
Unplanned Capability Loss Factor (UCL)	:	0.38 %
Planned Unavailability Factor (PUF)	:	5.1 %
Externally cause unavailability (XUF)	:	1.58 %
Total off-line time	:	424 hours

Annual Summary



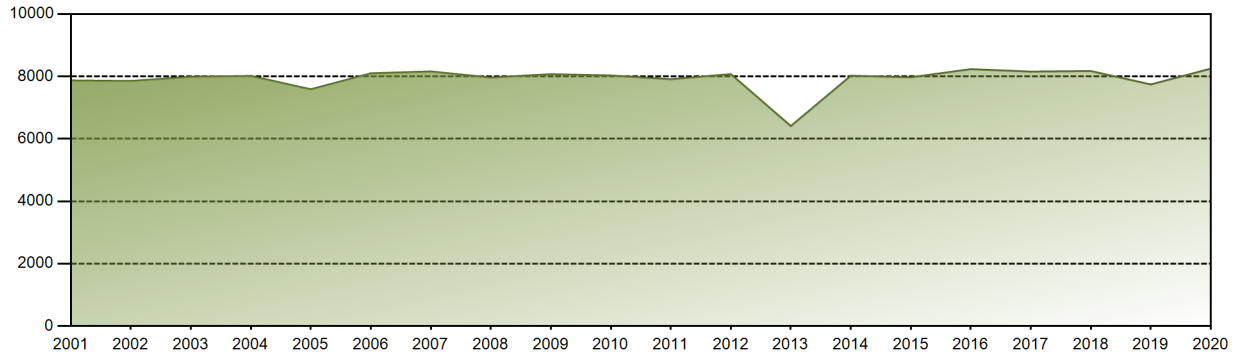
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	745.85	697.69	745.27	716.67	738.18	262.15	729.17	727.37	709.26	730.13	711.30	736.51	8249.56
EAF [%]	98.72	98.85	98.91	98.82	99.04	36.05	97.04	96.80	97.53	97.57	97.66	97.30	92.94
UCF [%]	99.80	99.99	99.98	99.99	100.00	38.03	99.99	99.95	99.98	98.50	98.74	98.34	94.52
LF [%]	99.26	99.25	99.18	98.55	98.24	36.05	97.04	96.80	97.53	97.16	97.81	98.01	92.99
OF [%]	100.00	100.00	99.87	100.00	100.00	42.08	100.00	100.00	100.00	99.46	100.00	99.73	95.17
FLR [%]	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	1.48	1.24	1.64	0.40
UCL [%]	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	1.48	1.24	1.64	0.38
PUF [%]	0.03	0.01	0.02	0.01	0.00	61.97	0.01	0.02	0.02	0.02	0.02	0.02	5.10
XUF [%]	1.08	1.13	1.07	1.17	0.96	1.98	2.95	3.15	2.44	0.93	1.08	1.04	1.58

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Historical Summary

Lifetime energy generation	:	305532.56 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.1 %
Cumulative Energy Availability Factor (EAF)	:	89.01 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1 %
Cumulative Unit Capability Factor (UCF)	:	89.81 %	Cumulative Planned Unavailability Factor (PUF)	:	9.19 %
Cumulative Load Factor (LF)	:	89.37 %	Cumulative Externally cause unavailability (XUF)	:	0.8 %
Cumulative Operating Factor (OF)	:	90.71 %			

Electricity Production (net) [GWh]

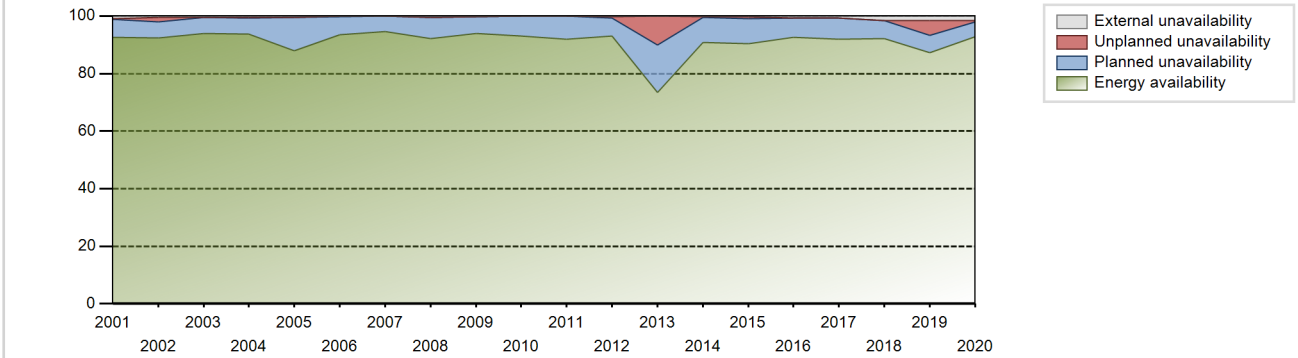


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1979	3398.70	4724	924	93.20	93.20	93.22	97.13	6.80	6.80	0.00	0.00
1980	5935.70	6819	920	73.47	73.47	73.45	77.63	9.11	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

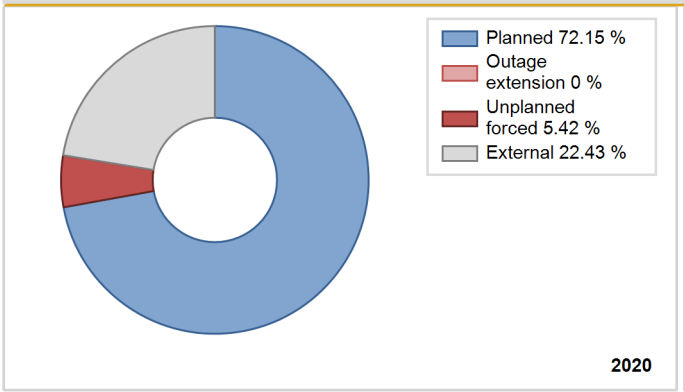
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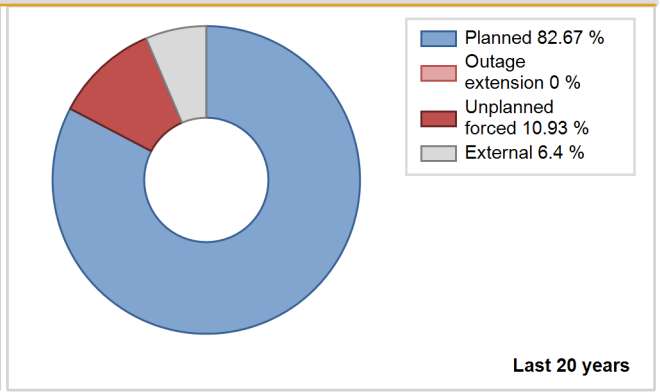
2016	8233.25	8232	1010	92.63	93.32	92.80	93.72	0.07	0.06	6.61	0.69
2017	8154.30	8148	1010	92.01	92.66	92.16	93.01	0.00	0.00	7.33	0.65
2018	8172.01	8244	1010	92.14	93.77	92.36	94.11	0.00	0.00	6.23	1.63
2019	7743.07	7835	1010	87.36	89.00	87.52	89.44	5.34	5.02	5.97	1.64
2020	8249.56	8360	1010	92.94	94.52	92.99	95.17	0.40	0.38	5.10	1.58

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1979 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					58	
C. Inspection, maintenance or repair combined with refuelling	417			756		
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		5			0	
Subtotal	417	5		756	58	0
Total		**422**			**814**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1979 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		0
15. Reactor Cooling Systems	5	0
16. Steam generation systems		1
31. Turbine and auxiliaries		3
32. Feedwater and Main Steam System		17
41. Main Generator Systems		24
42. Electrical Power Supply Systems		9
Total	**5**	**57**

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Highlights (2020)

6.-23. Juni 2020 Planned short outage with refuelling
19. Oktober 2020 Reactor Trip due to a human factor failure during a test
9. Dezember 2020 Turbine trip due to a human factor failure during a test
13. April 2020 Load reduction dur to external reason

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2020 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)	:	1220 MWe

Key Dates

Construction Date	:	1974-01-01
Grid Date	:	1984-05-24
Commercial Date	:	1984-12-15
Age at end of year	:	36 years

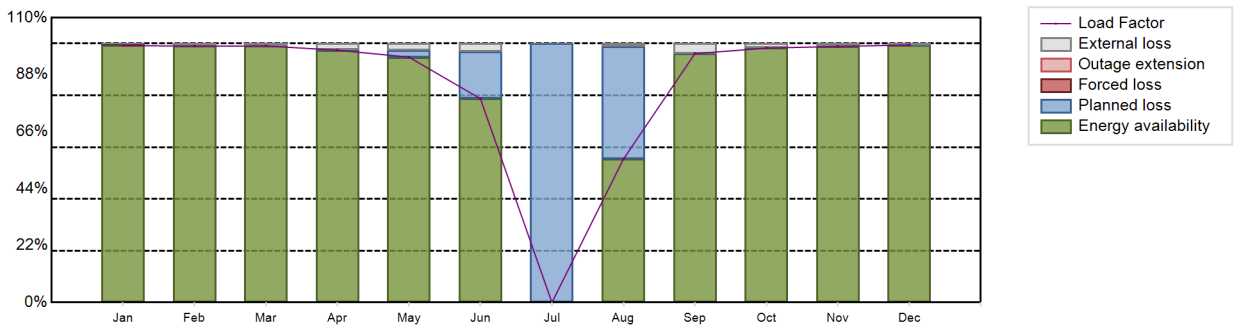
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.31
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	286
Fuel material	:	UO2	Number of SG	:	NA
Refuelling type	:	OFF-line	Containment type	:	-
Moderator material	:	H2O	Containment design pressure [MPa]	:	-
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	12	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	18	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	43000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	4.38	HP cylinder inlet steam pressure [MPa]	:	6.76
Active core height/length [m]	:	3.81	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	648	Primary means of condenser cooling	:	Cooling towers
Fuel linear heat generation rate [kW/m]	:	13.3	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**	:	none

Annual Production Results (2020)

Net Energy Production	:	9058.71 GW(e).h	Forced Loss Rate (FLR)	:	0.04 %
Energy Availability Factor (EAF)	:	84.53 %	Unplanned Capability Loss Factor (UCL)	:	0.03 %
Unit Capability Factor (UCF)	:	86.02 %	Planned Unavailability Factor (PUF)	:	13.95 %
Load Factor (LF)	:	84.53 %	Externally cause unavailability (XUF)	:	1.49 %
Operating Factor (OF)	:	87.97 %	Total off-line time	:	1057 hours

Annual Summary



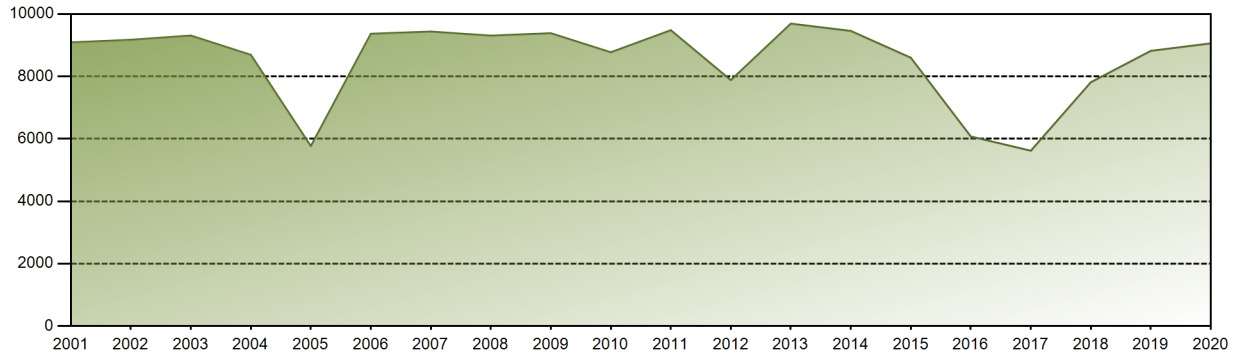
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	900.88	840.68	898.11	855.96	860.18	691.48	0.00	502.61	844.29	893.07	868.61	902.85	9058.71
EAF [%]	99.25	99.01	99.08	97.45	94.77	78.72	0.00	55.37	96.12	98.26	98.88	99.47	84.53
UCF [%]	99.47	99.99	99.99	99.70	97.29	81.76	0.00	56.45	99.86	99.99	99.82	99.99	86.02
LF [%]	99.25	99.01	99.08	97.45	94.77	78.72	0.00	55.37	96.12	98.26	98.88	99.47	84.53
OF [%]	100.00	100.00	100.00	100.00	100.00	95.00	0.00	62.77	100.00	100.00	100.00	100.00	87.97
FLR [%]	0.37	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 [%]	0.37	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 [%]	0.16	0.01	0.01	0.30	2.71	18.24	100.00	43.55	0.14	0.01	0.18	0.01	13.95
XUF [%]	0.22	0.98	0.91	2.26	2.53	3.04	0.00	1.08	3.74	1.73	0.94	0.52	1.49

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Historical Summary

Lifetime energy generation	:	293469.71 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.38 %
Cumulative Energy Availability Factor (EAF)	:	83.08 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.37 %
Cumulative Unit Capability Factor (UCF)	:	84.73 %	Cumulative Planned Unavailability Factor (PUF)	:	11.9 %
Cumulative Load Factor (LF)	:	83.23 %	Cumulative Externally cause unavailability (XUF)	:	1.65 %
Cumulative Operating Factor (OF)	:	86.84 %			

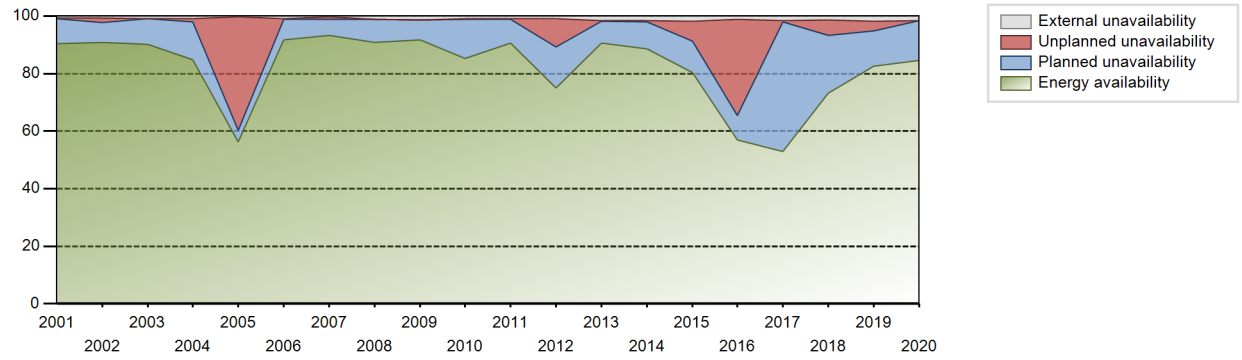
Electricity Production (net) [GWh]



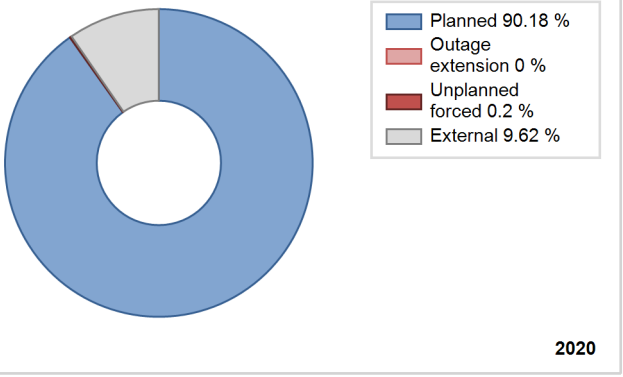
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	2.21	3361	1030	100.00	100.00	0.09	100.00	0.00	0.00	0.00	0.00
1985	6769.30	7233	951	80.12	80.12	81.24	82.57	1.82	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

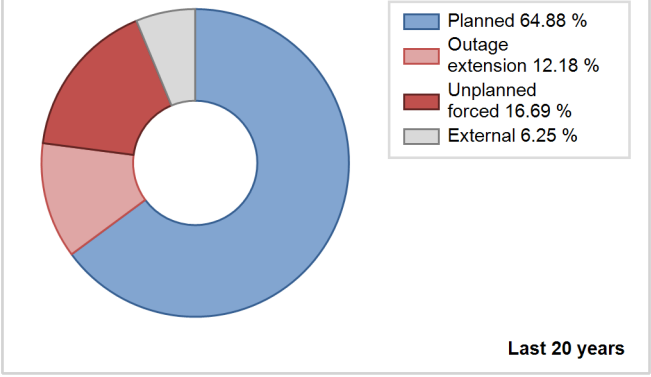
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					275	
C. Inspection, maintenance or repair combined with refuelling	1057			818		
D. Inspection, maintenance or repair without refuelling				12		
E. Testing of plant systems or components				0	1	
H. Nuclear regulatory requirements					1	
L. Human factor related					6	
Z. Other				2		
Subtotal	1057			832	283	
Total	**1057**			**1115**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		107
12. Reactor I&C Systems		4
14. Safety Systems		12
15. Reactor Cooling Systems		3
16. Steam generation systems		2
31. Turbine and auxiliaries		19
32. Feedwater and Main Steam System		8
34. Miscellaneous Systems		2
35. All other I&C Systems		2
41. Main Generator Systems		120
Total		**279**

Highlights (2020)

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2020 Operating Experience

TW-3 KUOSHENG-1 TAIWAN, CHINA

Status at end of year	:	**Operational**
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

Reactor type and model	:	BWR / BWR-6
Thermal power	:	2894 MWth
Gross electrical power	:	985 MWe
Reference unit power (net)	:	985 MWe

Key Dates

Construction Date	:	1975-11-19
Grid Date	:	1981-05-21
Commercial Date	:	1981-12-28
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 [%]	:	29
Average discharge burnup [MWd/t]	:	-
Active core diameter [m]	:	4.18
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	624
Fuel linear heat generation rate [kW/m]	:	17.6
Number of control rod assemblies	:	145
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

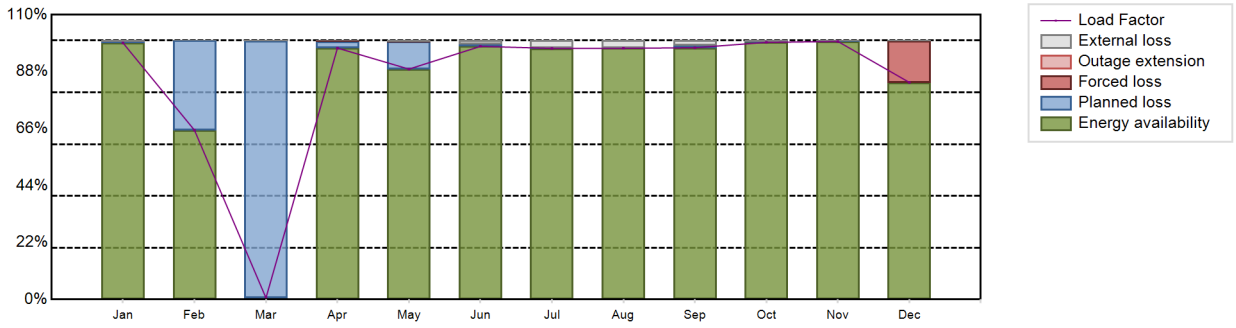
Operating coolant pressure [MPa]	:	7.32
Reactor outlet temperature [°C]	:	284
Number of SG	:	NA
Containment type	:	-
Containment design pressure [MPa]	:	1.06
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.64
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	:	none

Annual Production Results (2020)

Net Energy Production	:	7374.21 GW(e).h
Energy Availability Factor (EAF)	:	85.21 %
Unit Capability Factor (UCF)	:	86.05 %
Load Factor (LF)	:	85.23 %
Operating Factor (OF)	:	87.3 %

Forced Loss Rate (FLR)	:	1.6 %
Unplanned Capability Loss Factor (UCL)	:	1.4 %
Planned Unavailability Factor (PUF)	:	12.55 %
Externally cause unavailability (XUF)	:	0.84 %
Total off-line time	:	1116 hours

Annual Summary



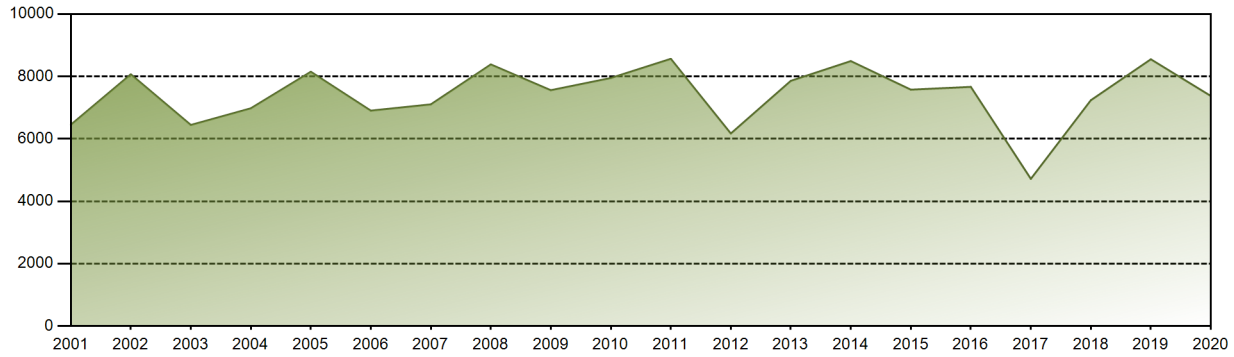
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	726.30	448.31	4.59	688.74	652.20	693.38	710.86	710.98	689.69	727.83	706.89	614.44	7374.21
EAF [%]	99.05	65.25	0.63	97.08	89.00	97.77	97.00	97.02	97.25	99.32	99.67	83.84	85.21
UCF [%]	99.33	65.25	0.65	97.08	89.40	99.13	99.89	99.80	99.16	99.58	99.76	83.86	86.05
LF [%]	99.11	65.39	0.63	97.11	89.00	97.77	97.00	97.02	97.25	99.32	99.67	83.84	85.23
OF [%]	100.00	65.66	3.76	100.00	91.67	100.00	100.00	100.00	100.00	100.00	100.00	86.69	87.30
FLR [%]	0.00	0.00	0.00	0.35	0.09	0.00	0.00	0.00	0.00	0.00	0.00	16.14	1.60
UCL [%]	0.00	0.00	0.00	0.34	0.08	0.00	0.00	0.00	0.00	0.00	0.00	16.14	1.40
PUF [%]	0.67	34.75	99.35	2.58	10.52	0.87	0.11	0.20	0.84	0.42	0.24	0.00	12.55
XUF [%]	0.27	0.00	0.03	0.00	0.40	1.37	2.89	2.78	1.91	0.26	0.09	0.02	0.84

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Historical Summary

Lifetime energy generation	:	266956.1 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.26 %
Cumulative Energy Availability Factor (EAF)	:	83.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.12 %
Cumulative Unit Capability Factor (UCF)	:	84.66 %	Cumulative Planned Unavailability Factor (PUF)	:	13.22 %
Cumulative Load Factor (LF)	:	83.25 %	Cumulative Externally cause unavailability (XUF)	:	0.73 %
Cumulative Operating Factor (OF)	:	86.39 %			

Electricity Production (net) [GWh]

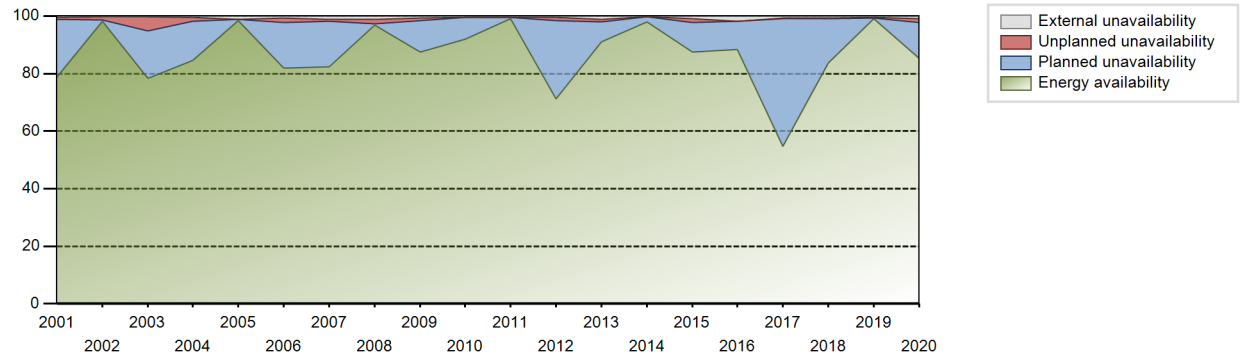


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	Data not provided										
1982	"										
1983	"										
1984	"										
1985	"										
1986	"										
1987	"										
1988	"										
1989	5329.05	6447	951	62.97	64.94	63.97	73.60	2.70	1.80	33.27	1.96
1990	6898.01	8201	918	86.76	87.39	85.78	93.62	4.72	4.32	8.28	0.63
1991	5850.77	6678	951	71.40	71.40	70.23	76.23	4.87	3.65	24.95	0.00
1992	6152.35	7126	951	78.43	78.43	73.65	81.12	6.31	5.28	16.28	0.00
1993	5679.52	6457	951	71.07	71.07	68.18	73.71	4.91	3.67	25.25	0.00
1994	6302.27	7077	950	76.94	77.80	75.73	80.79	1.78	1.41	20.79	0.86
1995	6897.91	7734	948	84.56	84.73	83.06	88.29	10.72	10.17	5.10	0.17
1996	6950.76	7573	948	84.32	84.83	83.47	86.21	2.53	2.20	12.97	0.51
1997	6277.80	6978	948	77.51	77.69	75.60	79.66	6.02	4.97	17.34	0.18
1998	6426.04	7209	948	79.73	81.16	77.38	82.29	4.79	4.08	14.76	1.44
1999	7686.77	8439	948	93.81	95.10	92.56	96.34	4.03	3.99	0.91	1.28
2000	6588.58	7391	948	80.17	81.33	79.12	84.14	6.06	5.24	13.43	1.16
2001	6452.28	7070	948	78.81	79.38	77.70	80.71	0.86	0.69	19.93	0.57
2002	8068.54	8693	948	98.14	98.49	97.16	99.24	0.97	0.96	0.55	0.35
2003	6444.90	6968	948	78.30	78.48	77.61	79.54	0.05	4.95	16.57	0.18
2004	6978.48	7516	948	84.65	85.15	83.80	85.56	1.52	1.32	13.54	0.49
2005	8150.12	8749	948	98.45	99.66	98.14	99.87	0.02	0.02	0.32	1.21
2006	6903.61	7325	985	81.88	82.57	81.01	83.62	1.91	1.61	15.83	0.69
2007	7104.56	7429	985	82.33	83.49	82.34	84.81	0.81	0.68	15.83	1.16
2008	8384.82	8673	985	96.89	97.97	96.91	98.74	1.68	1.68	0.35	1.08
2009	7558.45	7823	985	87.52	88.31	87.60	89.30	0.97	0.87	10.83	0.78
2010	7949.61	8150	985	91.91	92.42	92.13	93.04	0.01	0.01	7.57	0.50
2011	8564.68	8760	985	99.10	99.67	99.26	100.00	0.00	0.00	0.33	0.57
2012	6170.62	6412	985	71.31	71.83	71.32	73.00	1.48	1.08	27.09	0.51
2013	7859.12	8165	985	91.05	92.16	91.08	93.21	0.90	0.84	7.00	1.11
2014	8490.72	8664	985	97.96	98.25	98.40	98.90	0.04	0.04	1.72	0.28
2015	7575.91	7807	985	87.49	88.53	87.80	89.12	0.81	1.23	10.25	1.04
2016	7665.07	7980	985	88.43	90.27	88.59	90.85	0.01	0.01	9.72	1.84
2017	4716.99	4916	985	54.63	55.24	54.67	56.12	0.52	0.29	44.47	0.61

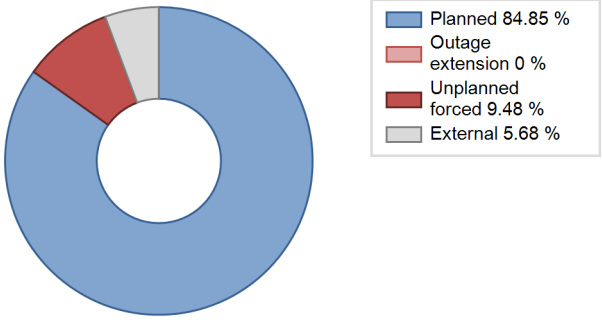
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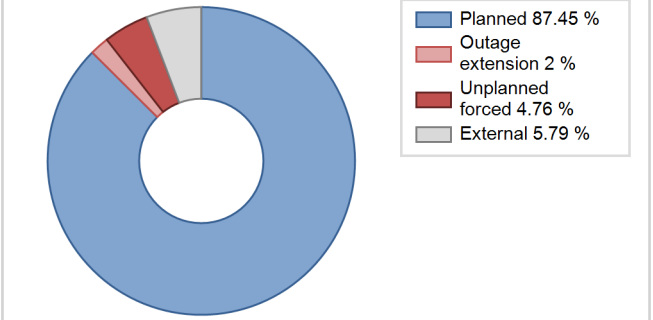
2018	7236.39	7486	985	83.71	84.52	83.87	85.46	0.22	0.19	15.30	0.81
2019	8549.07	8760	985	98.97	99.57	99.08	100.00	0.11	0.11	0.33	0.59
2020	7374.21	7668	985	85.21	86.05	85.23	87.30	1.60	1.40	12.55	0.84

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		99			101	
B.	Refuelling without maintenance				35		
C.	Inspection, maintenance or repair combined with refuelling	955			982		
D.	Inspection, maintenance or repair without refuelling	62			58		
E.	Testing of plant systems or components				7		
J.	Grid limitation, failure or grid unavailability						2
L.	Human factor related					10	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						4
Z.	Other						2
Subtotal		1017	99		1082	111	8
Total			**1116**			**1201**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		19
12. Reactor I&C Systems		5
13. Reactor Auxiliary Systems		4
15. Reactor Cooling Systems		7
31. Turbine and auxiliaries	99	26
32. Feedwater and Main Steam System		22
33. Circulating Water System		7
35. All other I&C Systems		1
41. Main Generator Systems		14
42. Electrical Power Supply Systems		10
Total	**99**	**115**

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2020 Operating Experience

TW-4 KUOSHENG-2 TAIWAN, CHINA

Status at end of year	:	**Operational**
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

Reactor type and model	:	BWR / BWR-6
Thermal power	:	2894 MWth
Gross electrical power	:	985 MWe
Reference unit power (net)	:	985 MWe

Key Dates

Construction Date	:	1976-03-15
Grid Date	:	1982-06-29
Commercial Date	:	1983-03-16
Age at end of year	:	38 years

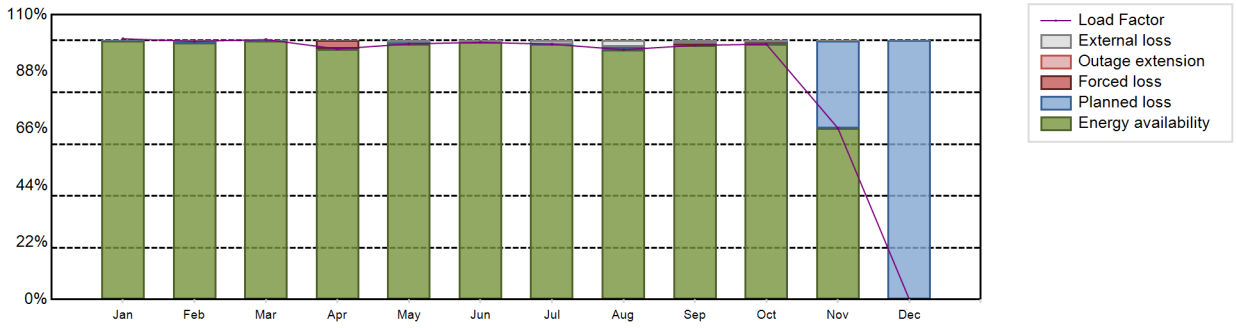
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.32
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	284
Fuel material	:	UO2	Number of SG	:	NA
Refuelling type	:	OFF-line	Containment type	:	-
Moderator material	:	H2O	Containment design pressure [MPa]	:	1.06
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	29	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	-	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	4.18	HP cylinder inlet steam pressure [MPa]	:	6.64
Active core height/length [m]	:	3.81	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	624	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	17.6	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 (2020)

Net Energy Production	:	7589.26 GW(e).h	Forced Loss Rate (FLR)	:	0.34 %
Energy Availability Factor (EAF)	:	87.56 %	Unplanned Capability Loss Factor (UCL)	:	0.3 %
Unit Capability Factor (UCF)	:	88.16 %	Planned Unavailability Factor (PUF)	:	11.53 %
Load Factor (LF)	:	87.71 %	Externally cause unavailability (XUF)	:	0.61 %
Operating Factor (OF)	:	88.81 %	Total off-line time	:	983 hours

Annual Summary



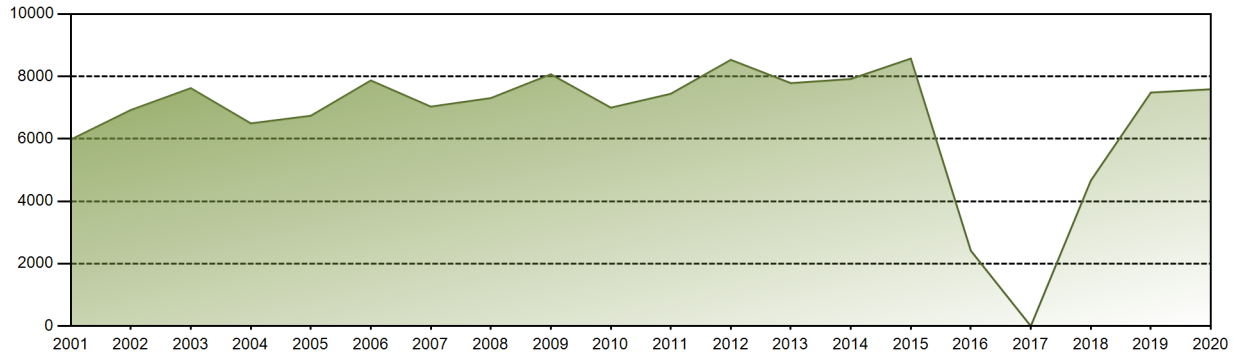
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	737.86	683.55	735.68	686.40	723.35	704.37	722.73	707.10	696.20	722.52	469.51	0.00	7589.27
EAF [%]	99.93	99.15	99.91	96.69	98.70	99.32	98.62	96.49	98.17	98.59	66.20	0.00	87.56
UCF [%]	99.93	99.51	99.91	96.69	99.38	99.92	99.95	98.78	99.38	99.32	66.23	0.00	88.16
LF [%]	100.69	99.71	100.39	96.79	98.70	99.32	98.62	96.49	98.17	98.59	66.20	0.00	87.71
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	66.81	0.00	88.81
FLR [%]	0.00	0.00	0.00	3.22	0.00	0.00	0.00	0.00	0.49	0.01	0.00	0.00	0.34
UCL [%]	0.00	0.00	0.00	3.22	0.00	0.00	0.00	0.00	0.49	0.01	0.00	0.00	0.30
PUF [%]	0.07	0.49	0.09	0.10	0.62	0.08	0.05	1.22	0.13	0.66	33.77	100.00	11.53
XUF [%]	0.00	0.36	0.00	0.00	0.68	0.60	1.33	2.29	1.22	0.73	0.03	0.00	0.61

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Historical Summary

Lifetime energy generation	:	248570.76 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.48 %
Cumulative Energy Availability Factor (EAF)	:	83.33 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.15 %
Cumulative Unit Capability Factor (UCF)	:	84.29 %	Cumulative Planned Unavailability Factor (PUF)	:	13.56 %
Cumulative Load Factor (LF)	:	78.66 %	Cumulative Externally cause unavailability (XUF)	:	0.97 %
Cumulative Operating Factor (OF)	:	82 %			

Electricity Production (net) [GWh]

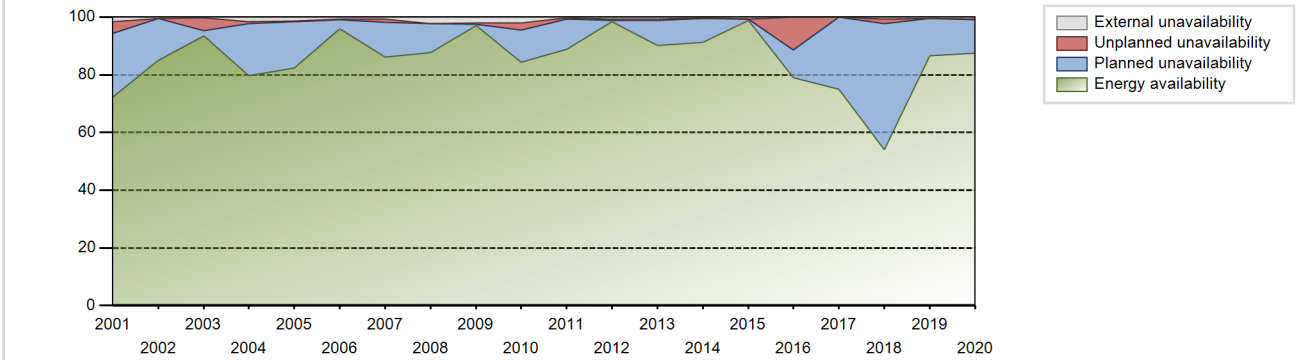


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983				Data not provided							
1984				"							
1985				"							
1986				"							
1987				"							
1988				"							
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

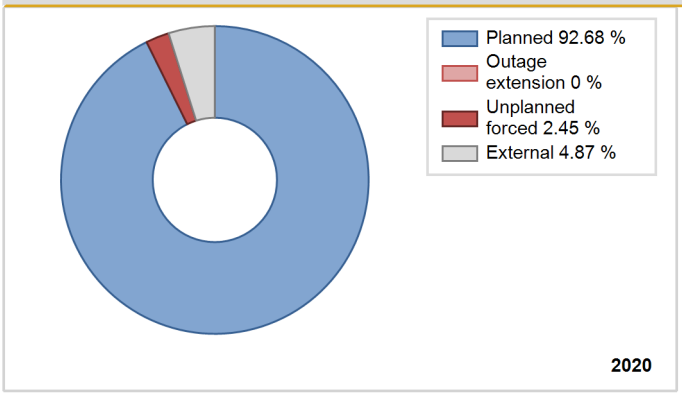
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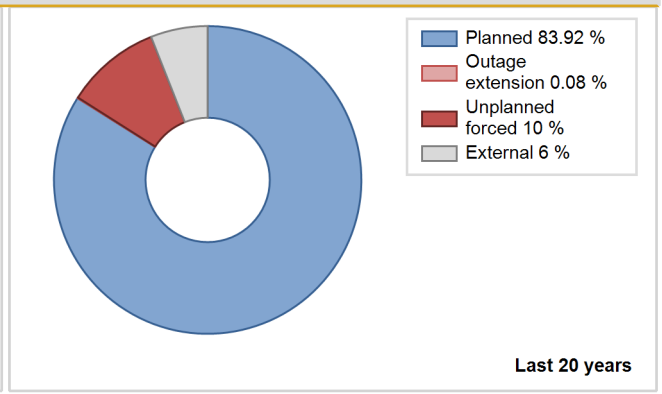
2020	7589.27	7801	985	87.56	88.16	87.71	88.81	0.34	0.30	11.53	0.61

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1983 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					123	
B. Refuelling without maintenance				35		
C. Inspection, maintenance or repair combined with refuelling	983			780		
D. Inspection, maintenance or repair without refuelling				253		
E. Testing of plant systems or components				13		
J. Grid limitation, failure or grid unavailability						6
L. Human factor related					10	
M. Governmental requirements or court decisions						347
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						10
Z. Other					1	1
Subtotal	983			1081	134	364
Total	**983**			**1579**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		30
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		2
14. Safety Systems		4
15. Reactor Cooling Systems		14
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		10
32. Feedwater and Main Steam System		20
33. Circulating Water System		5
35. All other I&C Systems		6
41. Main Generator Systems		4
42. Electrical Power Supply Systems		388
Total		**490**

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2020 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

Reactor type and model	:	PWR / WH 3LP (WE 312)
Thermal power	:	2822 MWth
Gross electrical power	:	951 MWe
Reference unit power (net)	:	936 MWe

Key Dates

Construction Date	:	1978-08-21
Grid Date	:	1984-05-09
Commercial Date	:	1984-07-27
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 [%]	:	40
Average discharge burnup [MWd/t]	:	43000
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]	:	17.75
Number of control rod assemblies	:	28
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

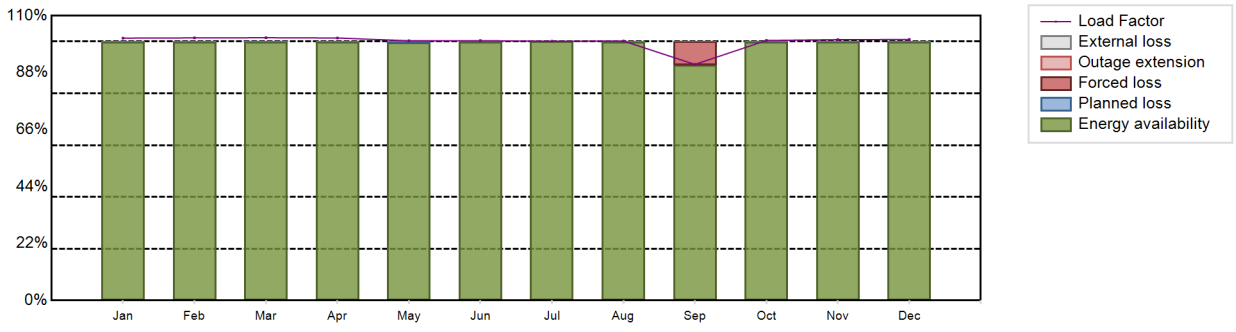
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	328.7
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	4.22
Secondary systems		
Number of turbine-generators per unit/reactor	:	3
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.56
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 (2020)

Net Energy Production	:	8222.12 GW(e).h
Energy Availability Factor (EAF)	:	99.19 %
Unit Capability Factor (UCF)	:	99.19 %
Load Factor (LF)	:	100 %
Operating Factor (OF)	:	99.36 %

Forced Loss Rate (FLR)	:	0.74 %
Unplanned Capability Loss Factor (UCL)	:	0.74 %
Planned Unavailability Factor (PUF)	:	0.07 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	56 hours

Annual Summary



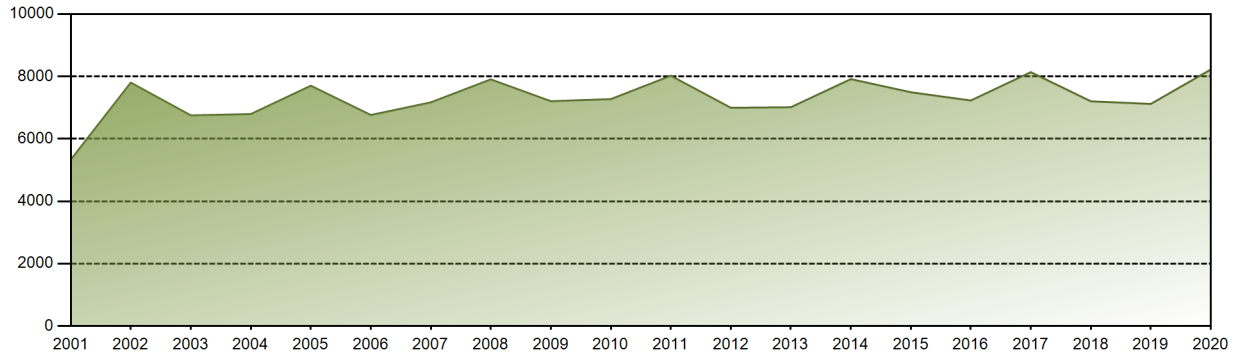
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	705.77	660.84	706.82	683.30	698.64	676.38	697.35	698.01	614.51	699.37	679.00	702.14	8222.12
EAF [%]	99.95	99.95	99.96	99.95	99.66	99.95	100.00	99.89	91.01	99.95	99.95	99.95	99.19
UCF [%]	99.95	99.95	99.96	99.95	99.66	99.95	100.00	99.89	91.01	99.95	99.95	99.95	99.19
LF [%]	101.35	101.44	101.50	101.39	100.32	100.36	100.14	100.23	91.18	100.43	100.75	100.83	100.00
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.22	100.00	100.00	100.00	99.36
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.99	0.00	0.00	0.00	0.74
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.99	0.00	0.00	0.00	0.74
PUF [%]	0.05	0.05	0.04	0.05	0.34	0.05	0.00	0.11	0.00	0.05	0.05	0.05	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

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Historical Summary

Lifetime energy generation	:	239618.9 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.91 %
Cumulative Energy Availability Factor (EAF)	:	86.73 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.71 %
Cumulative Unit Capability Factor (UCF)	:	87.74 %	Cumulative Planned Unavailability Factor (PUF)	:	9.55 %
Cumulative Load Factor (LF)	:	87.67 %	Cumulative Externally cause unavailability (XUF)	:	1.01 %
Cumulative Operating Factor (OF)	:	87.82 %			

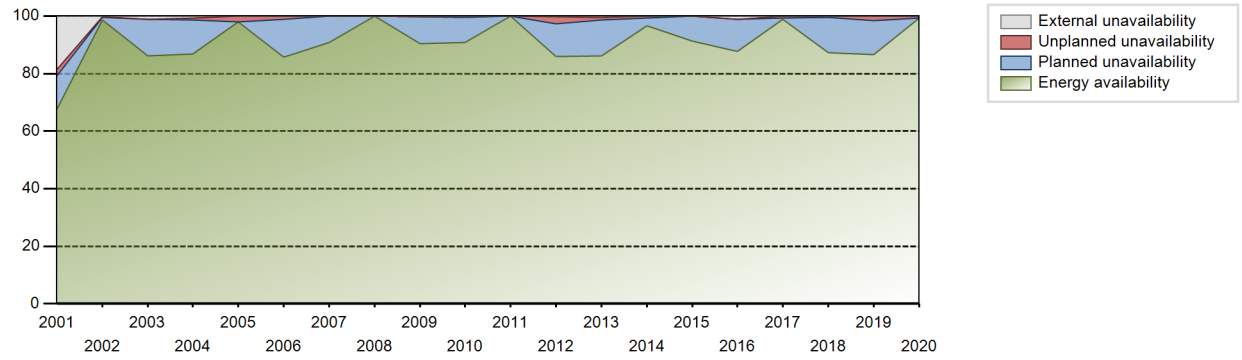
Electricity Production (net) [GWh]



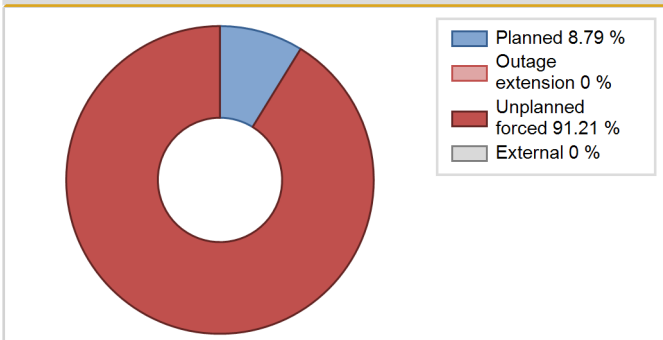
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984					Data not provided						
1985					"						
1986					"						
1987					"						
1988					"						
1989	5418.45	6305	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

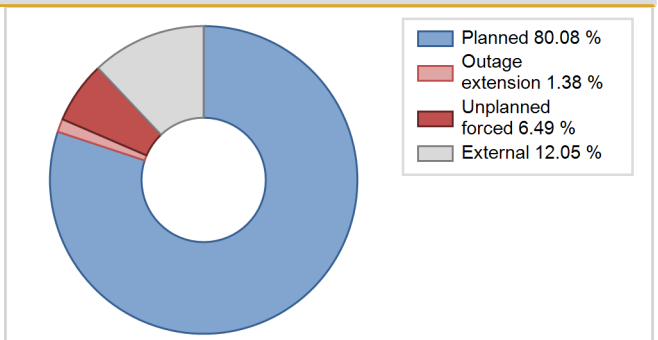
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					197	
B. Refuelling without maintenance				24		
C. Inspection, maintenance or repair combined with refuelling				761		
D. Inspection, maintenance or repair without refuelling				16		
E. Testing of plant systems or components				5		
H. Nuclear regulatory requirements					0	
J. Grid limitation, failure or grid unavailability						52
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						6
Subtotal				806	203	63
Total		**0**			**1072**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		66
13. Reactor Auxiliary Systems		6
15. Reactor Cooling Systems		17
16. Steam generation systems		17
31. Turbine and auxiliaries		13
32. Feedwater and Main Steam System		7
35. All other I&C Systems		1
41. Main Generator Systems		53
42. Electrical Power Supply Systems		30
Total		**210**

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Highlights (2020)

2020-09-12 Unit shutdown forRepaired condensate AD-P011 Pump and AD-P010 motor.

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2020 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

Reactor type and model	:	PWR / WH 3LP (WE 312)
Thermal power	:	2822 MWth
Gross electrical power	:	951 MWe
Reference unit power (net)	:	938 MWe

Key Dates

Construction Date	:	1979-02-21
Grid Date	:	1985-02-25
Commercial Date	:	1985-05-18
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 [%]	:	40
Average discharge burnup [MWd/t]	:	43000
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]	:	17.75
Number of control rod assemblies	:	28
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

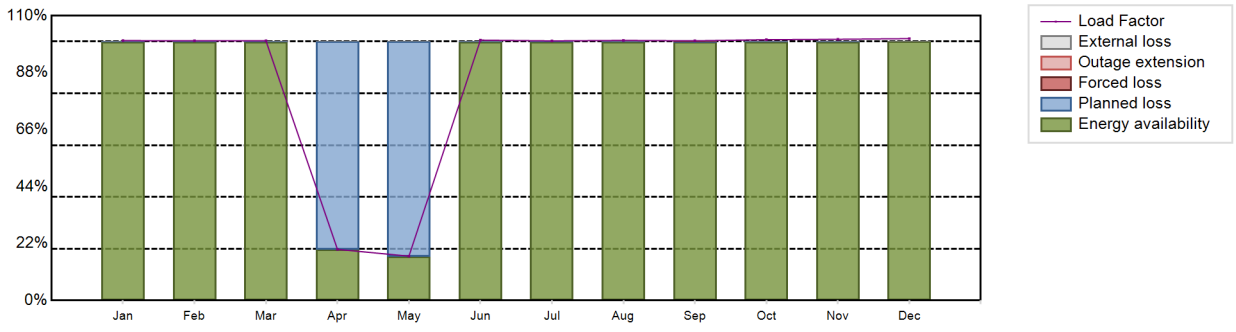
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	326
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	4.22
Secondary systems		
Number of turbine-generators per unit/reactor	:	3
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.56
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 (2020)

Net Energy Production	:	7156.32 GW(e).h
Energy Availability Factor (EAF)	:	86.34 %
Unit Capability Factor (UCF)	:	86.34 %
Load Factor (LF)	:	86.85 %
Operating Factor (OF)	:	86.7 %

Forced Loss Rate (FLR)	:	0.01 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	13.65 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1168 hours

Annual Summary



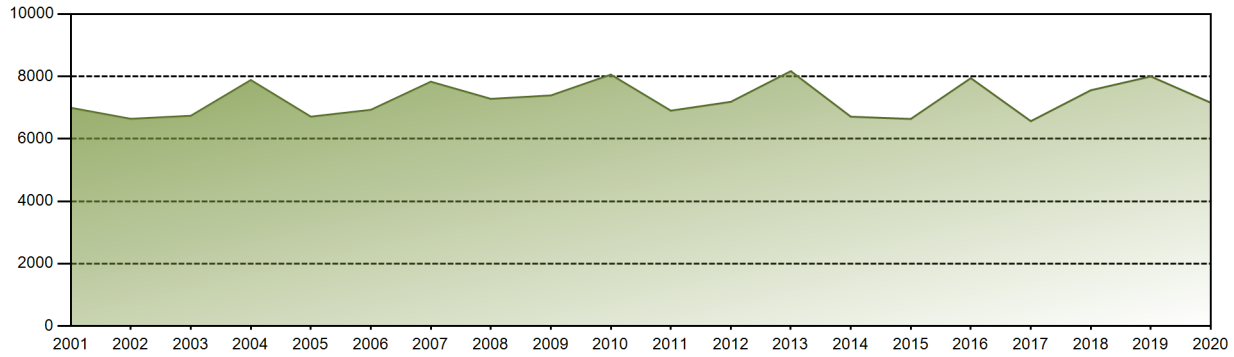
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	700.54	654.95	699.97	133.42	119.64	679.23	699.76	701.10	677.38	703.01	681.48	705.84	7156.32
EAF [%]	99.94	99.91	99.93	19.69	17.06	99.95	99.95	99.95	99.86	99.96	99.96	100.00	86.34
UCF [%]	99.94	99.91	99.93	19.69	17.06	99.95	99.95	99.95	99.86	99.96	99.96	100.00	86.34
LF [%]	100.38	100.32	100.30	19.76	17.14	100.57	100.27	100.46	100.30	100.74	100.91	101.14	86.85
OF [%]	100.00	100.00	100.00	20.28	20.16	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.70
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	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	0.05	0.00	0.00	0.00	0.00
PUF [%]	0.06	0.09	0.07	80.31	82.94	0.05	0.05	0.05	0.08	0.04	0.04	0.00	13.65
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

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Historical Summary

Lifetime energy generation	:	241092.37 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.14 %
Cumulative Energy Availability Factor (EAF)	:	86.19 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.45 %
Cumulative Unit Capability Factor (UCF)	:	87.41 %	Cumulative Planned Unavailability Factor (PUF)	:	10.14 %
Cumulative Load Factor (LF)	:	87.46 %	Cumulative Externally cause unavailability (XUF)	:	1.22 %
Cumulative Operating Factor (OF)	:	88.07 %			

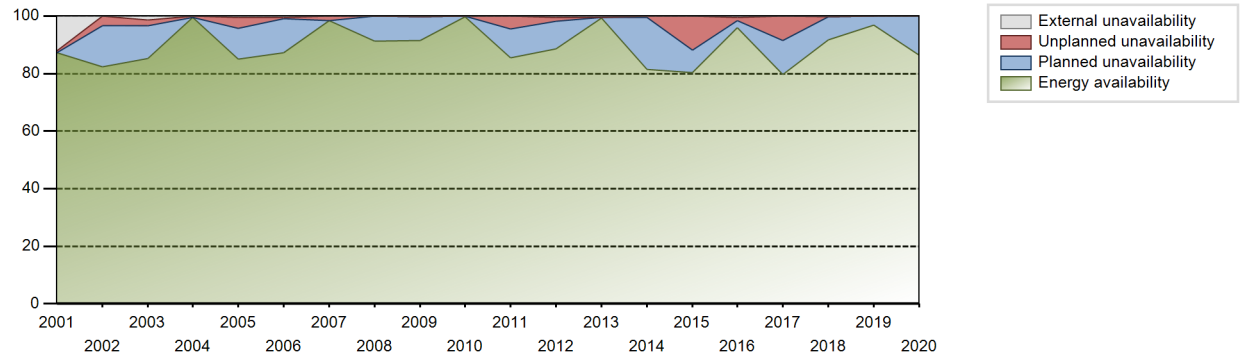
Electricity Production (net) [GWh]



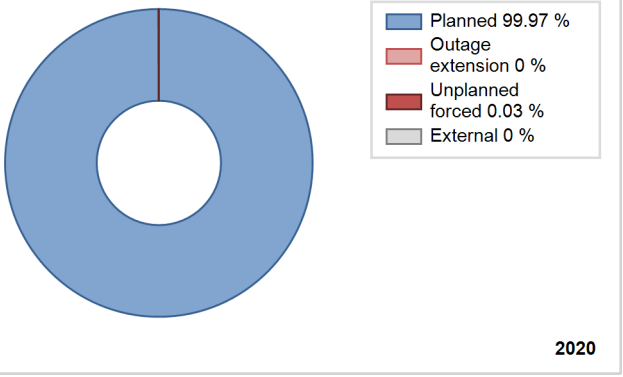
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985					Data not provided						
1986					"						
1987					"						
1988					"						
1989	5283.33	6434	890	58.14	58.84	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

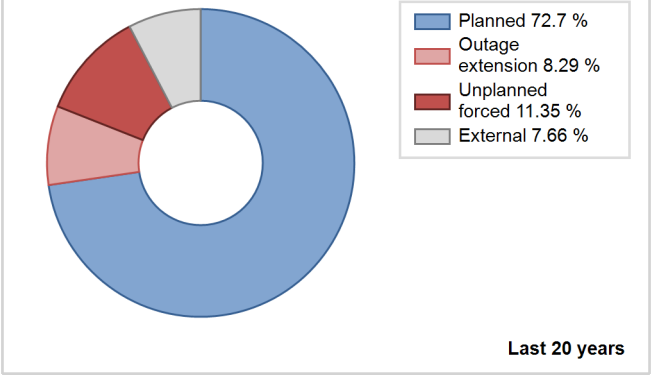
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					162	
C. Inspection, maintenance or repair combined with refuelling	1167			839	2	
D. Inspection, maintenance or repair without refuelling				9		
E. Testing of plant systems or components				1		
J. Grid limitation, failure or grid unavailability						32
L. Human factor related					1	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						8
Z. Other					1	
Subtotal	1167			849	166	40
Total	**1167**			**1055**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		21
12. Reactor I&C Systems		32
13. Reactor Auxiliary Systems		4
15. Reactor Cooling Systems		25
16. Steam generation systems		6
31. Turbine and auxiliaries		14
32. Feedwater and Main Steam System		4
35. All other I&C Systems		4
41. Main Generator Systems		26
42. Electrical Power Supply Systems		63
Total		**199**

Highlights (2020)

2020/04/07 02:23 Unit off-line for EOC-25

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2020 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

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	:	1981-11-01
Grid Date	:	1987-12-31
Commercial Date	:	1988-08-13
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]	:	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

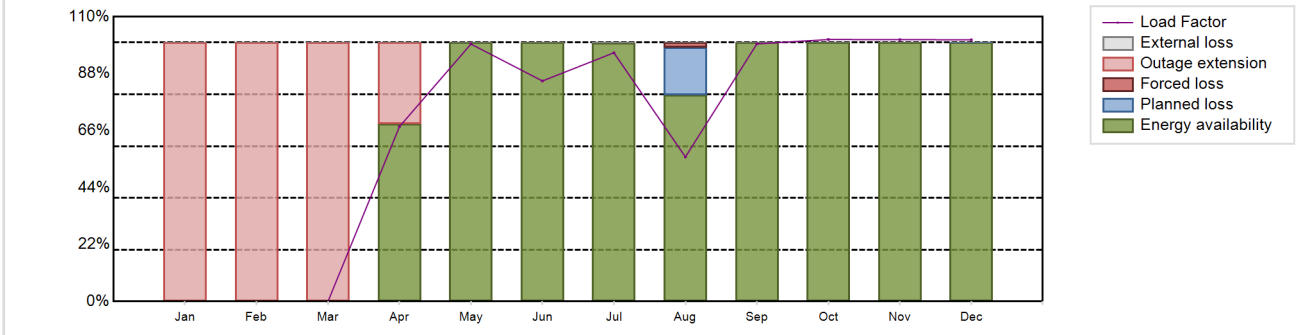
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5624.09 GW(e).h
Energy Availability Factor (EAF)	:	70.86 %
Unit Capability Factor (UCF)	:	70.86 %
Load Factor (LF)	:	67.4 %
Operating Factor (OF)	:	71.21 %
Equivalent non-electrical energy generated (NEG)	:	37.19 GW(e).h

Forced Loss Rate (FLR)	:	0.22 %
Unplanned Capability Loss Factor (UCL)	:	27.58 %
Planned Unavailability Factor (PUF)	:	1.56 %
Externally cause unavailability (XUF)	:	0.01 %
Total off-line time	:	2529 hours

Annual Summary



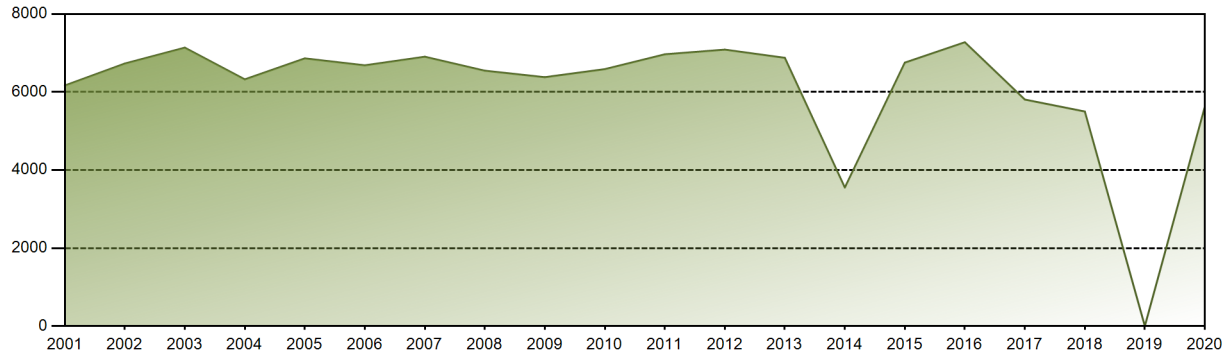
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	462.09	702.82	582.62	678.96	394.60	680.67	716.13	691.81	714.39	5624.09
EAF [%]	0.00	0.00	0.00	68.57	100.00	100.00	99.93	79.82	100.00	100.00	100.00	100.00	70.86
UCF [%]	0.00	0.00	0.00	68.57	100.00	100.00	100.00	79.82	100.00	100.00	100.00	100.00	70.86
LF [%]	0.00	0.00	0.00	67.56	99.44	85.18	96.06	55.83	99.51	101.18	101.14	101.07	67.40
OF [%]	0.00	0.00	0.00	69.86	100.00	100.00	100.00	82.66	100.00	100.00	100.00	100.00	71.21
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22	0.00	0.00	0.00	0.00	0.22
UCL [%]	100.00	100.00	100.00	31.43	0.00	0.00	0.00	1.81	0.00	0.00	0.00	0.00	27.58
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.36	0.00	0.00	0.00	0.00	1.56
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.01

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Historical Summary

Lifetime energy generation	:	187901.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.48 %
Cumulative Energy Availability Factor (EAF)	:	71.66 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.73 %
Cumulative Unit Capability Factor (UCF)	:	72.85 %	Cumulative Planned Unavailability Factor (PUF)	:	22.42 %
Cumulative Load Factor (LF)	:	71.33 %	Cumulative Externally cause unavailability (XUF)	:	1.19 %
Cumulative Operating Factor (OF)	:	74.2 %			

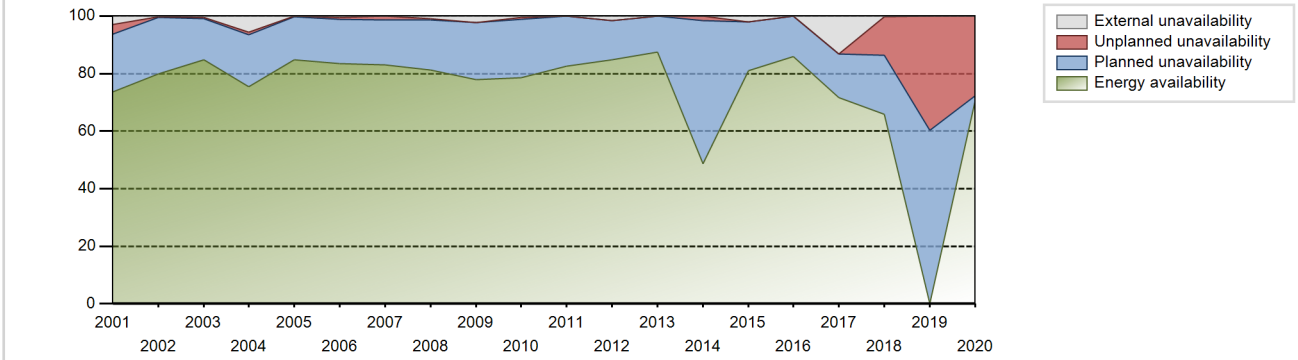
Electricity Production (net) [GWh]



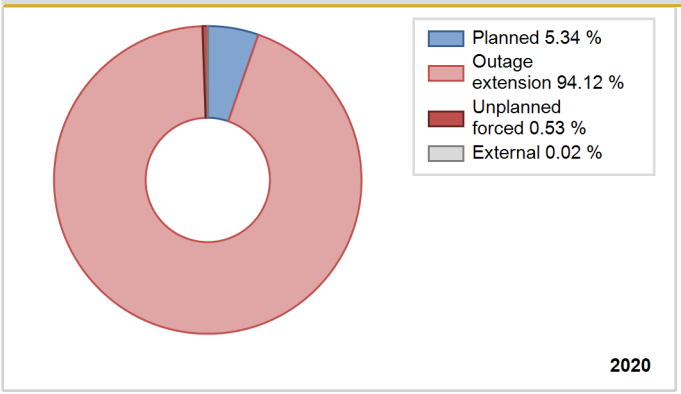
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	3578.19	5266	950	67.05	67.05	61.13	74.95	32.78	32.70	0.25	0.00
1989	5872.26	6295	950	70.62	70.68	70.56	71.86	6.04	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

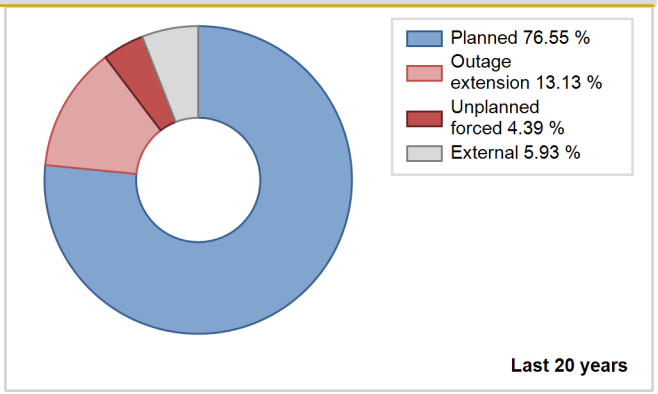
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1988 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		2400			370	
C. Inspection, maintenance or repair combined with refuelling				1473		
D. Inspection, maintenance or repair without refuelling	129			194		
E. Testing of plant systems or components				12		
F. Major backfitting, refurbishment or upgrading activities with refuelling				190		
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	129	2400		1869	375	6
Total	**2529**			**2250**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1988 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		8
14. Safety Systems		1
15. Reactor Cooling Systems		16
16. Steam generation systems		5
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		9
33. Circulating Water System		1
35. All other I&C Systems		1
41. Main Generator Systems	2400	286
42. Electrical Power Supply Systems		4
Total	**2400**	**367**

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2020 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

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	:	1985-02-01
Grid Date	:	2004-08-07
Commercial Date	:	2005-12-15
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]	:	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

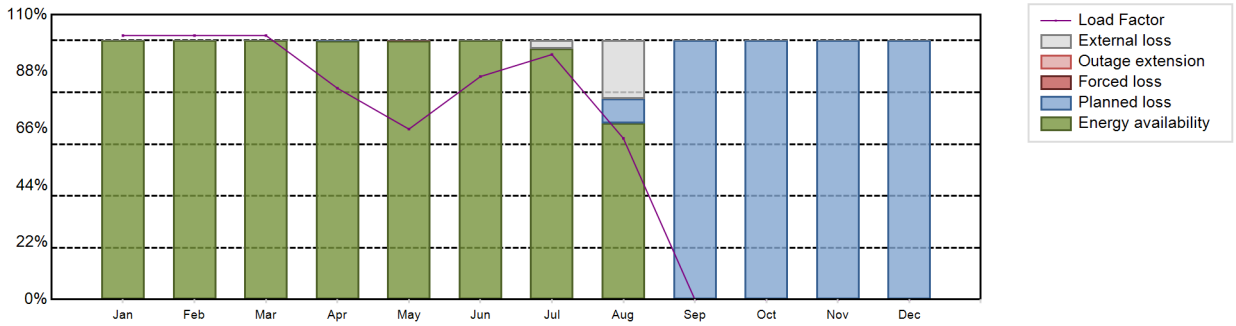
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4835.27 GW(e).h
Energy Availability Factor (EAF)	:	63.67 %
Unit Capability Factor (UCF)	:	65.82 %
Load Factor (LF)	:	57.94 %
Operating Factor (OF)	:	65.86 %
Equivalent non-electrical energy generated (NEG)	:	50.05 GW(e).h

Forced Loss Rate (FLR)	:	0.02 %
Unplanned Capability Loss Factor (UCL)	:	0.02 %
Planned Unavailability Factor (PUF)	:	34.16 %
Externally cause unavailability (XUF)	:	2.15 %
Total off-line time	:	2999 hours

Annual Summary



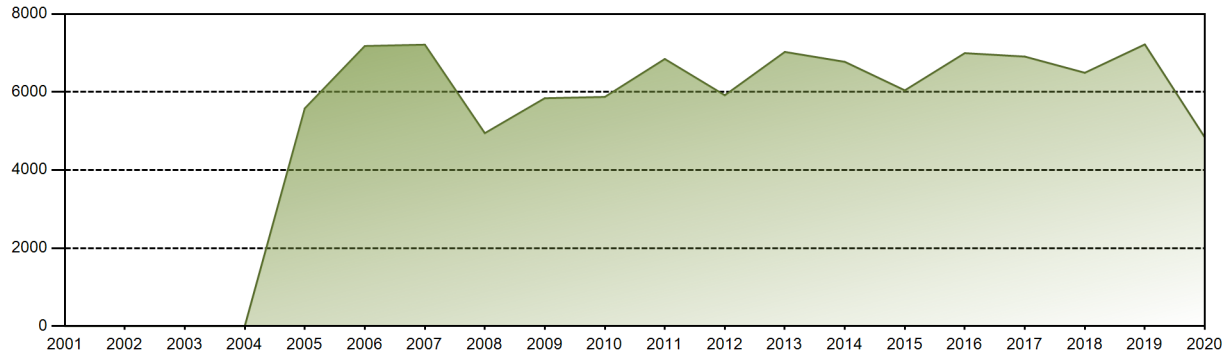
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	720.57	674.10	719.71	558.07	465.15	589.06	668.80	439.81	0.00	0.00	0.00	0.00	4835.27
EAF [%]	100.00	100.00	100.00	99.94	99.81	100.00	96.99	68.03	0.00	0.00	0.00	0.00	63.67
UCF [%]	100.00	100.00	100.00	99.94	99.81	100.00	100.00	90.41	0.00	0.00	0.00	0.00	65.82
LF [%]	101.95	101.95	101.96	81.59	65.81	86.12	94.62	62.23	0.00	0.00	0.00	0.00	57.94
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.59	0.00	0.00	0.00	0.00	65.86
FLR [%]	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
UCL [%]	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
PUF [%]	0.00	0.00	0.00	0.06	0.00	0.00	0.00	9.59	100.00	100.00	100.00	100.00	34.16
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	3.01	22.38	0.00	0.00	0.00	0.00	2.15

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Historical Summary

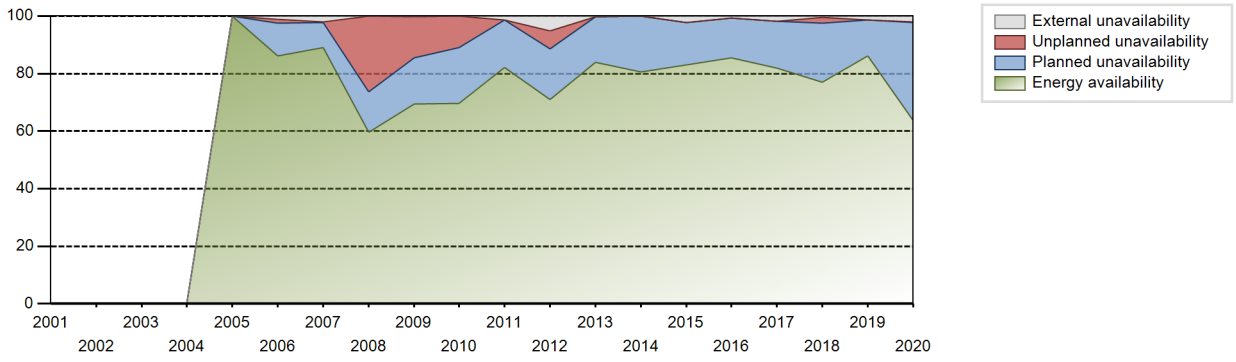
Lifetime energy generation	:	103265.27 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.75 %
Cumulative Energy Availability Factor (EAF)	:	78.06 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.04 %
Cumulative Unit Capability Factor (UCF)	:	79.36 %	Cumulative Planned Unavailability Factor (PUF)	:	16.6 %
Cumulative Load Factor (LF)	:	76.71 %	Cumulative Externally cause unavailability (XUF)	:	1.3 %
Cumulative Operating Factor (OF)	:	79.31 %			

Electricity Production (net) [GWh]



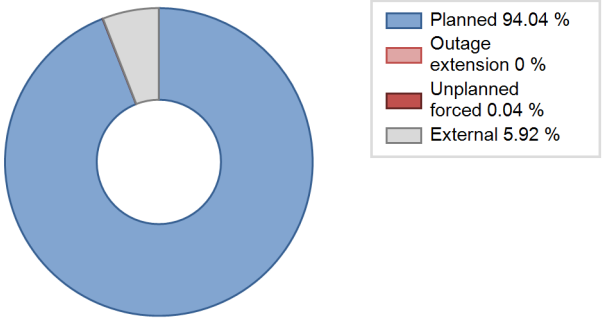
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2005	5581.51	6376	950	100.00	100.00	36.98	39.78	0.00	0.00	0.00	0.00
2006	7178.29	7697	950	86.15	87.36	86.26	87.87	1.35	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

Key Factors in Last 20 Years [%]

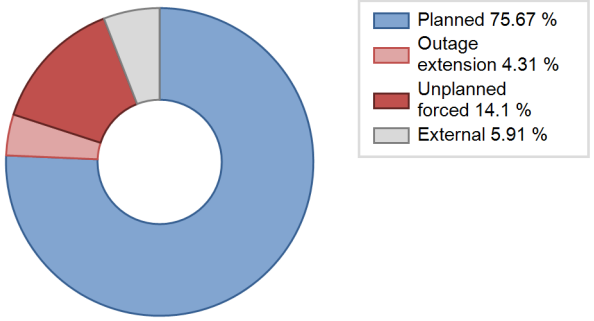


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2005 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					268	
C. Inspection, maintenance or repair combined with refuelling	2998			1403		
D. Inspection, maintenance or repair without refuelling				40		
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.)					83	
Subtotal	2998			1443	351	
Total	**2998**			**1794**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2005 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		9
14. Safety Systems		5
16. Steam generation systems		0
31. Turbine and auxiliaries		1
32. Feedwater and Main Steam System		0
41. Main Generator Systems		253
Total		**268**

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2020 Operating Experience

UA-27 ROVNO-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	:	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]	:	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

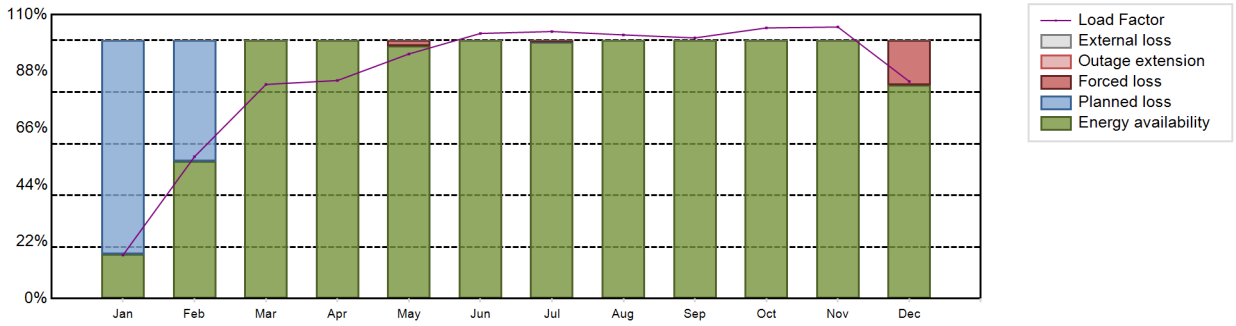
Operating coolant pressure [MPa]	:	12.5
Reactor outlet temperature [°C]	:	295.8
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	4.4
Output voltage [kV]	:	-
Primary means of condenser cooling	:	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 (2020)

Net Energy Production	:	2895 GW(e).h
Energy Availability Factor (EAF)	:	87.57 %
Unit Capability Factor (UCF)	:	87.57 %
Load Factor (LF)	:	86.5 %
Operating Factor (OF)	:	88.49 %
Equivalent non-electrical energy generated (NEG)	:	11.97 GW(e).h

Forced Loss Rate (FLR)	:	1.91 %
Unplanned Capability Loss Factor (UCL)	:	1.71 %
Planned Unavailability Factor (PUF)	:	10.72 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1011 hours

Annual Summary



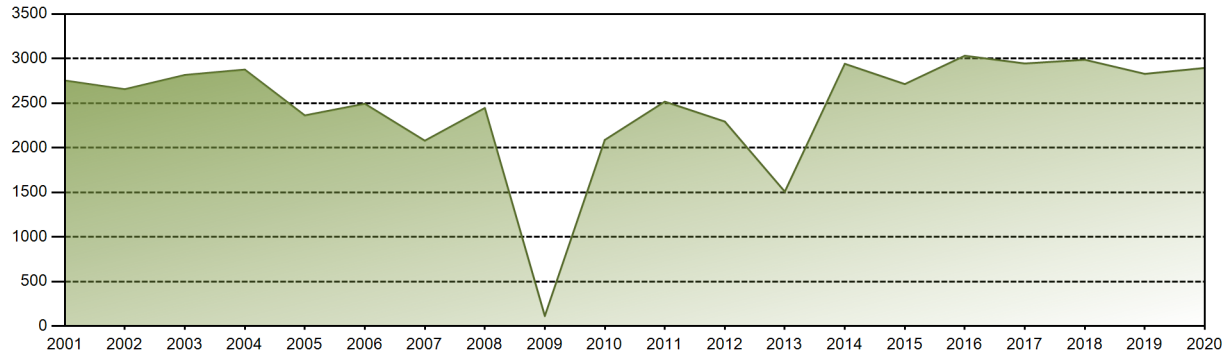
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	47.82	145.74	234.86	231.74	268.63	281.77	293.23	289.58	277.04	297.59	288.61	238.39	2895.00
EAF [%]	17.31	53.18	100.00	100.00	97.76	100.00	99.36	100.00	100.00	100.00	100.00	82.65	87.57
UCF [%]	17.31	53.18	100.00	100.00	97.76	100.00	99.36	100.00	100.00	100.00	100.00	82.65	87.57
LF [%]	16.87	54.96	82.96	84.48	94.77	102.72	103.44	102.16	100.99	104.84	105.21	84.10	86.50
OF [%]	17.47	54.02	100.00	100.00	92.61	100.00	100.00	100.00	100.00	100.00	100.00	97.04	88.49
FLR [%]	0.00	0.00	0.00	0.00	2.24	0.00	0.57	0.00	0.00	0.00	0.00	17.35	1.91
UCL [%]	0.00	0.00	0.00	0.00	2.24	0.00	0.57	0.00	0.00	0.00	0.00	17.35	1.71
PUF [%]	82.69	46.82	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	10.72
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

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Historical Summary

Lifetime energy generation	:	100417 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.76 %
Cumulative Energy Availability Factor (EAF)	:	79.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.27 %
Cumulative Unit Capability Factor (UCF)	:	79.74 %	Cumulative Planned Unavailability Factor (PUF)	:	17.99 %
Cumulative Load Factor (LF)	:	77.13 %	Cumulative Externally cause unavailability (XUF)	:	0.64 %
Cumulative Operating Factor (OF)	:	80.52 %			

Electricity Production (net) [GWh]

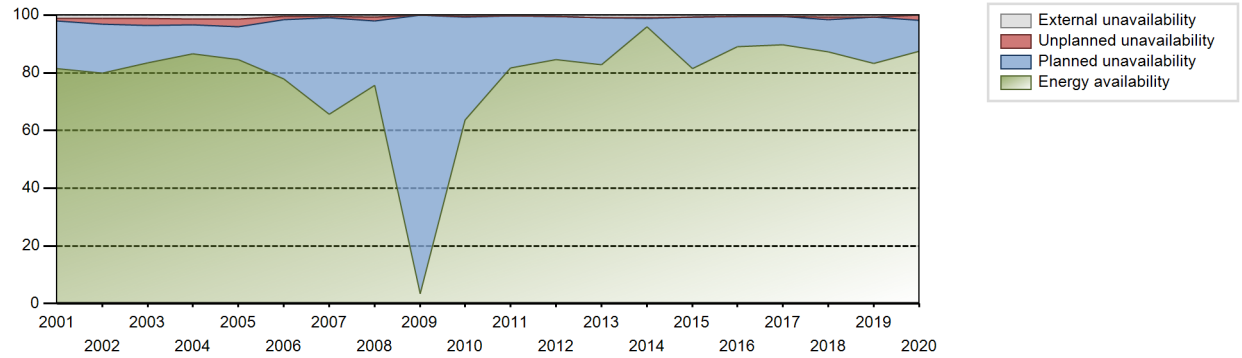


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	1685.10	6968	361	88.09	88.09	90.12	99.95	11.91	11.91	0.00	0.00
1982	1725.21	5498	361	51.94	51.94	54.55	62.76	13.79	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

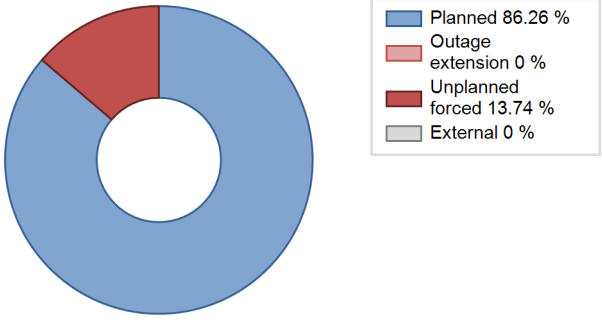
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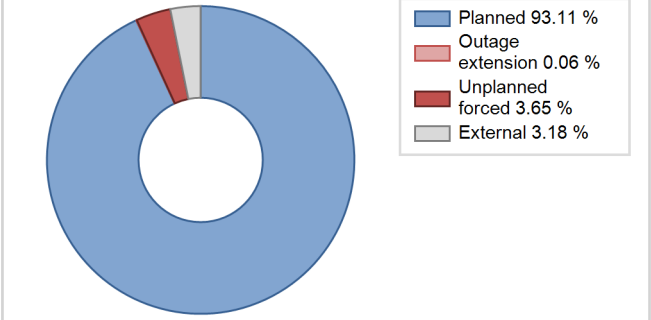
2018	2986.77	7778	381	87.24	87.99	89.49	88.79	1.00	0.89	11.12	0.75
2019	2828.40	7419	381	83.35	84.05	84.74	84.69	0.06	0.05	15.90	0.70
2020	2895.00	7773	381	87.57	87.57	86.50	88.49	1.91	1.71	10.72	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		38			38	
C. Inspection, maintenance or repair combined with refuelling	933			1367		
D. Inspection, maintenance or repair without refuelling				106		
J. Grid limitation, failure or grid unavailability						10
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			38			112
L. Human factor related					0	
M. Governmental requirements or court decisions					1	
Subtotal	933	38	38	1473	39	122
Total	**1009**			**1634**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	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	17	1
15. Reactor Cooling Systems		11
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	22	5
Total	**39**	**36**

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2020 Operating Experience

UA-28 ROVNO-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	:	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]	:	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

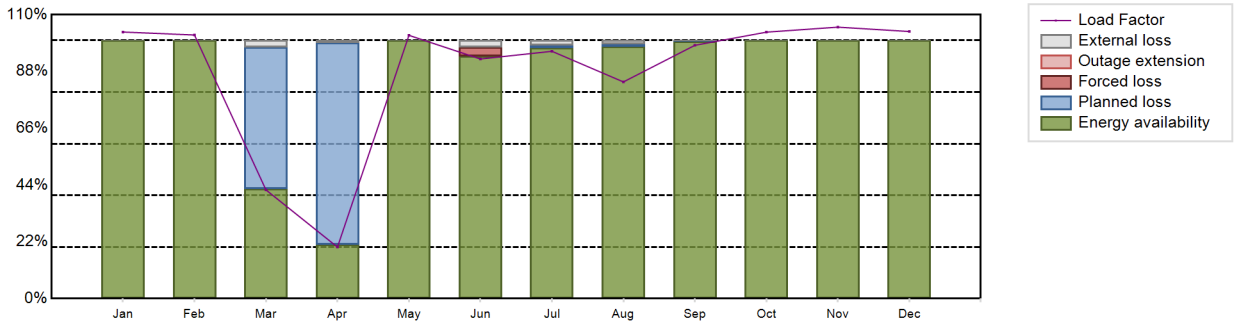
Operating coolant pressure [MPa]	:	12.5
Reactor outlet temperature [°C]	:	295.8
Number of SG	:	6
Containment type	:	Confinement
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	4.4
Output voltage [kV]	:	-
Primary means of condenser cooling	:	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 (2020)

Net Energy Production	:	2896.19 GW(e).h
Energy Availability Factor (EAF)	:	87.68 %
Unit Capability Factor (UCF)	:	88.49 %
Load Factor (LF)	:	87.69 %
Operating Factor (OF)	:	90.1 %
Equivalent non-electrical energy generated (NEG)	:	22.98 GW(e).h

Forced Loss Rate (FLR)	:	0.33 %
Unplanned Capability Loss Factor (UCL)	:	0.29 %
Planned Unavailability Factor (PUF)	:	11.22 %
Externally cause unavailability (XUF)	:	0.8 %
Total off-line time	:	870 hours

Annual Summary



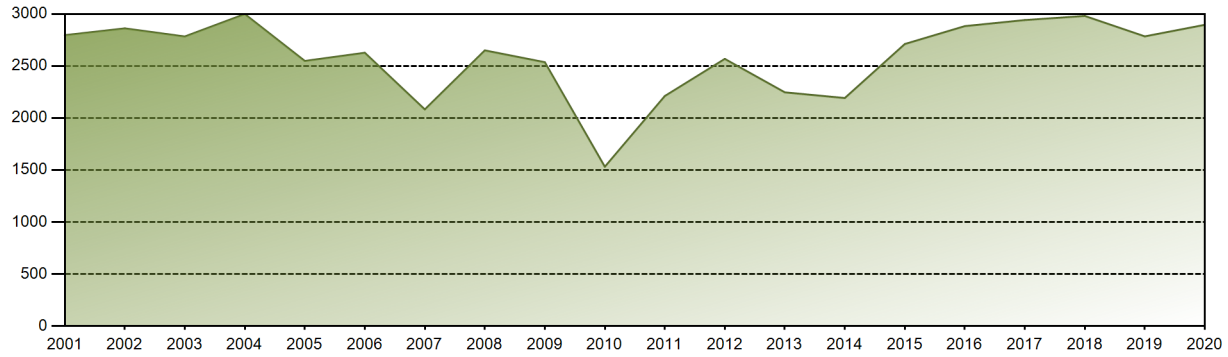
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	288.88	267.23	117.67	54.05	285.31	251.29	268.03	234.83	265.65	289.12	284.69	289.45	2896.19
EAF [%]	100.00	100.00	42.47	20.96	100.00	93.87	97.19	97.57	99.69	100.00	100.00	100.00	87.68
UCF [%]	100.00	100.00	45.05	21.88	100.00	96.46	99.11	98.96	99.90	100.00	100.00	100.00	88.49
LF [%]	103.26	102.11	42.12	19.96	101.99	92.82	95.81	83.94	98.13	103.21	105.16	103.47	87.69
OF [%]	100.00	100.00	45.22	35.69	100.00	100.00	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	3.54	0.00	0.00	0.00	0.00	0.00	0.00	0.33
UCL [%]	0.00	0.00	0.00	0.00	0.00	3.54	0.00	0.00	0.00	0.00	0.00	0.00	0.29
PUF [%]	0.00	0.00	54.95	78.12	0.00	0.00	0.89	1.04	0.10	0.00	0.00	0.00	11.22
XUF [%]	0.00	0.00	2.57	0.92	0.00	2.59	1.93	1.39	0.21	0.00	0.00	0.00	0.80

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Historical Summary

Lifetime energy generation	:	101367.19 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.33 %
Cumulative Energy Availability Factor (EAF)	:	80.39 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.8 %
Cumulative Unit Capability Factor (UCF)	:	81.34 %	Cumulative Planned Unavailability Factor (PUF)	:	15.86 %
Cumulative Load Factor (LF)	:	78.56 %	Cumulative Externally cause unavailability (XUF)	:	0.95 %
Cumulative Operating Factor (OF)	:	82.77 %			

Electricity Production (net) [GWh]

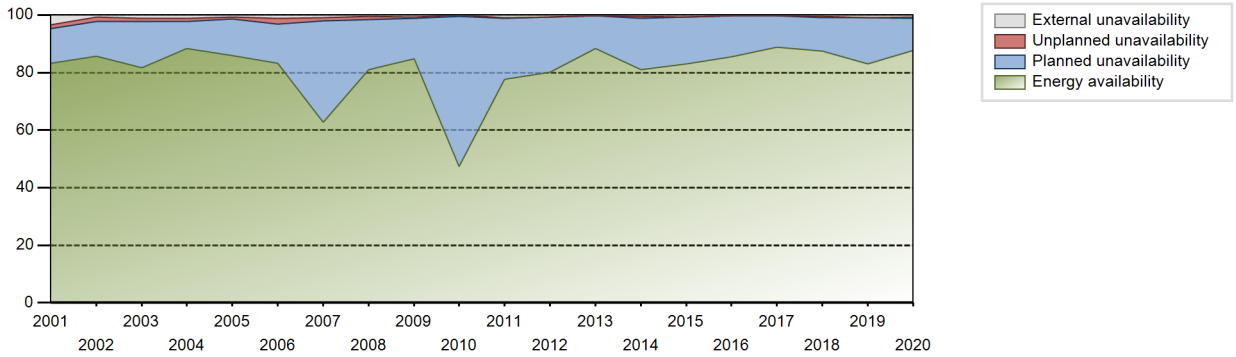


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1982	2062.20	8011	384	88.98	88.98	85.84	99.70	11.02	11.02	0.00	0.00
1983	1926.94	5572	384	58.00	58.00	57.28	63.61	9.34	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

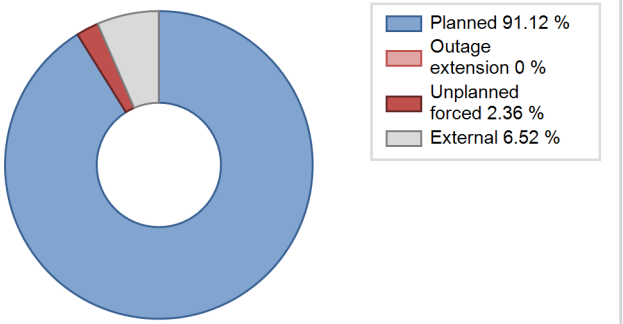
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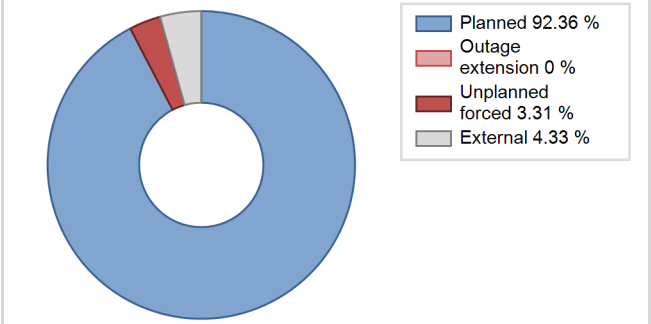
2019	2785.09	7395	376	83.01	83.84	84.56	84.42	0.00	0.00	16.16	0.82
2020	2896.19	7914	376	87.68	88.49	87.69	90.10	0.33	0.29	11.22	0.80

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1982 to 2020 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	870			1129		
D.	Inspection, maintenance or repair without refuelling				165		
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)						67
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				28		
Subtotal		870			1322	104	76
Total		**870**			**1502**		

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Equipment Related Unplanned Full Outages, Analysis by System		
System	2020	1982 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		2
15. Reactor Cooling Systems		5
16. Steam generation systems		61
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		0
32. Feedwater and Main Steam System		11
41. Main Generator Systems		2
42. Electrical Power Supply Systems		6
Total		**100**

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2020 Operating Experience

UA-29 ROVNO-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	:	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

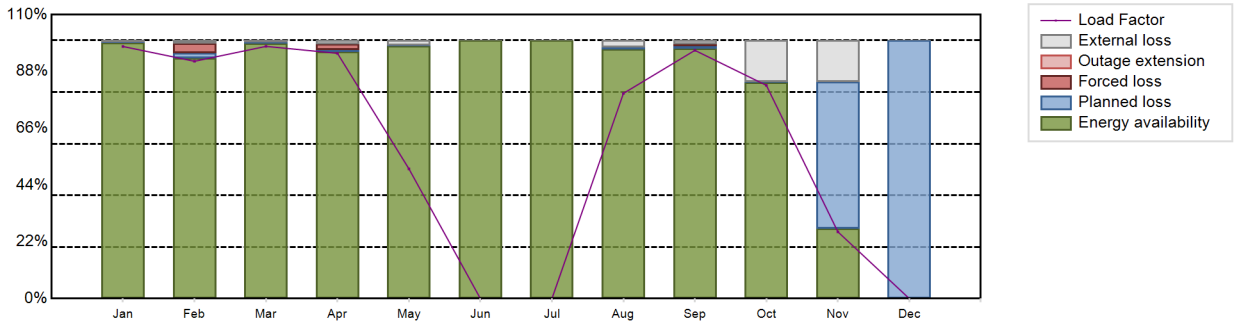
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.4
Output voltage [kV]	:	-
Primary means of condenser cooling	:	Cooling towers
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 (2020)

Net Energy Production	:	4974.66 GW(e).h
Energy Availability Factor (EAF)	:	82.41 %
Unit Capability Factor (UCF)	:	85.86 %
Load Factor (LF)	:	59.61 %
Operating Factor (OF)	:	65.93 %
Equivalent non-electrical energy generated (NEG)	:	31.7 GW(e).h

Forced Loss Rate (FLR)	:	0.65 %
Unplanned Capability Loss Factor (UCL)	:	0.56 %
Planned Unavailability Factor (PUF)	:	13.57 %
Externally cause unavailability (XUF)	:	3.46 %
Total off-line time	:	2993 hours

Annual Summary



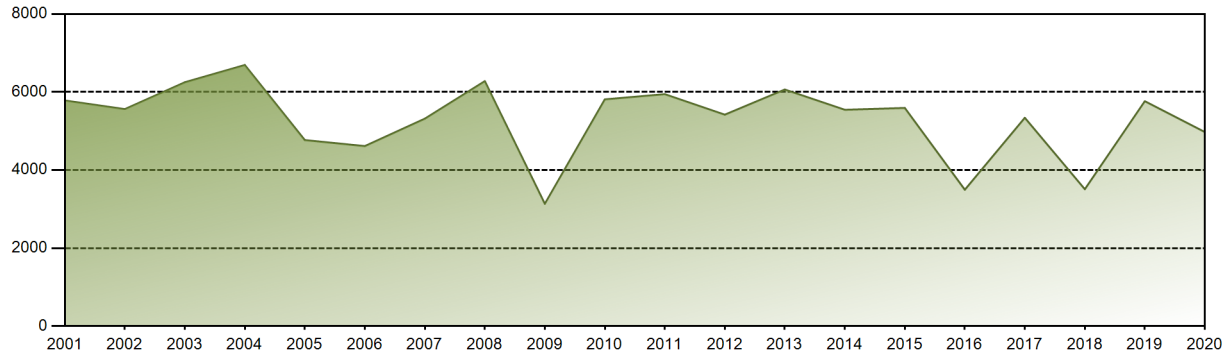
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	690.32	607.85	689.67	649.95	355.37	0.00	0.00	561.92	657.80	584.66	177.11	0.00	4974.66
EAF [%]	99.10	93.24	98.90	95.66	97.84	100.00	100.00	96.55	96.95	83.85	27.18	0.00	82.41
UCF [%]	99.66	94.29	99.65	96.99	99.62	100.00	100.00	99.28	98.25	99.78	43.26	0.00	85.86
LF [%]	97.67	91.93	97.71	95.02	50.28	0.00	0.00	79.50	96.17	82.61	25.89	0.00	59.61
OF [%]	100.00	96.41	100.00	99.31	66.26	0.00	0.00	87.10	100.00	100.00	43.33	0.00	65.93
FLR [%]	0.00	3.97	0.00	2.33	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.65
UCL [%]	0.00	3.90	0.00	2.31	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.56
PUF [%]	0.34	1.81	0.35	0.70	0.38	0.00	0.00	0.72	0.97	0.22	56.74	100.00	13.57
XUF [%]	0.56	1.06	0.75	1.33	1.78	0.00	0.00	2.72	1.30	15.93	16.08	0.00	3.46

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Historical Summary

Lifetime energy generation	:	185306.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.9 %
Cumulative Energy Availability Factor (EAF)	:	69.37 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.6 %
Cumulative Unit Capability Factor (UCF)	:	71.27 %	Cumulative Planned Unavailability Factor (PUF)	:	24.13 %
Cumulative Load Factor (LF)	:	65.82 %	Cumulative Externally cause unavailability (XUF)	:	1.9 %
Cumulative Operating Factor (OF)	:	72.4 %			

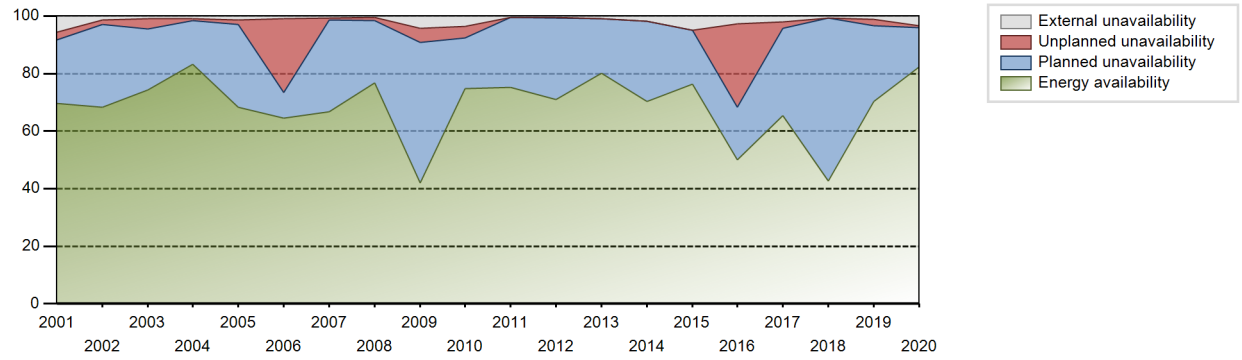
Electricity Production (net) [GWh]



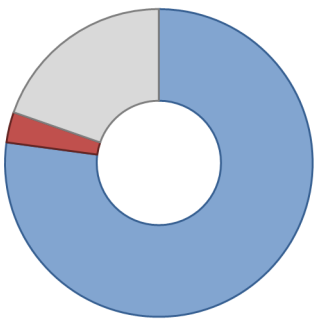
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	5202.19	6485	1000	82.32	82.32	70.62	79.97	13.74	13.11	4.57	0.00
1988	5661.32	6357	950	71.05	71.05	67.84	72.37	4.72	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

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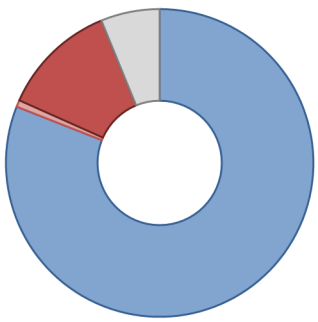
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		29			296	
C. Inspection, maintenance or repair combined with refuelling	1152			1609		
D. Inspection, maintenance or repair without refuelling				213		
E. Testing of plant systems or components				17		
F. Major backfitting, refurbishment or upgrading activities with refuelling				162		
H. Nuclear regulatory requirements					11	
J. Grid limitation, failure or grid unavailability						5
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			1811			68
L. Human factor related					6	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)						6
Z. Other					2	22
Subtotal	1152	29	1811	2001	315	101
Total		**2992**			**2417**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		24
13. Reactor Auxiliary Systems		13
15. Reactor Cooling Systems		16
16. Steam generation systems		20
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries	25	28
32. Feedwater and Main Steam System		7
33. Circulating Water System		1
34. Miscellaneous Systems	5	0
35. All other I&C Systems		1
41. Main Generator Systems		177
42. Electrical Power Supply Systems		26
Total	**30**	**333**

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2020 Operating Experience

UA-69 ROVNO-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	:	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]	:	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

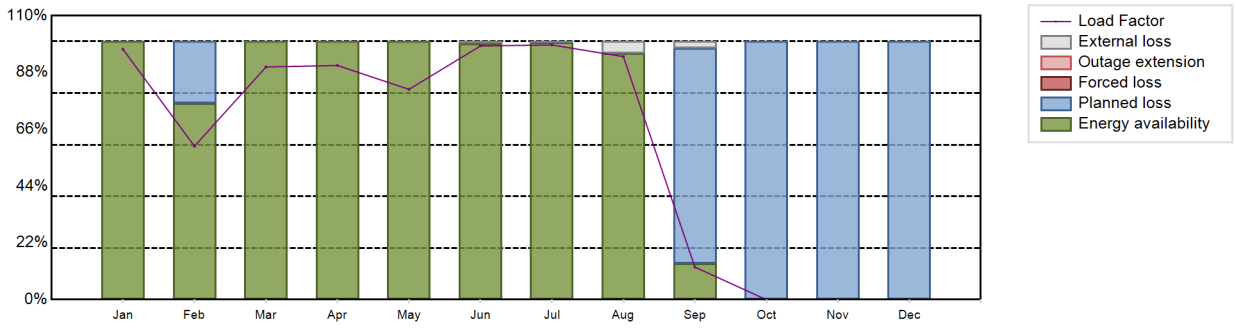
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.4
Output voltage [kV]	:	-
Primary means of condenser cooling	:	Cooling towers
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 (2020)

Net Energy Production	:	5031.02 GW(e).h
Energy Availability Factor (EAF)	:	65.39 %
Unit Capability Factor (UCF)	:	66.07 %
Load Factor (LF)	:	60.29 %
Operating Factor (OF)	:	64.87 %
Equivalent non-electrical energy generated (NEG)	:	45.9 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	33.93 %
Externally cause unavailability (XUF)	:	0.68 %
Total off-line time	:	3086 hours

Annual Summary



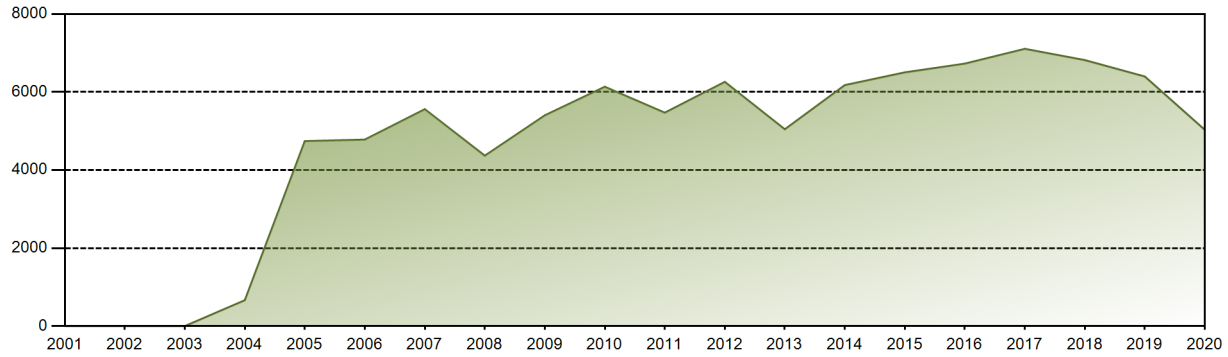
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	685.41	392.90	635.98	620.37	575.71	672.02	697.23	665.21	86.18	0.00	0.00	0.00	5031.02
EAF [%]	100.00	75.93	100.00	100.00	100.00	99.17	99.59	95.34	13.89	0.00	0.00	0.00	65.39
UCF [%]	100.00	75.93	100.00	100.00	100.00	99.75	99.90	99.90	16.55	0.00	0.00	0.00	66.07
LF [%]	96.97	59.42	90.10	90.70	81.45	98.25	98.65	94.12	12.60	0.00	0.00	0.00	60.29
OF [%]	100.00	67.96	100.00	100.00	92.74	100.00	100.00	100.00	16.67	0.00	0.00	0.00	64.87
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	24.07	0.00	0.00	0.00	0.25	0.10	0.10	83.45	100.00	100.00	100.00	33.93
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.58	0.31	4.56	2.66	0.00	0.00	0.00	0.68

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Historical Summary

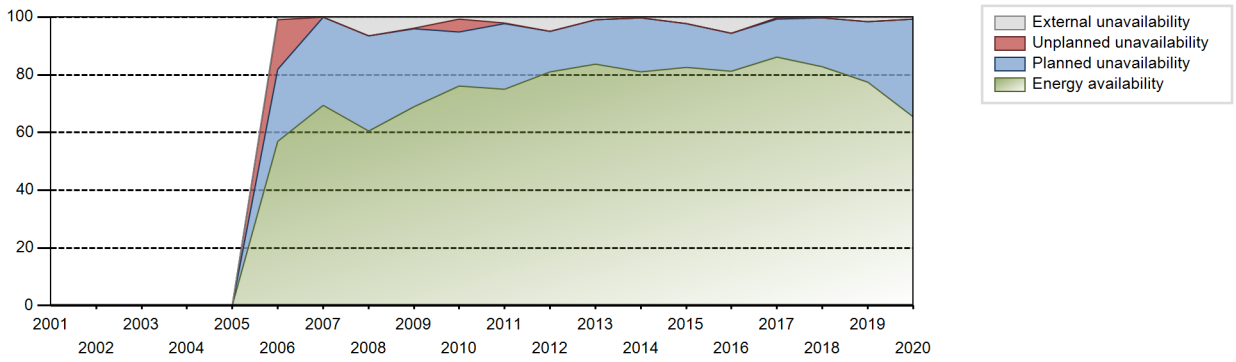
Lifetime energy generation	:	93293.02 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.43 %
Cumulative Energy Availability Factor (EAF)	:	75.51 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.23 %
Cumulative Unit Capability Factor (UCF)	:	77.58 %	Cumulative Planned Unavailability Factor (PUF)	:	21.19 %
Cumulative Load Factor (LF)	:	70.2 %	Cumulative Externally cause unavailability (XUF)	:	2.07 %
Cumulative Operating Factor (OF)	:	81.68 %			

Electricity Production (net) [GWh]



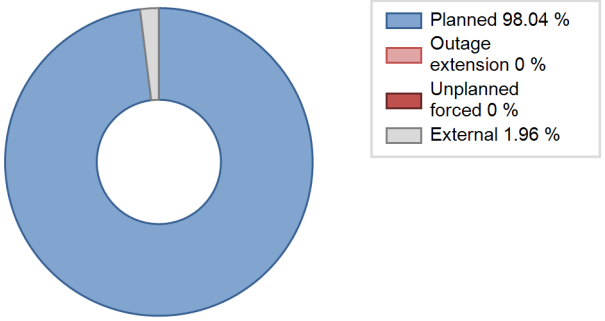
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2006	4781.15	6030	950	57.03	57.93	51.75	65.55	22.84	17.15	24.92	0.90
2007	5560.92	7657	950	69.47	69.56	66.82	87.41	0.06	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

Key Factors in Last 20 Years [%]

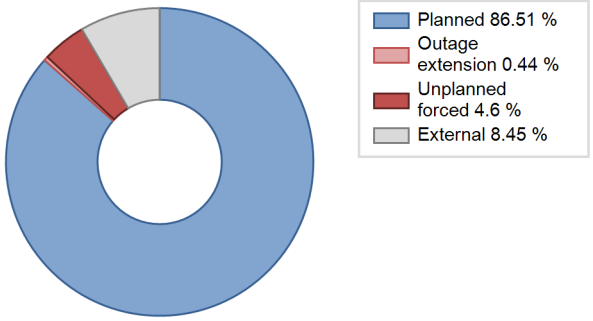


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Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			2006 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					46	
C. Inspection, maintenance or repair combined with refuelling	2808			1409		
D. Inspection, maintenance or repair without refuelling	166			144		
H. Nuclear regulatory requirements					9	
J. Grid limitation, failure or grid unavailability						1
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			111			27
Subtotal	2974		111	1553	55	28
Total	**3085**			**1636**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	2006 to 2020 Average hours lost per reactor-year
31. Turbine and auxiliaries		1
41. Main Generator Systems		43
42. Electrical Power Supply Systems		2
Total		**46**

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2020 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

Reactor type and model	:	PWR / VVER V-302
Thermal power	:	3000 MWth
Gross electrical power	:	1000 MWe
Reference unit power (net)	:	950 MWe

Key Dates

Construction Date	:	1976-08-01
Grid Date	:	1982-12-31
Commercial Date	:	1983-12-02
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]	:	-
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	:	49
Number of external reactor coolant loops	:	4
Coolant type	:	H2O

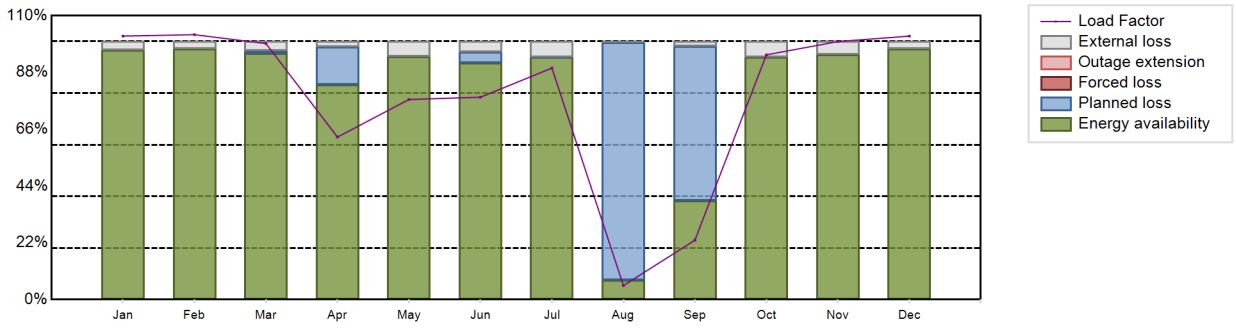
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	6521.17 GW(e).h
Energy Availability Factor (EAF)	:	81.97 %
Unit Capability Factor (UCF)	:	85.67 %
Load Factor (LF)	:	78.15 %
Operating Factor (OF)	:	85.7 %
Equivalent non-electrical energy generated (NEG)	:	26.51 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	14.33 %
Externally cause unavailability (XUF)	:	3.7 %
Total off-line time	:	1256 hours

Annual Summary



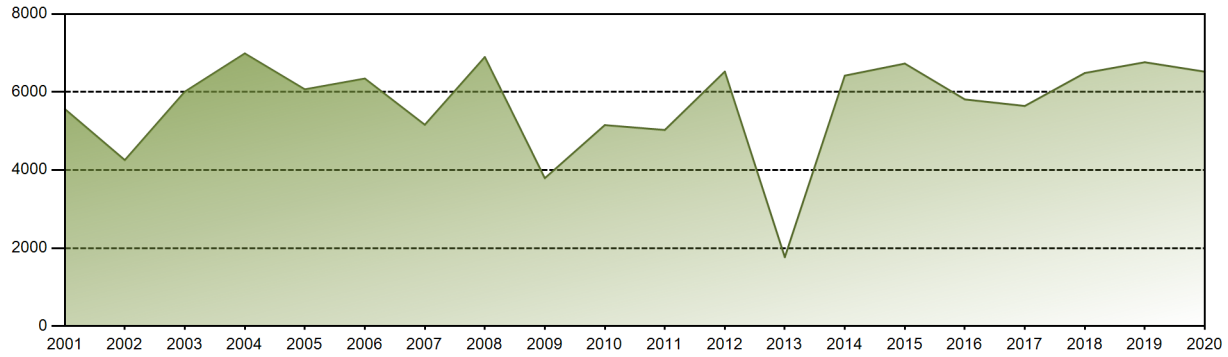
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	721.60	678.55	700.05	430.73	547.87	536.28	633.96	38.51	157.41	671.08	683.70	721.42	6521.17
EAF [%]	96.64	97.15	95.48	83.22	94.23	91.70	94.02	7.47	38.21	93.80	94.97	97.12	81.97
UCF [%]	100.00	100.00	99.12	85.37	100.00	95.79	100.00	7.87	40.17	100.00	100.00	100.00	85.67
LF [%]	102.09	102.62	99.18	62.97	77.51	78.40	89.69	5.45	23.01	94.82	99.96	102.07	78.15
OF [%]	100.00	100.00	100.00	82.92	100.00	97.08	100.00	8.06	40.56	100.00	100.00	100.00	85.70
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	0.88	14.63	0.00	4.21	0.00	92.13	59.83	0.00	0.00	0.00	14.33
XUF [%]	3.36	2.85	3.64	2.15	5.77	4.10	5.98	0.39	1.96	6.20	5.03	2.88	3.70

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Historical Summary

Lifetime energy generation	:	203283.17 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.69 %
Cumulative Energy Availability Factor (EAF)	:	68.01 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.31 %
Cumulative Unit Capability Factor (UCF)	:	70.28 %	Cumulative Planned Unavailability Factor (PUF)	:	25.41 %
Cumulative Load Factor (LF)	:	67.22 %	Cumulative Externally cause unavailability (XUF)	:	2.27 %
Cumulative Operating Factor (OF)	:	72.21 %			

Electricity Production (net) [GWh]

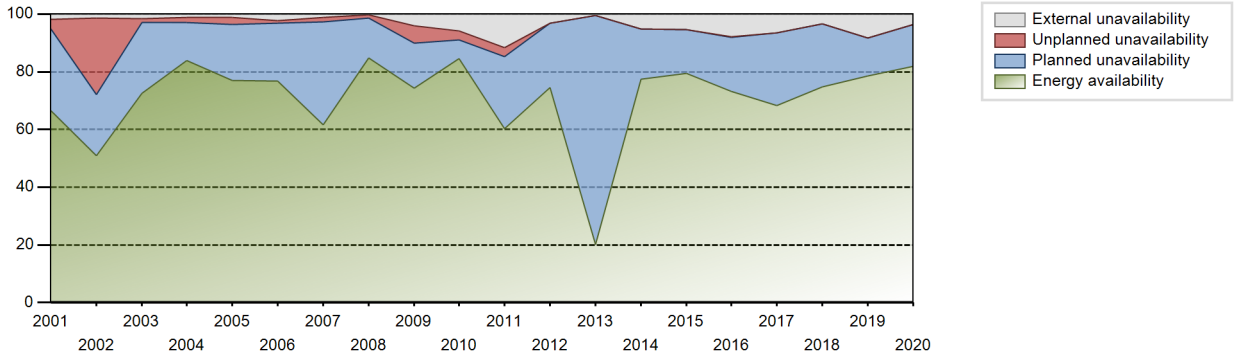


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	2558.83	3708	950	95.23	95.23	95.74	95.30	4.77	4.77	0.00	0.00
1984	6075.07	6364	950	71.66	71.66	72.80	72.45	11.12	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

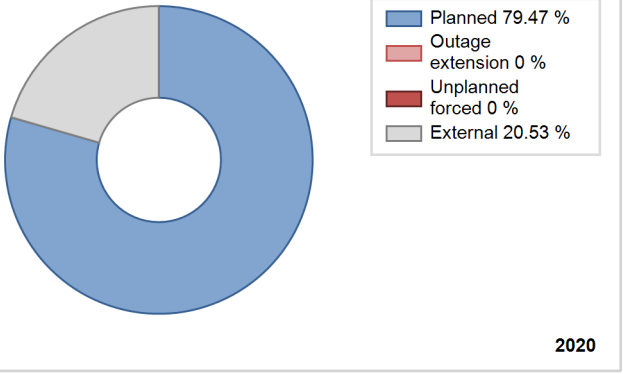
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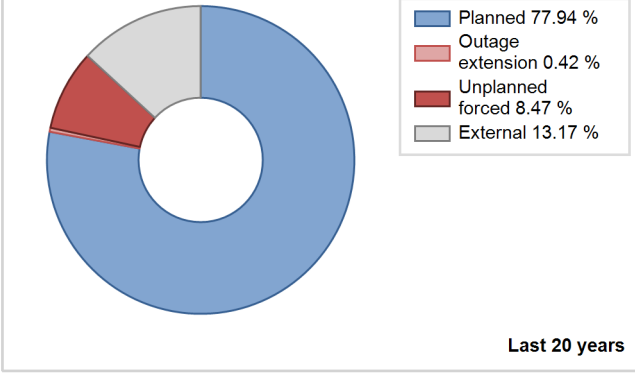
2020	6521.17	7528	950	81.97	85.67	78.15	85.70	0.00	0.00	14.33	3.70

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1983 to 2020 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	1111			1719		
D. Inspection, maintenance or repair without refuelling	144			282		
E. Testing of plant systems or components				8	1	
J. Grid limitation, failure or grid unavailability						1
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						108
L. Human factor related					2	
Z. Other					29	1
Subtotal	1255			2009	344	110
Total	**1255**			**2463**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1983 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		10
14. Safety Systems		1
15. Reactor Cooling Systems		4
16. Steam generation systems		149
31. Turbine and auxiliaries		44
32. Feedwater and Main Steam System		6
33. Circulating Water System		1
34. Miscellaneous Systems		1
35. All other I&C Systems		1
41. Main Generator Systems		88
42. Electrical Power Supply Systems		2
Total		**307**

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2020 Operating Experience

UA-45 SOUTH UKRAINE-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	:	PAA (PRODUCTION AMALGAMATION 'ATOMMASH', VOLGODONSK)
Turbine Supplier	:	KTP (Kharkiv Turbine Plant "Turboatom")

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	:	1981-07-01
Grid Date	:	1985-01-06
Commercial Date	:	1985-04-06
Age at end of year	:	35 years

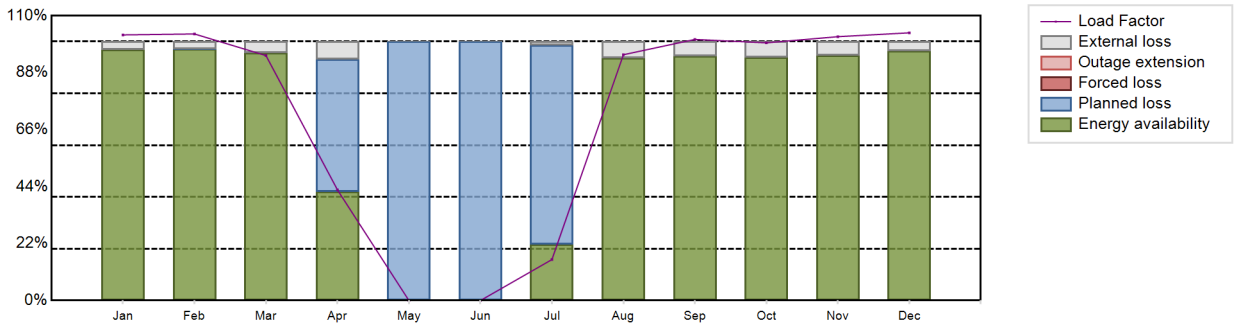
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	H2O
Average fuel enrichment [% of U235]	:	-
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 (2020)

Net Energy Production	:	5970.49 GW(e).h
Energy Availability Factor (EAF)	:	68.83 %
Unit Capability Factor (UCF)	:	72.63 %
Load Factor (LF)	:	71.55 %
Operating Factor (OF)	:	72.78 %
Equivalent non-electrical energy generated (NEG)	:	42.31 GW(e).h
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	27.37 %
Externally cause unavailability (XUF)	:	3.8 %
Total off-line time	:	2391 hours

Annual Summary



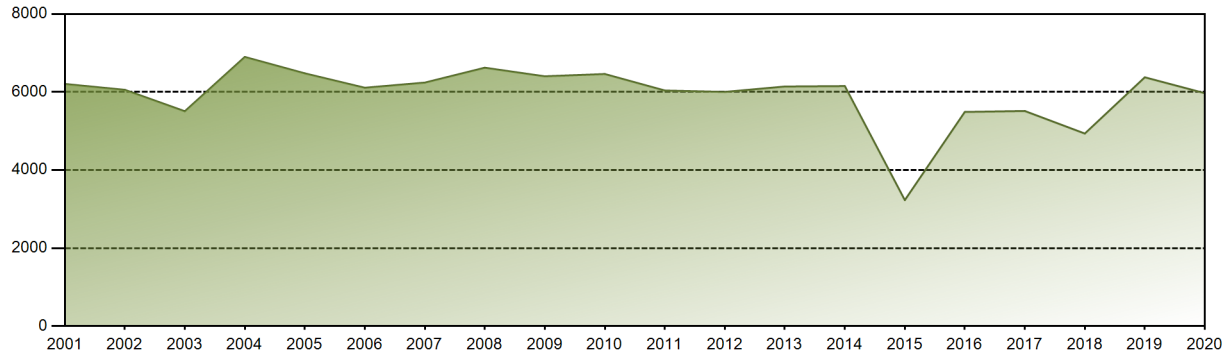
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	725.01	680.71	667.77	292.38	0.00	0.00	111.84	670.93	689.68	704.44	696.97	730.74	5970.49
EAF [%]	96.80	97.23	95.62	42.10	0.00	0.00	21.62	93.70	94.30	93.98	94.55	96.48	68.83
UCF [%]	100.00	99.99	100.00	48.95	0.00	0.00	23.03	100.00	100.00	100.00	100.00	100.00	72.63
LF [%]	102.58	102.95	94.61	42.75	0.00	0.00	15.82	94.93	100.83	99.53	101.90	103.39	71.55
OF [%]	100.00	100.00	100.00	49.17	0.00	0.00	24.60	100.00	100.00	100.00	100.00	100.00	72.78
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	51.05	100.00	100.00	76.97	0.00	0.00	0.00	0.00	0.00	27.37
XUF [%]	3.20	2.76	4.38	6.85	0.00	0.00	1.41	6.30	5.70	6.02	5.45	3.52	3.80

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Historical Summary

Lifetime energy generation	:	190488.49 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	11.96 %
Cumulative Energy Availability Factor (EAF)	:	64.83 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.16 %
Cumulative Unit Capability Factor (UCF)	:	67.09 %	Cumulative Planned Unavailability Factor (PUF)	:	23.75 %
Cumulative Load Factor (LF)	:	64.99 %	Cumulative Externally cause unavailability (XUF)	:	2.27 %
Cumulative Operating Factor (OF)	:	71.63 %			

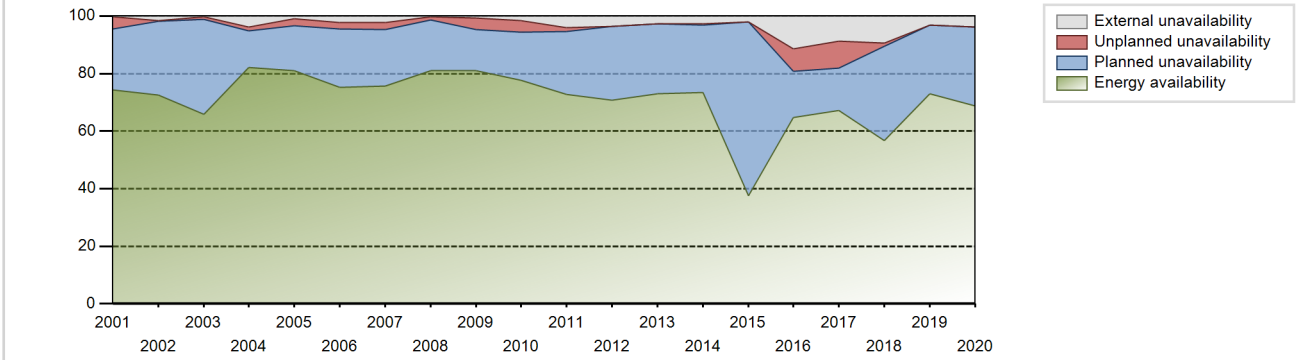
Electricity Production (net) [GWh]



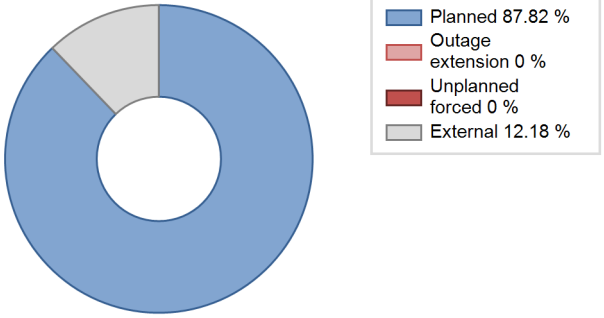
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	5603.65	6379	950	73.30	73.30	74.42	74.59	9.42	7.63	19.07	0.00
1986	5565.48	6315	950	66.25	67.00	66.88	72.09	10.56	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

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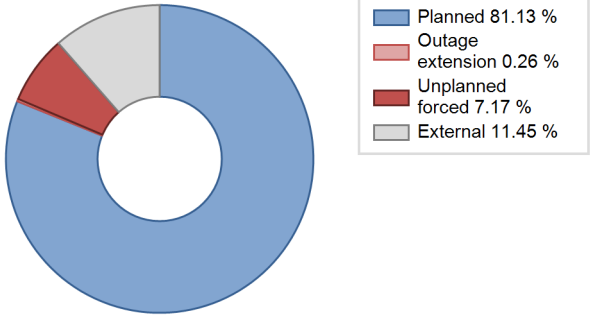
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					398	
C. Inspection, maintenance or repair combined with refuelling	2391			1476		
D. Inspection, maintenance or repair without refuelling				339		
E. Testing of plant systems or components				8		
F. Major backfitting, refurbishment or upgrading activities with refuelling				146		
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					43	
Subtotal	2391			1969	446	4
Total	**2391**			**2419**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		43
12. Reactor I&C Systems		6
14. Safety Systems		0
15. Reactor Cooling Systems		21
16. Steam generation systems		265
17. Safety I&C Systems (excluding reactor I&C)		7
31. Turbine and auxiliaries		20
32. Feedwater and Main Steam System		24
34. Miscellaneous Systems		4
41. Main Generator Systems		47
42. Electrical Power Supply Systems		1
Total		**438**

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2020 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

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	:	1984-11-01
Grid Date	:	1989-09-20
Commercial Date	:	1989-12-29
Age at end of year	:	31 years

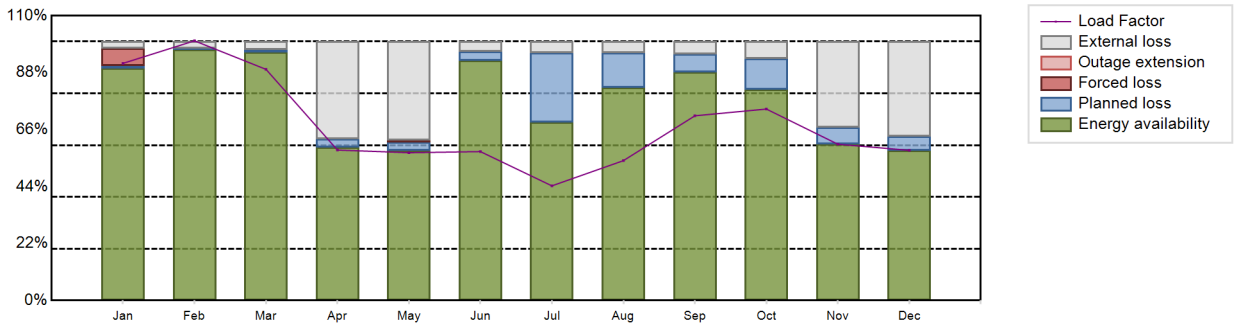
Design Characteristics

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]	:	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]	:	3000
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 (2020)

Net Energy Production	:	5664.51 GW(e).h
Energy Availability Factor (EAF)	:	77.55 %
Unit Capability Factor (UCF)	:	92.38 %
Load Factor (LF)	:	67.88 %
Operating Factor (OF)	:	96.65 %
Equivalent non-electrical energy generated (NEG)	:	47.96 GW(e).h
Forced Loss Rate (FLR)	:	0.69 %
Unplanned Capability Loss Factor (UCL)	:	0.64 %
Planned Unavailability Factor (PUF)	:	6.97 %
Externally cause unavailability (XUF)	:	14.84 %
Total off-line time	:	294 hours

Annual Summary



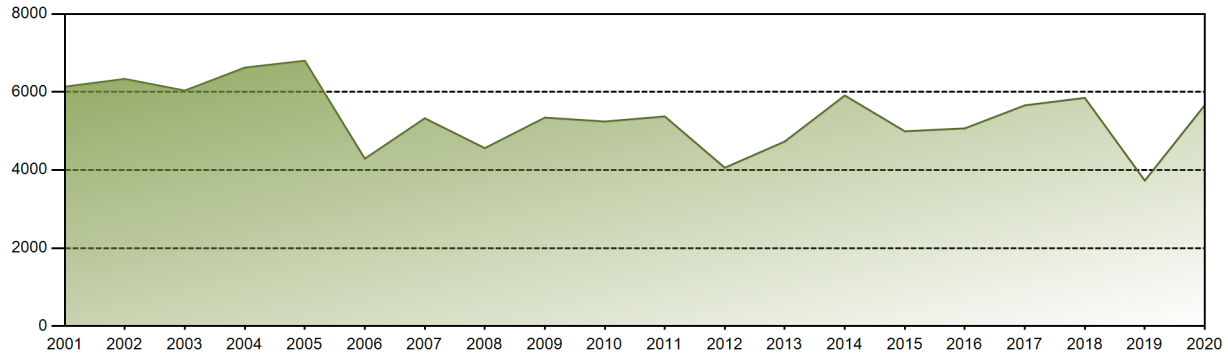
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	647.41	663.20	630.30	397.47	403.49	393.39	313.07	381.84	487.99	523.39	412.93	410.03	5664.51
EAF [%]	89.63	96.89	95.85	59.20	58.04	92.72	68.88	82.35	88.09	81.54	60.36	57.98	77.55
UCF [%]	92.15	99.39	98.93	96.87	96.09	96.67	73.21	86.76	92.97	88.07	93.63	94.66	92.38
LF [%]	91.60	100.30	89.30	58.11	57.09	57.51	44.29	54.02	71.34	73.95	60.37	58.01	67.88
OF [%]	93.68	100.00	100.00	100.00	99.19	100.00	77.82	92.20	100.00	97.58	100.00	100.00	96.65
FLR [%]	6.94	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69
UCL [%]	6.88	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64
PUF [%]	0.98	0.61	1.07	3.13	3.19	3.33	26.79	13.24	7.03	11.93	6.37	5.34	6.97
XUF [%]	2.52	2.50	3.08	37.67	38.06	3.95	4.33	4.41	4.88	6.53	33.27	36.68	14.84

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Historical Summary

Lifetime energy generation	:	167148.51 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.09 %
Cumulative Energy Availability Factor (EAF)	:	68.6 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.04 %
Cumulative Unit Capability Factor (UCF)	:	71.93 %	Cumulative Planned Unavailability Factor (PUF)	:	24.04 %
Cumulative Load Factor (LF)	:	66.54 %	Cumulative Externally cause unavailability (XUF)	:	3.33 %
Cumulative Operating Factor (OF)	:	74 %			

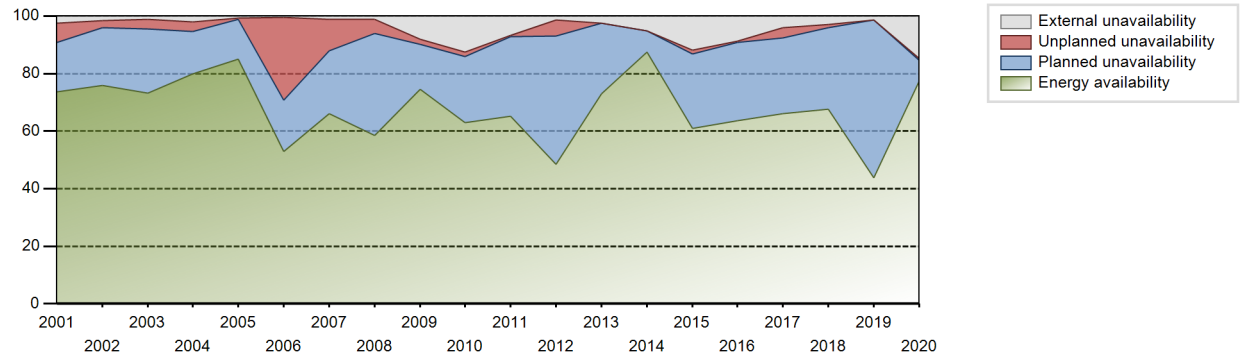
Electricity Production (net) [GWh]



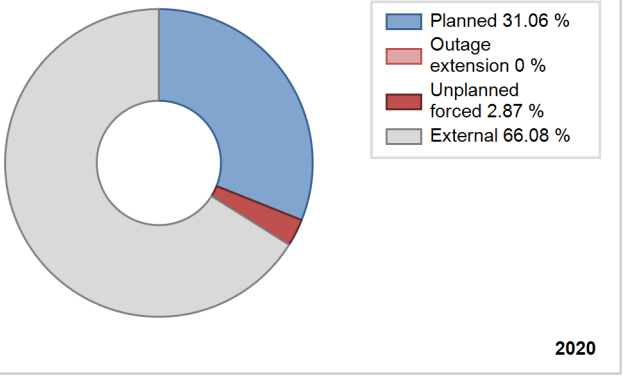
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	1299.66	1992	950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	5691.56	6408	950	69.37	69.37	68.39	73.15	13.24	10.58	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

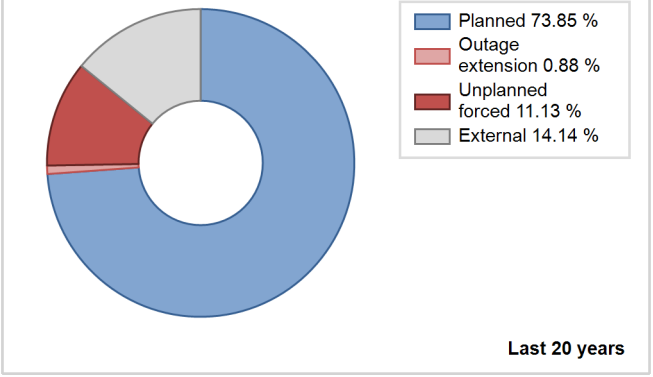
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		53			213	
C. Inspection, maintenance or repair combined with refuelling				1747		
D. Inspection, maintenance or repair without refuelling	241			220		
E. Testing of plant systems or components				13		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						67
L. Human factor related					0	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					16	
Subtotal	241	53		1980	229	67
Total		**294**			**2276**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems		0
15. Reactor Cooling Systems		2
16. Steam generation systems		5
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		19
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	47	174
42. Electrical Power Supply Systems	6	1
Total	**53**	**212**

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2020 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

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	:	1980-04-01
Grid Date	:	1984-12-10
Commercial Date	:	1985-12-25
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]	:	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

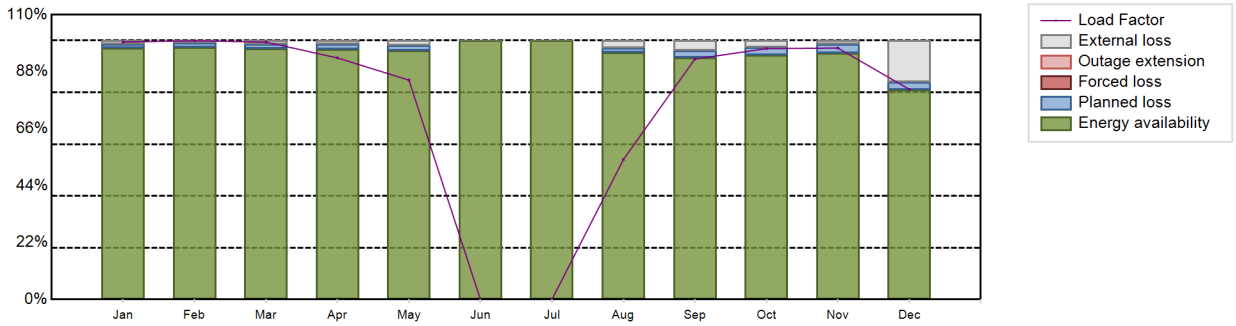
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	6243.86 GW(e).h
Energy Availability Factor (EAF)	:	95.29 %
Unit Capability Factor (UCF)	:	98.09 %
Load Factor (LF)	:	74.82 %
Operating Factor (OF)	:	80.9 %
Equivalent non-electrical energy generated (NEG)	:	44.45 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	1.91 %
Externally cause unavailability (XUF)	:	2.8 %
Total off-line time	:	1678 hours

Annual Summary



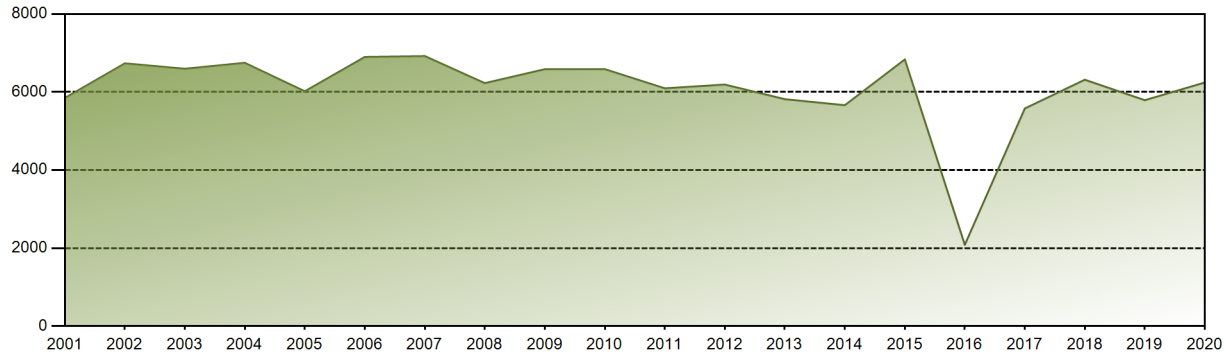
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	702.93	660.81	701.84	638.17	598.90	0.00	0.00	382.24	635.37	685.72	664.33	573.56	6243.86
EAF [%]	97.20	97.49	96.86	96.74	96.26	100.00	100.00	95.28	93.31	94.35	95.15	81.10	95.29
UCF [%]	98.47	98.43	98.22	98.00	98.09	100.00	100.00	98.05	97.10	96.87	96.61	97.24	98.09
LF [%]	99.45	99.94	99.43	93.30	84.73	0.00	0.00	54.08	92.89	96.89	97.12	81.15	74.82
OF [%]	100.00	100.00	100.00	100.00	100.00	1.53	0.00	69.76	100.00	100.00	100.00	100.00	80.90
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 [%]	1.53	1.57	1.78	2.00	1.91	0.00	0.00	1.95	2.90	3.13	3.39	2.76	1.91
XUF [%]	1.26	0.95	1.36	1.26	1.83	0.00	0.00	2.77	3.79	2.52	1.46	16.14	2.80

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Historical Summary

Lifetime energy generation	:	189423.86 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.1 %
Cumulative Energy Availability Factor (EAF)	:	66.72 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.41 %
Cumulative Unit Capability Factor (UCF)	:	68.85 %	Cumulative Planned Unavailability Factor (PUF)	:	25.74 %
Cumulative Load Factor (LF)	:	65.16 %	Cumulative Externally cause unavailability (XUF)	:	2.14 %
Cumulative Operating Factor (OF)	:	71.02 %			

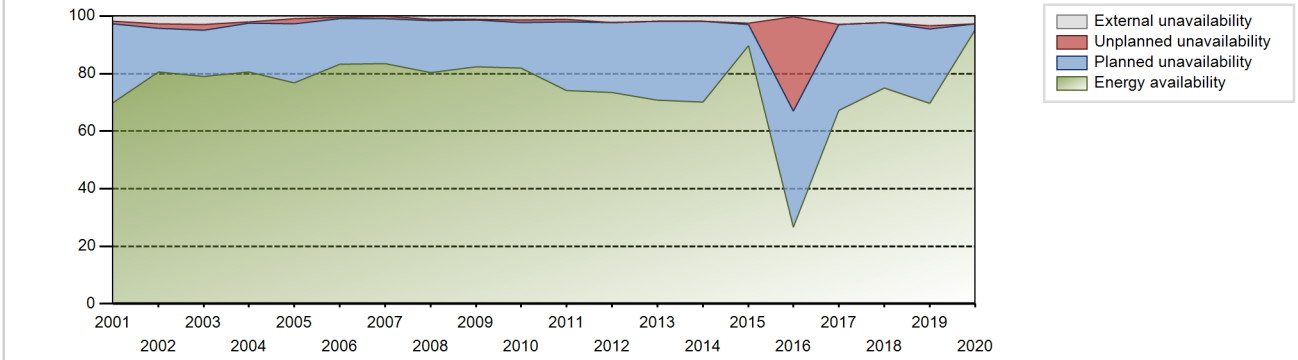
Electricity Production (net) [GWh]



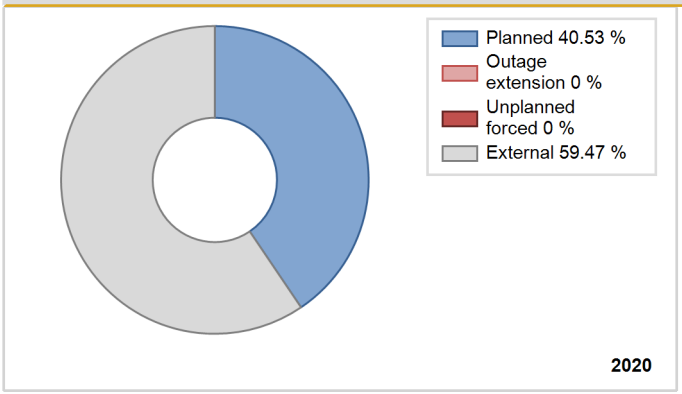
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	4051.06	5893	950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1986	4826.26	5580	950	58.26	61.54	57.99	63.70	19.03	14.46	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

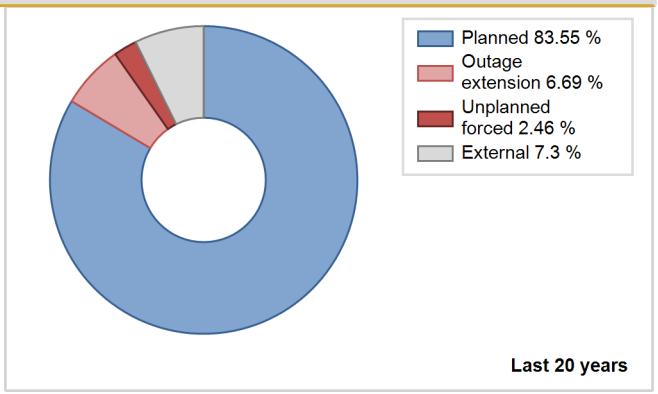
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 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				1558	23	
D. Inspection, maintenance or repair without refuelling				487		
E. Testing of plant systems or components				4		
F. Major backfitting, refurbishment or upgrading activities with refuelling				108	82	
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			1678			72
L. Human factor related					8	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						6
Z. Other					3	
Subtotal			1678	2157	342	78
Total		**1678**			**2577**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		31
15. Reactor Cooling Systems		22
16. Steam generation systems		59
17. Safety I&C Systems (excluding reactor I&C)		5
31. Turbine and auxiliaries		37
32. Feedwater and Main Steam System		24
33. Circulating Water System		2
34. Miscellaneous Systems		10
35. All other I&C Systems		0
41. Main Generator Systems		24
42. Electrical Power Supply Systems		10
Total		**227**

Highlights (2020)

During the year there was not maintenance combined with refuelling.

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2020 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	:	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]	:	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

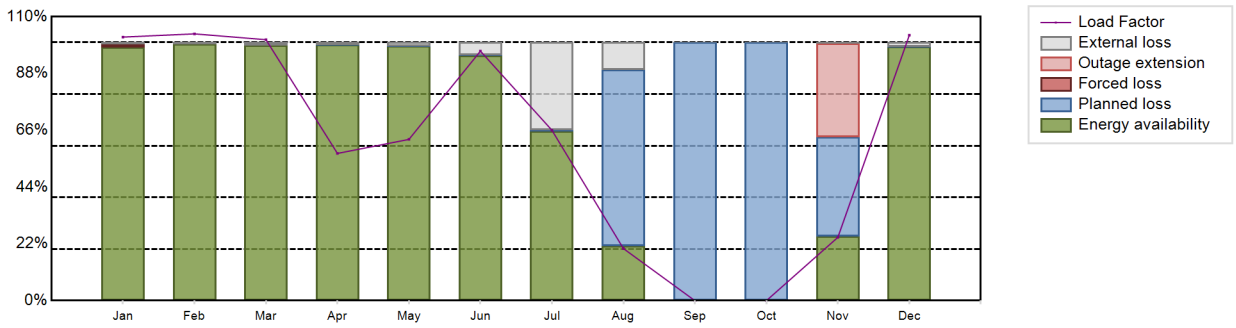
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	5114.54 GW(e).h
Energy Availability Factor (EAF)	:	66.52 %
Unit Capability Factor (UCF)	:	71.24 %
Load Factor (LF)	:	61.29 %
Operating Factor (OF)	:	65.84 %
Equivalent non-electrical energy generated (NEG)	:	30.82 GW(e).h

Forced Loss Rate (FLR)	:	0.13 %
Unplanned Capability Loss Factor (UCL)	:	3.07 %
Planned Unavailability Factor (PUF)	:	25.7 %
Externally cause unavailability (XUF)	:	4.71 %
Total off-line time	:	3001 hours

Annual Summary



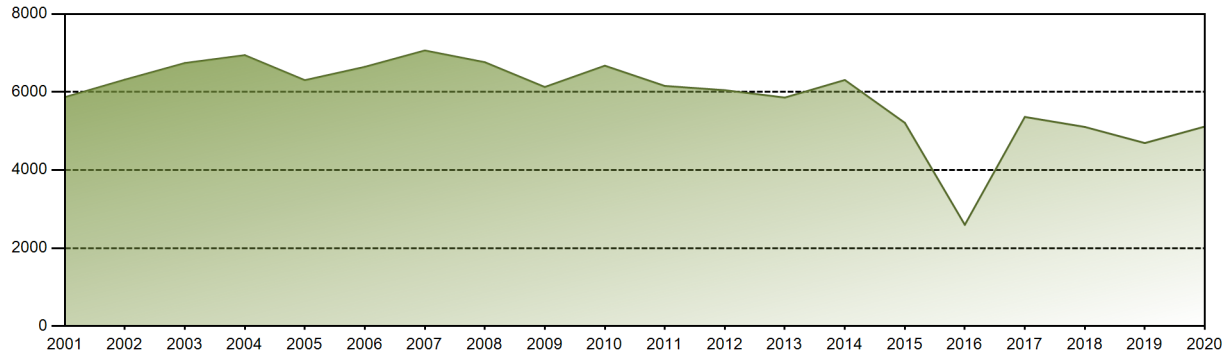
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	721.50	683.24	713.42	390.05	441.43	661.08	466.57	142.68	0.00	0.00	167.74	726.84	5114.55
EAF [%]	98.12	99.40	98.86	99.01	98.63	95.01	65.65	21.09	0.00	0.00	24.94	98.31	66.52
UCF [%]	98.87	100.00	100.00	99.86	99.93	99.90	99.48	31.73	0.00	0.00	25.28	99.84	71.24
LF [%]	102.08	103.33	101.07	57.02	62.45	96.65	66.01	20.19	0.00	0.00	24.52	102.84	61.29
OF [%]	99.19	100.00	100.00	66.94	64.65	100.00	100.00	32.26	0.00	0.00	27.08	100.00	65.84
FLR [%]	1.13	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 [%]	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.25	0.00	3.07
PUF [%]	0.00	0.00	0.00	0.14	0.07	0.10	0.52	68.27	100.00	100.00	38.47	0.16	25.70
XUF [%]	0.75	0.60	1.14	0.85	1.30	4.89	33.83	10.65	0.00	0.00	0.33	1.53	4.71

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Historical Summary

Lifetime energy generation	:	188718.54 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.93 %
Cumulative Energy Availability Factor (EAF)	:	68.38 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.01 %
Cumulative Unit Capability Factor (UCF)	:	70.93 %	Cumulative Planned Unavailability Factor (PUF)	:	25.06 %
Cumulative Load Factor (LF)	:	65.96 %	Cumulative Externally cause unavailability (XUF)	:	2.55 %
Cumulative Operating Factor (OF)	:	72.56 %			

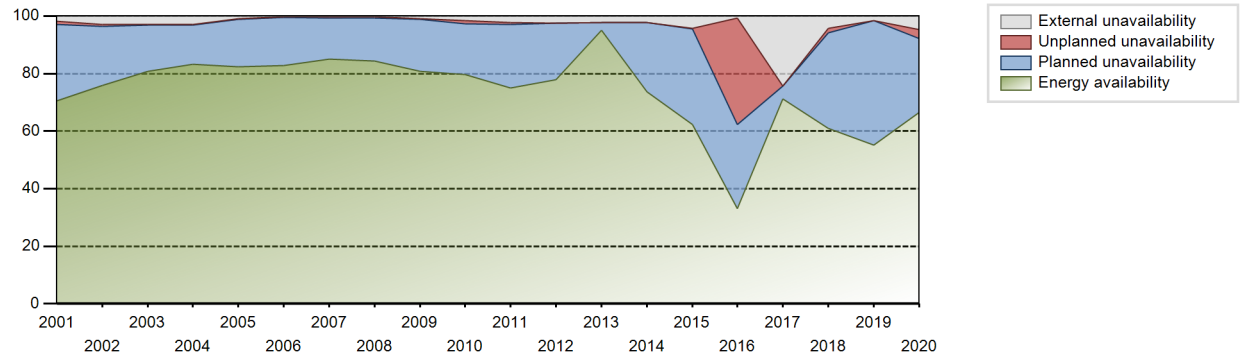
Electricity Production (net) [GWh]



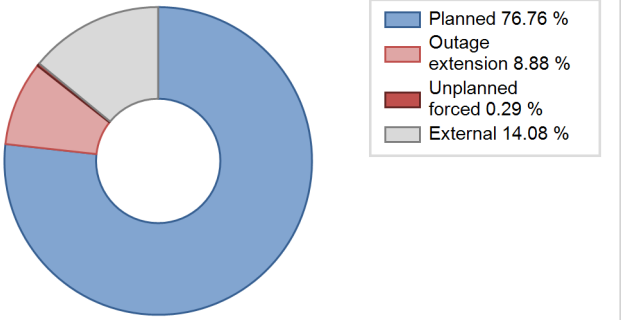
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	5651.61	6417	950	65.51	68.22	65.41	70.29	13.53	10.68	21.10	2.72
1987	6058.32	6675	1000	76.04	76.04	69.16	76.20	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

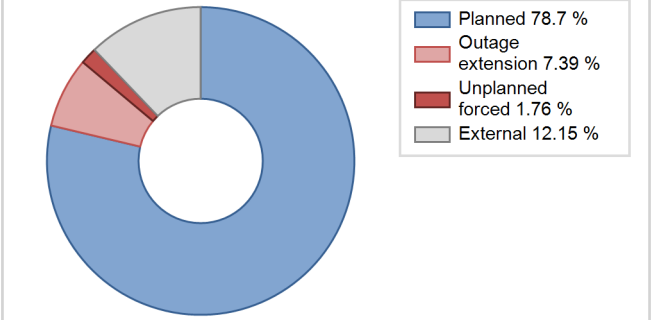
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		266			279	
C. Inspection, maintenance or repair combined with refuelling	2233			1548		
D. Inspection, maintenance or repair without refuelling				342		
E. Testing of plant systems or components				4		
F. Major backfitting, refurbishment or upgrading activities with refuelling				72	90	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			501			58
L. Human factor related					3	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						5
Z. Other					2	
Subtotal	2233	266	501	1966	374	63
Total	**3000**			**2403**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		7
13. Reactor Auxiliary Systems		0
14. Safety Systems	260	7
15. Reactor Cooling Systems		13
16. Steam generation systems		159
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		24
32. Feedwater and Main Steam System		6
34. Miscellaneous Systems		7
35. All other I&C Systems		5
41. Main Generator Systems		43
42. Electrical Power Supply Systems	6	8
Total	**266**	**282**

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2020 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	:	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

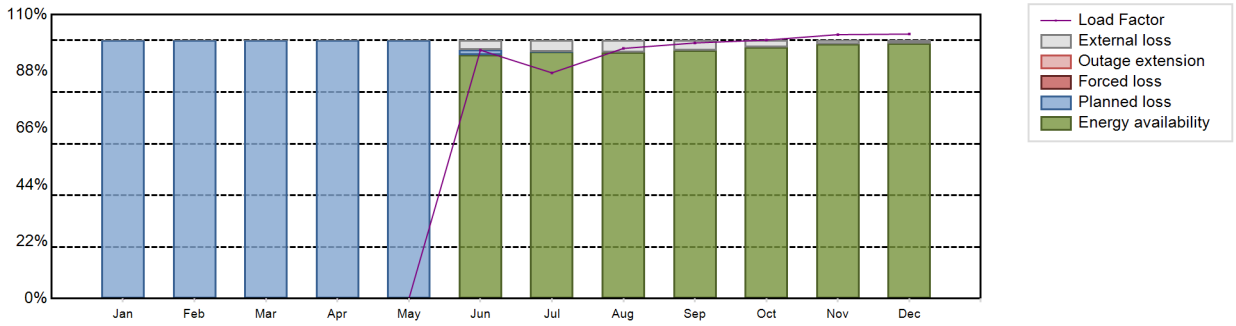
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4771.2 GW(e).h
Energy Availability Factor (EAF)	:	56.51 %
Unit Capability Factor (UCF)	:	58.3 %
Load Factor (LF)	:	57.18 %
Operating Factor (OF)	:	58.47 %
Equivalent non-electrical energy generated (NEG)	:	24.51 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	41.7 %
Externally cause unavailability (XUF)	:	1.8 %
Total off-line time	:	3648 hours

Annual Summary



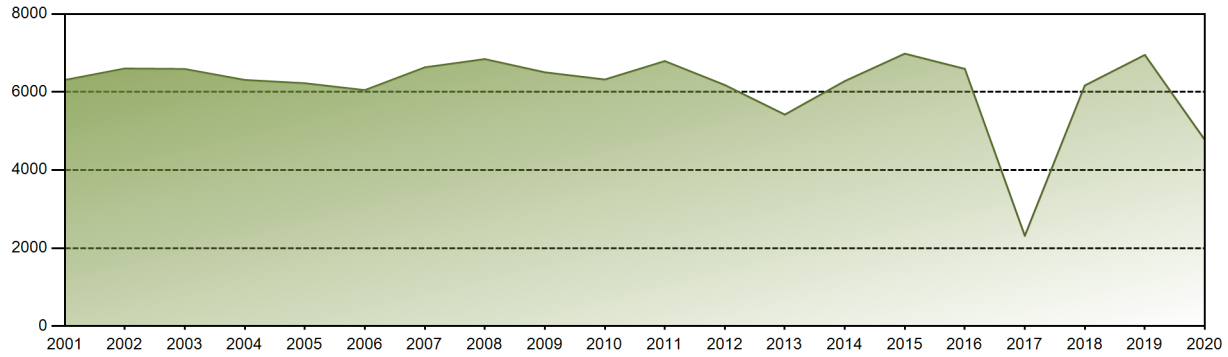
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	0.00	0.00	658.27	618.07	684.99	677.38	708.77	699.41	724.31	4771.20
EAF [%]	0.00	0.00	0.00	0.00	0.00	94.29	95.52	95.51	96.22	97.28	98.51	98.99	56.51
UCF [%]	0.00	0.00	0.00	0.00	0.00	97.96	99.87	100.00	100.00	100.00	100.00	100.00	58.30
LF [%]	0.00	0.00	0.00	0.00	0.00	96.24	87.45	96.91	99.03	100.14	102.25	102.48	57.18
OF [%]	0.00	0.00	0.00	0.00	0.00	99.86	100.00	100.00	100.00	100.00	100.00	100.00	58.47
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 [%]	100.00	100.00	100.00	100.00	100.00	2.04	0.13	0.00	0.00	0.00	0.00	0.00	41.70
XUF [%]	0.00	0.00	0.00	0.00	0.00	3.67	4.34	4.49	3.78	2.72	1.49	1.01	1.80

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Historical Summary

Lifetime energy generation	:	190997.2 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.42 %
Cumulative Energy Availability Factor (EAF)	:	71.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.62 %
Cumulative Unit Capability Factor (UCF)	:	74.01 %	Cumulative Planned Unavailability Factor (PUF)	:	23.37 %
Cumulative Load Factor (LF)	:	69.48 %	Cumulative Externally cause unavailability (XUF)	:	2.71 %
Cumulative Operating Factor (OF)	:	76.49 %			

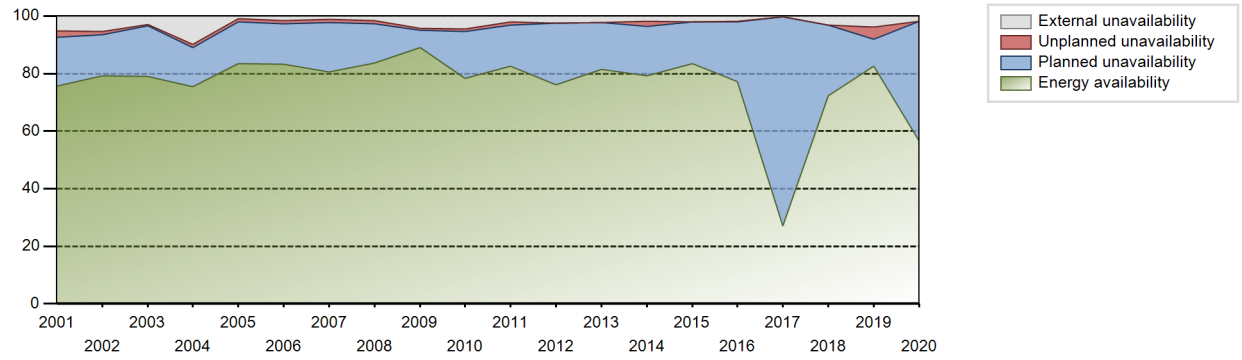
Electricity Production (net) [GWh]



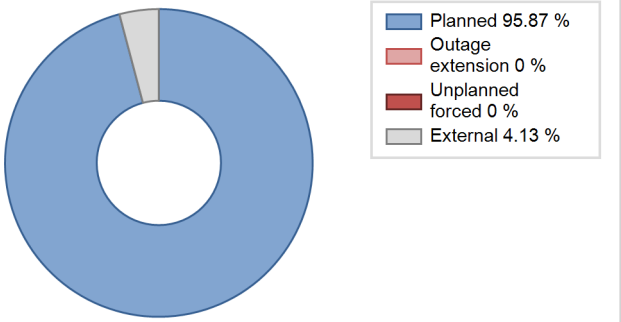
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	6690.98	7222	1000	80.32	80.32	78.39	80.15	4.02	3.37	16.31	0.00
1988	6414.29	7077	950	81.35	81.35	76.87	80.57	5.32	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

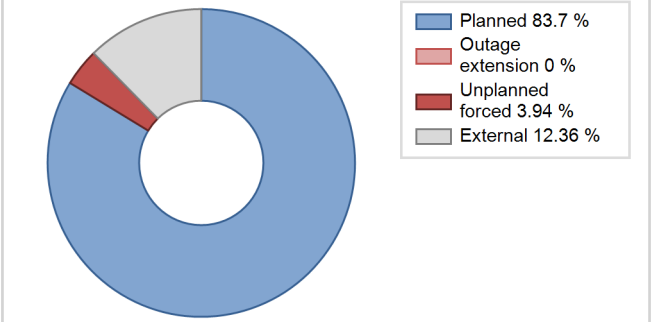
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		1			75	
C.	Inspection, maintenance or repair combined with refuelling	3648			1541		
D.	Inspection, maintenance or repair without refuelling				149		
E.	Testing of plant systems or components				14	2	
F.	Major backfitting, refurbishment or upgrading activities with refuelling				187		
J.	Grid limitation, failure or grid unavailability						8
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						56
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.)						8
Z.	Other				1	3	
Subtotal		3648	1		1892	85	72
Total		**3649**			**2049**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	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		10
17. Safety I&C Systems (excluding reactor I&C)		0
31. Turbine and auxiliaries		3
32. Feedwater and Main Steam System		9
33. Circulating Water System		1
34. Miscellaneous Systems		6
35. All other I&C Systems		1
41. Main Generator Systems		30
42. Electrical Power Supply Systems	1	10
Total	**1**	**81**

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2020 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

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	:	1983-04-01
Grid Date	:	1987-12-18
Commercial Date	:	1988-04-14
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]	:	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

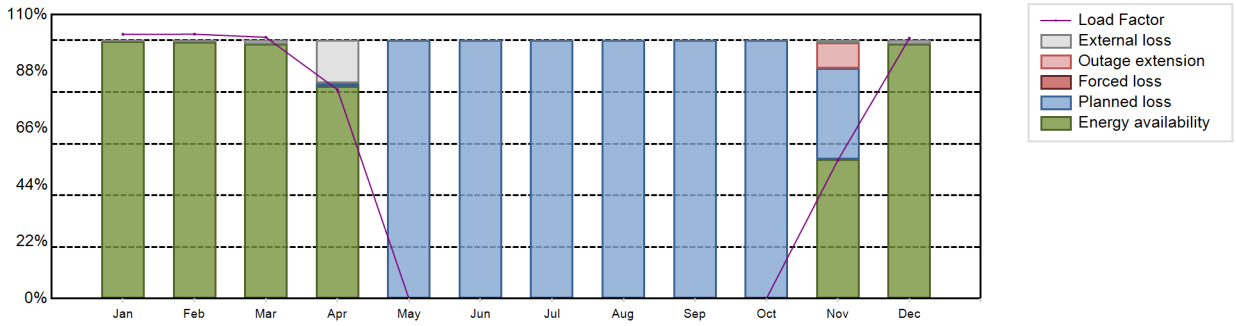
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	3748.24 GW(e).h
Energy Availability Factor (EAF)	:	44.18 %
Unit Capability Factor (UCF)	:	45.91 %
Load Factor (LF)	:	44.92 %
Operating Factor (OF)	:	46.16 %
Equivalent non-electrical energy generated (NEG)	:	22.23 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0.82 %
Planned Unavailability Factor (PUF)	:	53.27 %
Externally cause unavailability (XUF)	:	1.74 %
Total off-line time	:	4729 hours

Annual Summary



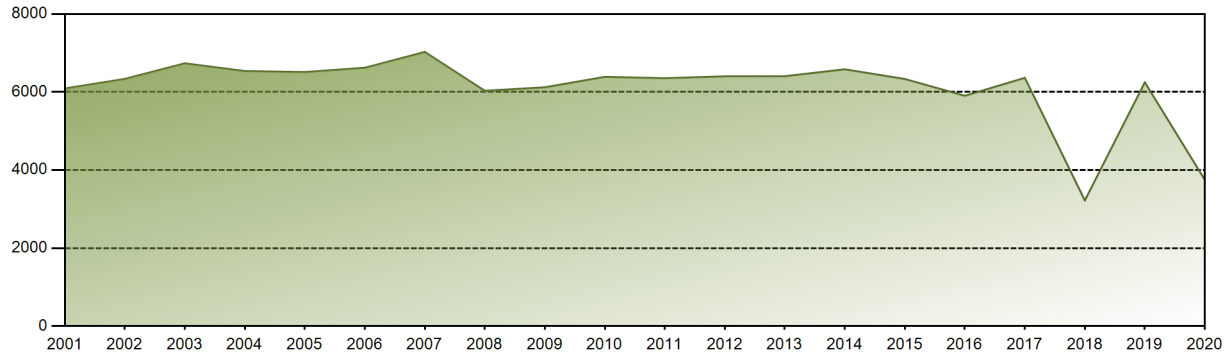
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	723.45	677.24	714.43	553.63	0.00	0.00	0.00	0.00	0.00	0.00	366.66	712.84	3748.25
EAF [%]	99.50	99.40	98.71	82.28	0.00	0.00	0.00	0.00	0.00	0.00	54.06	98.56	44.18
UCF [%]	100.00	100.00	100.00	98.75	0.00	0.00	0.00	0.00	0.00	0.00	54.85	100.00	45.91
LF [%]	102.36	102.43	101.22	80.94	0.00	0.00	0.00	0.00	0.00	0.00	53.60	100.85	44.92
OF [%]	100.00	100.00	100.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	56.67	100.00	46.16
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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.82
PUF [%]	0.00	0.00	0.00	1.25	100.00	100.00	100.00	100.00	100.00	100.00	35.15	0.00	53.27
XUF [%]	0.50	0.60	1.29	16.47	0.00	0.00	0.00	0.00	0.00	0.00	0.79	1.44	1.74

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Historical Summary

Lifetime energy generation	:	190543.24 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.92 %
Cumulative Energy Availability Factor (EAF)	:	72.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.29 %
Cumulative Unit Capability Factor (UCF)	:	75.23 %	Cumulative Planned Unavailability Factor (PUF)	:	22.49 %
Cumulative Load Factor (LF)	:	71.55 %	Cumulative Externally cause unavailability (XUF)	:	2.29 %
Cumulative Operating Factor (OF)	:	76.52 %			

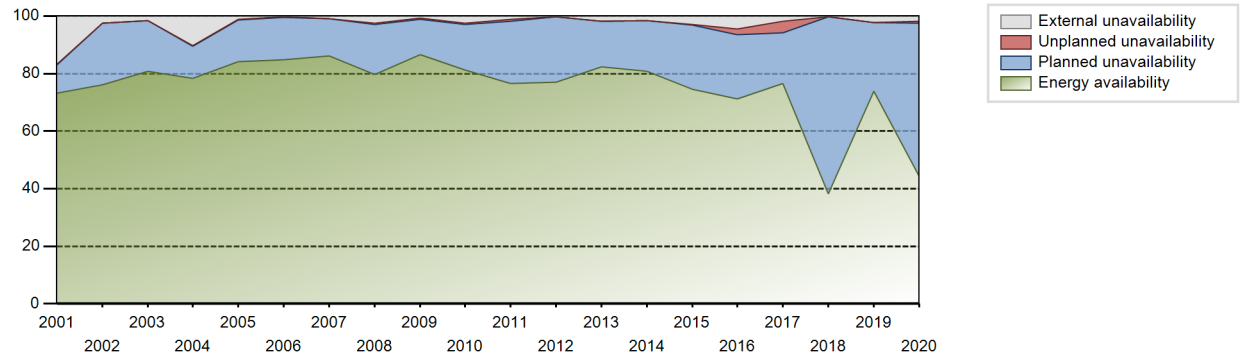
Electricity Production (net) [GWh]



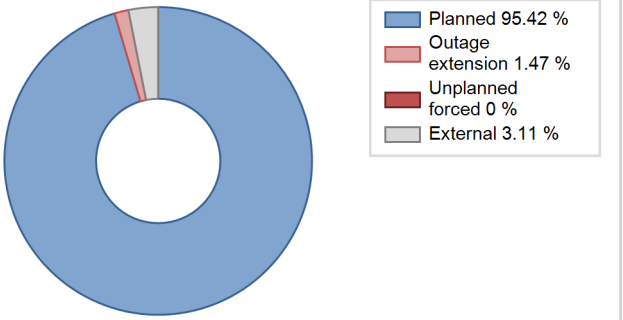
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	6431.44	7143	950	79.07	79.07	76.53	79.96	6.22	5.25	15.68	0.00
1989	5828.07	6613	950	73.08	73.08	70.03	75.49	10.85	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

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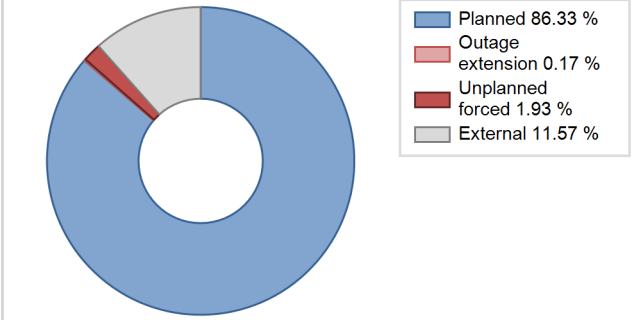
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		71			112	
C. Inspection, maintenance or repair combined with refuelling				1464		
D. Inspection, maintenance or repair without refuelling	4657			398		
E. Testing of plant systems or components				11	0	
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						56
L. Human factor related					20	
Subtotal	4657	71		1873	132	56
Total		**4728**			**2061**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		21
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		3
14. Safety Systems	71	3
15. Reactor Cooling Systems		7
16. Steam generation systems		13
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		58
42. Electrical Power Supply Systems		4
Total	**71**	**128**

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2020 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	:	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]	:	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

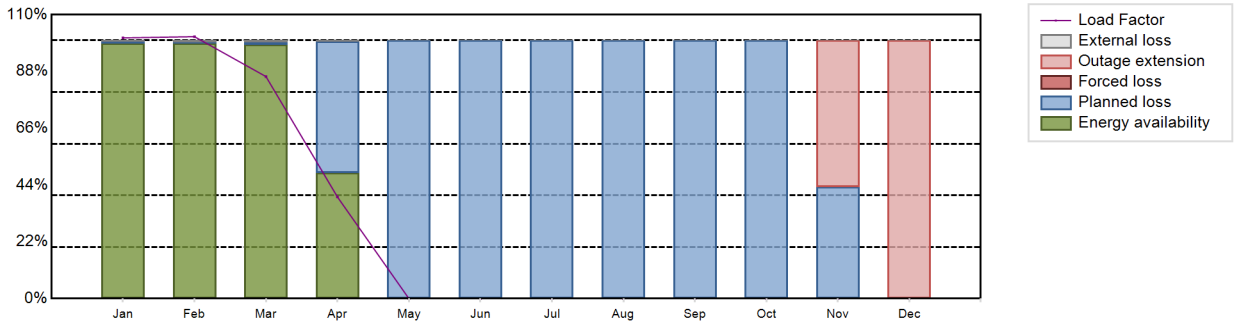
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	2261.14 GW(e).h
Energy Availability Factor (EAF)	:	28.52 %
Unit Capability Factor (UCF)	:	28.71 %
Load Factor (LF)	:	27.1 %
Operating Factor (OF)	:	28.98 %
Equivalent non-electrical energy generated (NEG)	:	25.39 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	13.11 %
Planned Unavailability Factor (PUF)	:	58.18 %
Externally cause unavailability (XUF)	:	0.18 %
Total off-line time	:	6238 hours

Annual Summary



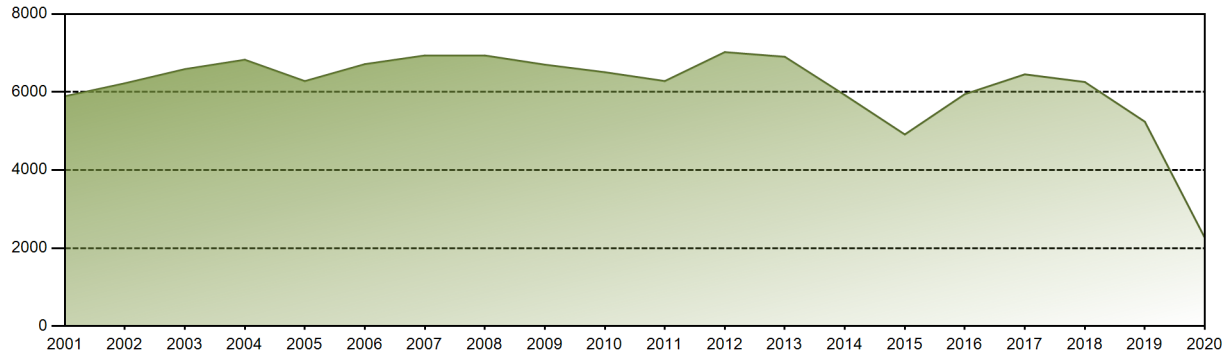
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	713.83	670.86	607.13	269.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2261.14
EAF [%]	98.86	98.76	98.47	48.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.52
UCF [%]	99.34	99.35	99.21	49.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.71
LF [%]	100.99	101.46	86.01	39.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.10
OF [%]	100.00	100.00	100.00	50.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.98
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	56.67	100.00	13.11
PUF [%]	0.66	0.65	0.79	50.86	100.00	100.00	100.00	100.00	100.00	100.00	43.33	0.00	58.18
XUF [%]	0.48	0.59	0.74	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18

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Historical Summary

Lifetime energy generation	:	182393.14 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.02 %
Cumulative Energy Availability Factor (EAF)	:	73.84 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.78 %
Cumulative Unit Capability Factor (UCF)	:	75.82 %	Cumulative Planned Unavailability Factor (PUF)	:	21.4 %
Cumulative Load Factor (LF)	:	72.18 %	Cumulative Externally cause unavailability (XUF)	:	1.98 %
Cumulative Operating Factor (OF)	:	77.49 %			

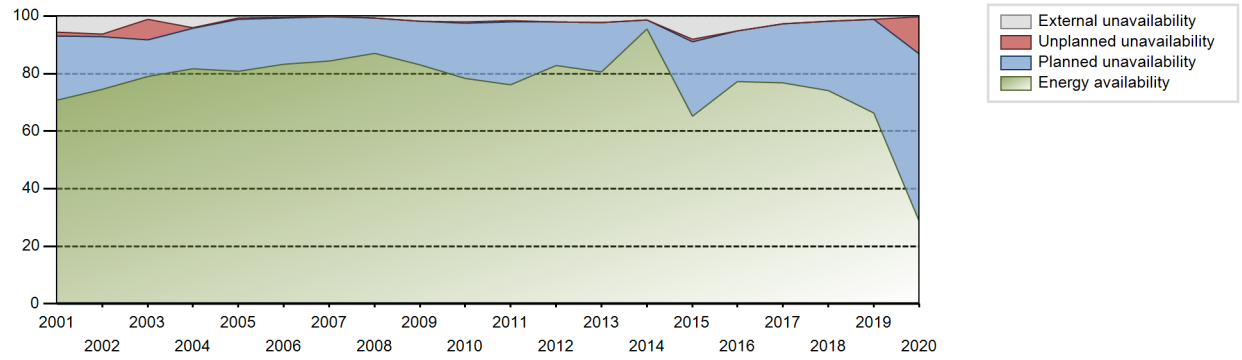
Electricity Production (net) [GWh]



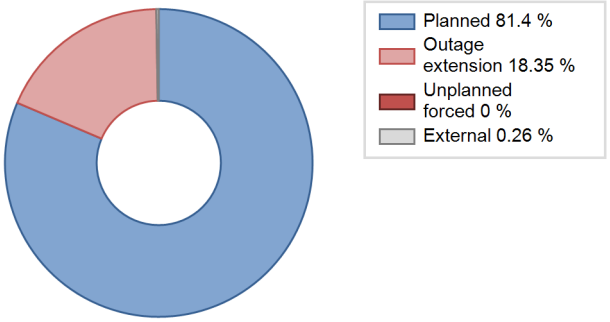
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	2147.46	2938	950	85.59	85.59	80.54	86.20	10.02	9.54	4.88	0.00
1990	4678.67	6002	950	56.65	57.92	56.22	68.52	20.69	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

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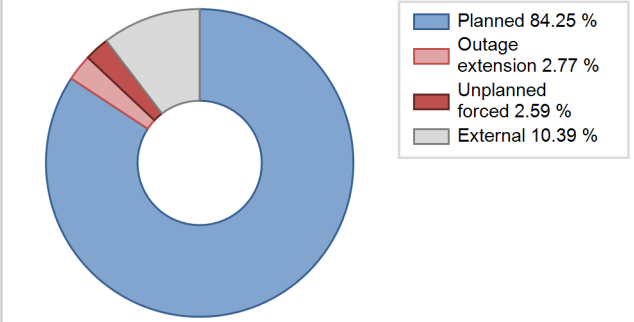
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		1151			99	
C. Inspection, maintenance or repair combined with refuelling				1463		
D. Inspection, maintenance or repair without refuelling				156		
E. Testing of plant systems or components				16		
F. Major backfitting, refurbishment or upgrading activities with refuelling	5086			163		
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						46
L. Human factor related					5	
Z. Other					1	
Subtotal	5086	1151		1798	105	46
Total	**6237**			**1949**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		5
14. Safety Systems	1151	37
15. Reactor Cooling Systems		8
16. Steam generation systems		27
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		5
32. Feedwater and Main Steam System		5
41. Main Generator Systems		5
42. Electrical Power Supply Systems		5
Total	**1151**	**98**

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2020 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

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	:	1986-06-01
Grid Date	:	1995-10-19
Commercial Date	:	1996-09-17
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]	:	-
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

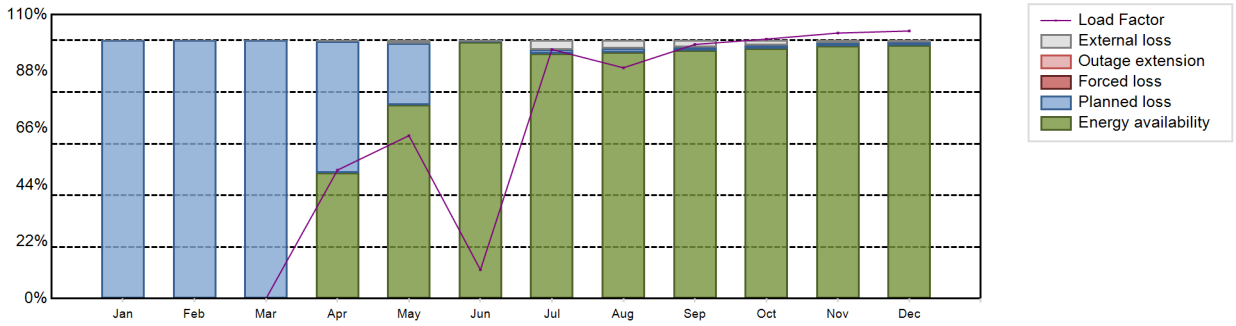
Operating coolant pressure [MPa]	:	16
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	5
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1500
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4998.2 GW(e).h
Energy Availability Factor (EAF)	:	67.05 %
Unit Capability Factor (UCF)	:	68.32 %
Load Factor (LF)	:	59.9 %
Operating Factor (OF)	:	62.52 %
Equivalent non-electrical energy generated (NEG)	:	18.91 GW(e).h

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	31.68 %
Externally cause unavailability (XUF)	:	1.27 %
Total off-line time	:	3292 hours

Annual Summary



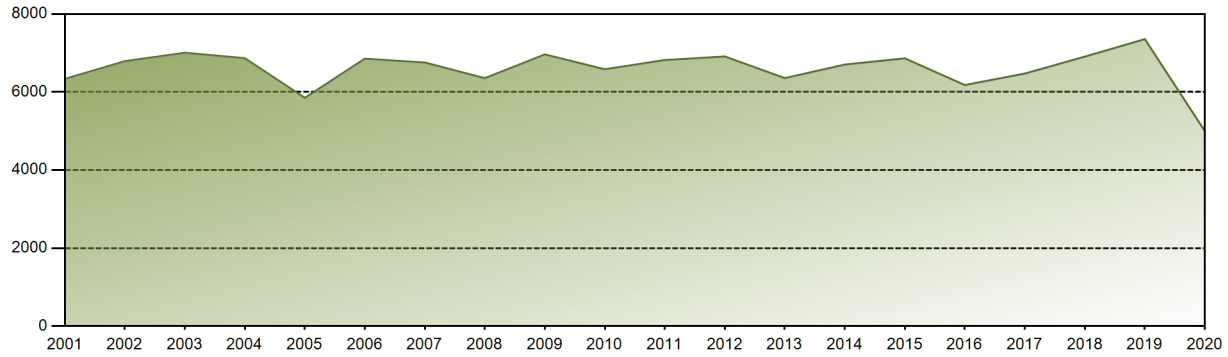
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	0.00	0.00	0.00	340.54	446.20	76.30	682.03	631.93	673.41	711.42	703.58	732.79	4998.20
EAF [%]	0.00	0.00	0.00	48.81	75.00	99.31	94.89	95.51	96.08	96.93	97.94	98.06	67.05
UCF [%]	0.00	0.00	0.00	49.29	76.08	99.79	98.49	98.70	98.81	98.85	98.90	98.76	68.32
LF [%]	0.00	0.00	0.00	49.79	63.13	11.15	96.50	89.41	98.45	100.52	102.86	103.68	59.90
OF [%]	0.00	0.00	0.00	51.25	77.55	17.92	100.00	100.00	100.00	100.00	100.00	100.00	62.52
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	50.71	23.92	0.21	1.51	1.30	1.19	1.15	1.10	1.24	31.68
XUF [%]	0.00	0.00	0.00	0.49	1.08	0.49	3.60	3.19	2.72	1.92	0.96	0.70	1.27

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Historical Summary

Lifetime energy generation	:	159165.2 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.55 %
Cumulative Energy Availability Factor (EAF)	:	79.34 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.45 %
Cumulative Unit Capability Factor (UCF)	:	81.43 %	Cumulative Planned Unavailability Factor (PUF)	:	18.13 %
Cumulative Load Factor (LF)	:	78.33 %	Cumulative Externally cause unavailability (XUF)	:	2.09 %
Cumulative Operating Factor (OF)	:	81.15 %			

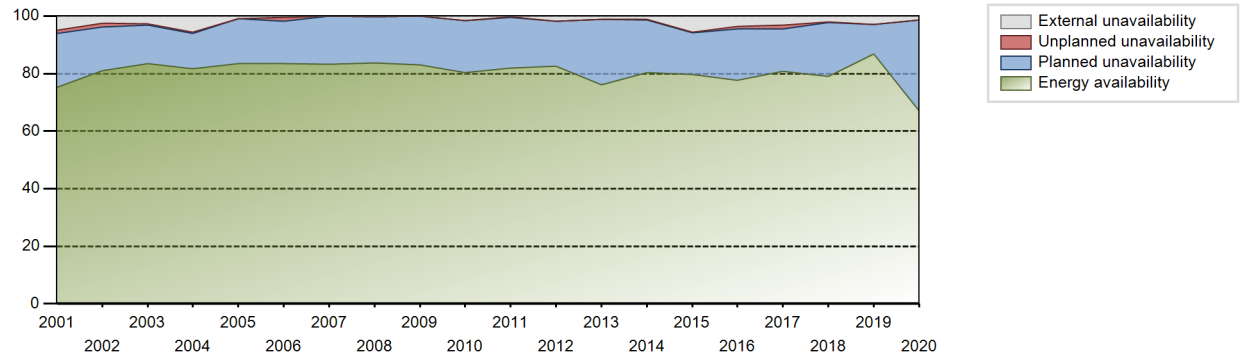
Electricity Production (net) [GWh]



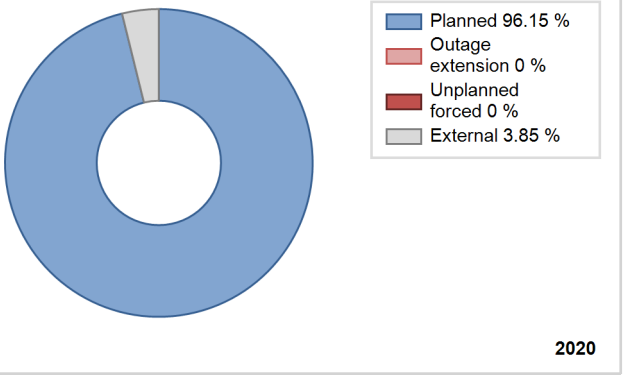
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1996	6403.54	7871	950	85.50	87.53	85.50	87.87	0.00	0.00	12.47	2.02
1997	6332.68	6640	950	75.18	75.50	76.10	75.80	0.96	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

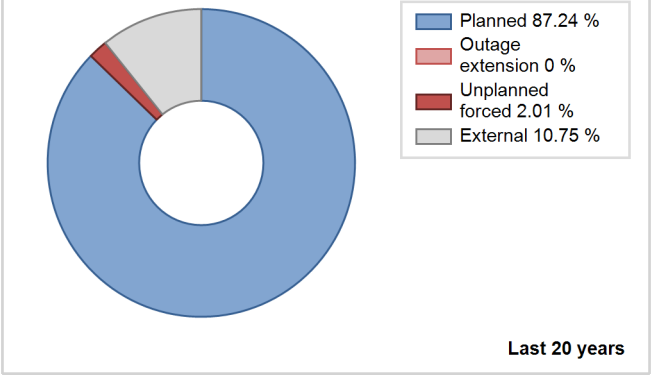
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1996 to 2020		
	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	2534			1485		
D. Inspection, maintenance or repair without refuelling	168			67		
E. Testing of plant systems or components				19		
J. Grid limitation, failure or grid unavailability						0
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)			591			81
Subtotal	2702		591	1571	30	81
Total	**3293**			**1682**		

Equipment Related Unplanned Full Outages, Analysis by System

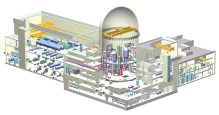
System	2020	1996 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		1
14. Safety Systems		1
15. Reactor Cooling Systems		6
16. Steam generation systems		7
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		6
32. Feedwater and Main Steam System		0
34. Miscellaneous Systems		1
35. All other I&C Systems		1
41. Main Generator Systems		3
42. Electrical Power Supply Systems		2
Total		**29**

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2020 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	:	1400 MWe
Reference unit power (net)	:	1345 MWe

Key Dates

Construction Date	:	2012-07-19
Grid Date	:	2020-08-19
Commercial Date	:	2021-04-01
Age at end of year	:	0 years

Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.513
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]	:	0.414
Average fuel enrichment [% of U235]	:	2.66	**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]	:	28914	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	3.647	HP cylinder inlet steam pressure [MPa]	:	6.629
Active core height/length [m]	:	3.81	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]	:	47.572	Number of main condensate pumps	:	3
Number of control rod assemblies	:	81	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 (2020)

Net Energy Production	:	1561.81 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	:	595 hours

Annual Summary

No data found

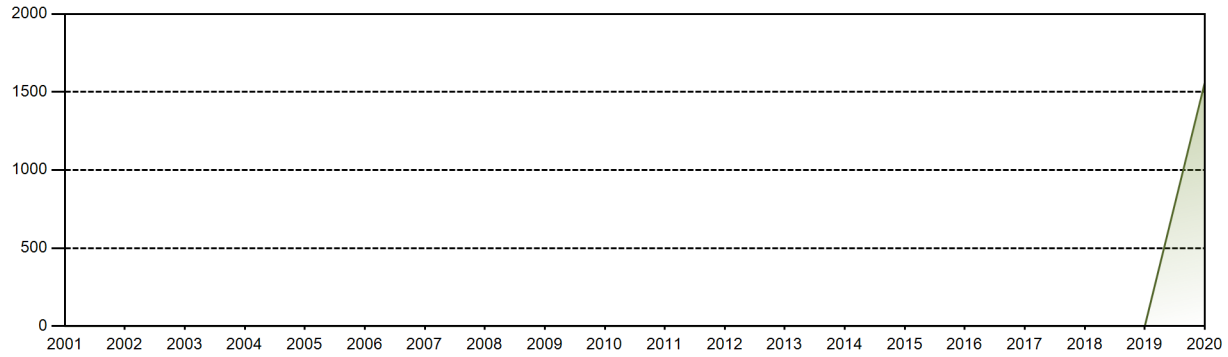
	Jan	Oct	Nov	Dec	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
GW(e)-h												
EAF [%]												
UCF [%]												
LF [%]												
OF [%]												
FLR [%]												
UCL [%]												
PUF [%]												
XUF [%]												

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Historical Summary

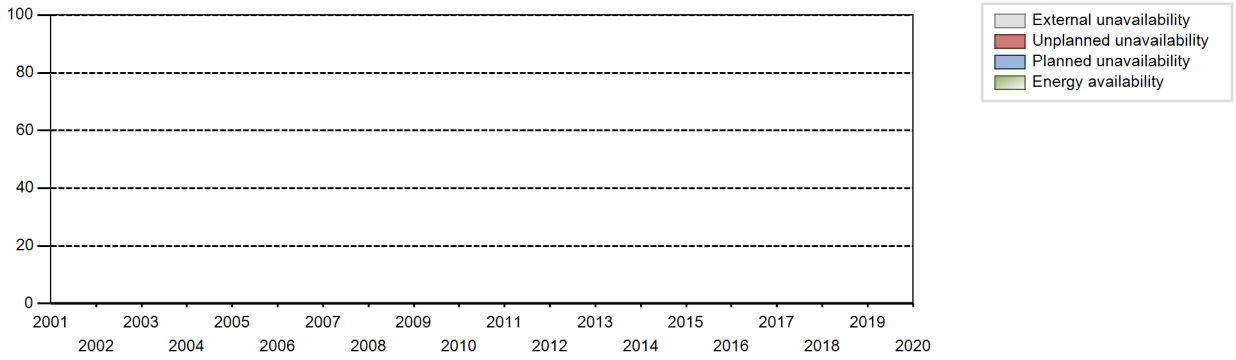
Lifetime energy generation	:	1561.81 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0 %
Cumulative Energy Availability Factor (EAF)	:	0 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0 %
Cumulative Unit Capability Factor (UCF)	:	0 %	Cumulative Planned Unavailability Factor (PUF)	:	0 %
Cumulative Load Factor (LF)	:	0 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	0 %			

Electricity Production (net) [GWh]

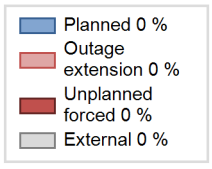


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]

Key Factors in Last 20 Years [%]



Energy Losses by Type



2020

No Data Available

Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			2021 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
Subtotal						
Total	0			0		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2021 to 2020
	Hours Lost	Average hours lost per reactor-year
Total		

Highlights (2020)

BNPP Unit-1 synchronized first time to grid on 19 August 2020. Undergoing power ascension testing for the remaining year 2020.

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2020 Operating Experience

GB-18A DUNGENESS B-1 UNITED KINGDOM

Status at end of year	:	**Operational**
Operator	:	EDF UK (EDF Energy)
Owner	:	EDF UK (EDF Energy)
Reactor Supplier	:	APC (ATOMIC POWER CONSTRUCTION, LTD.)
Turbine Supplier	:	PARSONS (C.A.PARSONS)

Reactor Unit Details

Reactor type and model	:	GCR / AGR
Thermal power	:	1500 MWth
Gross electrical power	:	615 MWe
Reference unit power (net)	:	545 MWe

Key Dates

Construction Date	:	1965-10-01
Grid Date	:	1983-04-03
Commercial Date	:	1985-04-01
Age at end of year	:	37 years

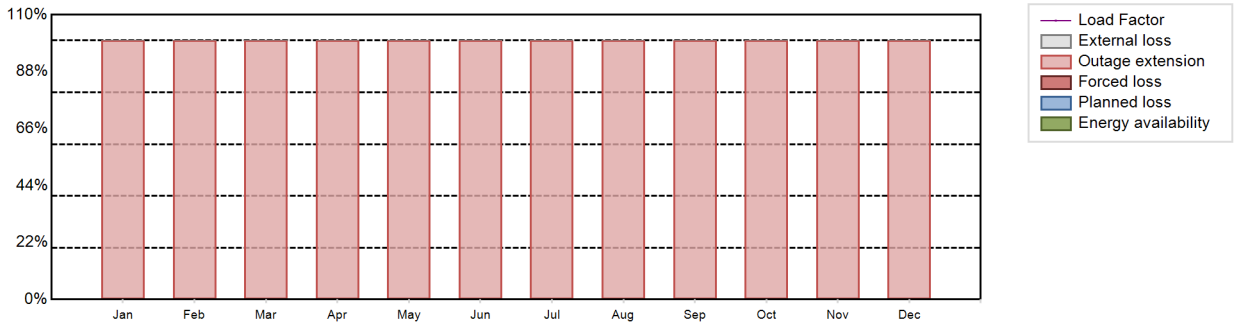
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	GRAPHITE
Average fuel enrichment [% of U235]	:	-
Refuelling frequency [month]	:	4
Part of the core refuelled [%]	:	4
Average discharge burnup [MWd/t]	:	-
Active core diameter [m]	:	9.4
Active core height/length [m]	:	7.3
Number of fissile fuel assemblies/bundles	:	2856
Fuel linear heat generation rate [kW/m]	:	14.4
Number of control rod assemblies	:	36
Number of external reactor coolant loops	:	4
Coolant type	:	CO2
Operating coolant pressure [MPa]	:	3.43
Reactor outlet temperature [°C]	:	673
Number of SG	:	4
Containment type	:	Confinement
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]	:	16.3
Output voltage [kV]	:	11
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	:	4
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	-92.66 GW(e).h
Energy Availability Factor (EAF)	:	0 %
Unit Capability Factor (UCF)	:	0 %
Load Factor (LF)	:	-1.94 %
Operating Factor (OF)	:	0 %
Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	100 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	8784 hours

Annual Summary



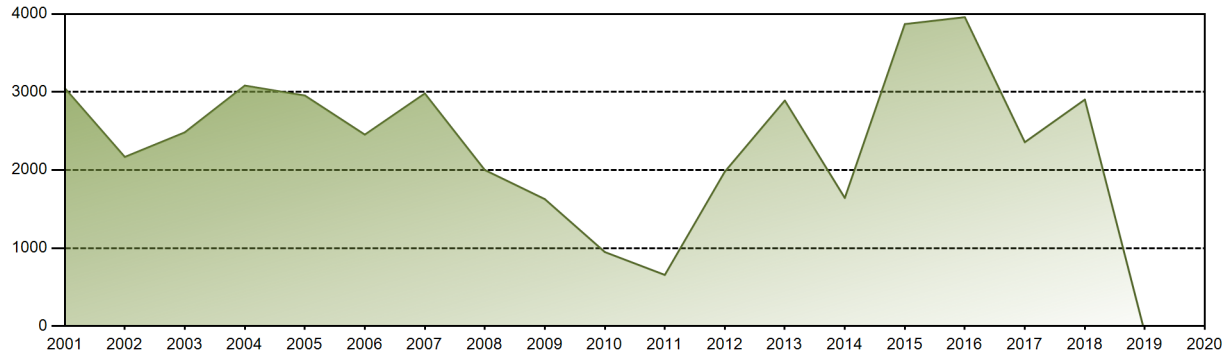
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	-8.58	-7.29	-7.79	-6.60	-7.62	-8.01	-7.67	-7.36	-6.36	-6.78	-6.90	-11.69	-92.66
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	-2.12	-1.92	-1.92	-1.68	-1.88	-2.04	-1.89	-1.81	-1.62	-1.67	-1.76	-2.88	-1.94
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 [%]	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
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

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Historical Summary

Lifetime energy generation	:	94531.43 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	27.32 %
Cumulative Energy Availability Factor (EAF)	:	43.51 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	30.14 %
Cumulative Unit Capability Factor (UCF)	:	44.74 %	Cumulative Planned Unavailability Factor (PUF)	:	25.13 %
Cumulative Load Factor (LF)	:	42.62 %	Cumulative Externally cause unavailability (XUF)	:	1.23 %
Cumulative Operating Factor (OF)	:	52.04 %			

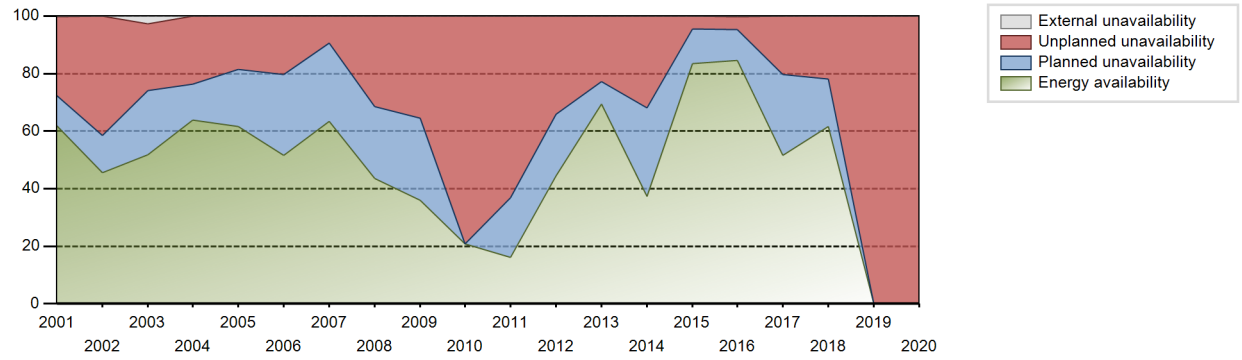
Electricity Production (net) [GWh]



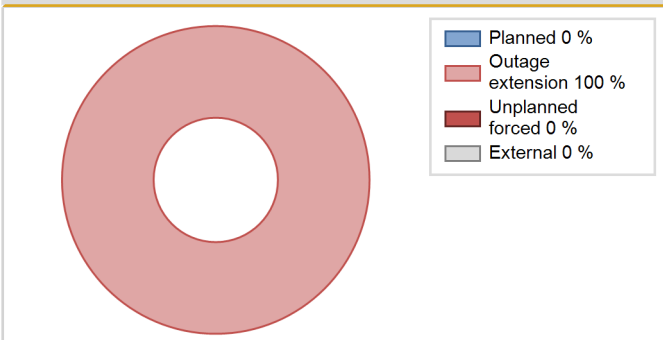
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	2438.25	6117	450	62.84	64.81	61.93	67.80	23.37	19.77	15.42	1.97
1986	1172.56	4447	450	29.07	33.65	29.83	50.90	38.13	20.74	45.61	4.58
1987	210.32	1179	450	6.47	13.24	5.25	13.24	41.87	9.54	77.22	6.77
1988	1233.94	3857	450	33.33	45.49	31.39	44.15	6.80	3.32	51.19	12.16
1989	647.20	2650	412	24.78	43.75	17.99	30.33	0.37	0.16	56.09	18.97
1990	757.96	5093	360	26.32	26.32	24.10	58.30	10.34	3.04	70.64	0.00
1991	2656.18	7329	410	74.54	74.54	74.02	83.89	7.06	5.66	19.80	0.00
1992	1052.26	2670	441	27.43	27.54	26.69	29.99	54.87	33.49	38.97	0.11
1993	3493.16	7138	516	77.05	77.45	77.45	81.71	6.43	5.32	17.23	0.40
1994	2385.68	4676	555	49.24	51.48	49.20	53.53	28.25	20.27	28.24	2.25
1995	873.72	1587	555	18.20	18.20	17.92	18.07	78.90	68.03	13.78	0.00
1996	2516.97	5311	555	51.63	51.63	51.63	60.46	20.19	13.06	35.31	0.00
1997	2078.19	4549	555	42.90	42.90	42.63	51.79	41.77	30.78	26.32	0.00
1998	2198.30	5716	555	47.03	47.42	45.09	65.07	37.44	28.38	24.20	0.39
1999	1584.20	4752	555	33.04	33.04	32.50	54.10	42.29	24.21	42.74	0.00
2000	409.64	1201	555	8.40	8.40	8.40	13.67	85.65	50.16	41.44	0.00
2001	3049.09	7108	555	61.88	62.20	62.54	80.92	30.49	27.29	10.52	0.31
2002	2167.58	5043	555	45.52	45.57	44.58	57.57	45.59	41.46	12.97	0.05
2003	2482.86	5212	555	51.92	54.62	51.07	59.50	26.22	23.25	22.14	2.70
2004	3082.47	6305	555	63.83	63.83	63.23	71.78	25.75	23.71	12.46	0.00
2005	2955.14	6039	555	61.59	61.67	60.78	68.94	15.96	18.41	19.92	0.08
2006	2453.84	5246	555	51.64	51.67	51.17	59.89	12.01	20.37	27.96	0.03
2007	2981.31	6447	545	63.30	63.30	62.45	73.60	10.44	9.31	27.39	0.00
2008	1999.90	4467	520	43.67	43.67	43.27	50.85	7.34	31.38	24.94	0.00
2009	1627.03	3527	520	35.99	35.99	35.72	40.26	17.14	35.58	28.42	0.00
2010	948.94	3233	520	20.83	20.83	20.83	36.91	42.34	79.17	0.00	0.00
2011	655.60	2517	520	16.14	16.14	14.39	28.73	57.52	63.16	20.70	0.00
2012	1979.08	4632	520	44.40	44.40	43.33	52.73	31.16	34.09	21.51	0.00
2013	2891.06	6215	520	69.52	69.52	63.47	70.95	9.46	22.82	7.66	0.00
2014	1641.91	4409	520	37.41	37.41	36.04	50.33	39.57	31.95	30.65	0.00
2015	3870.67	7679	525	83.44	83.46	84.16	87.66	4.58	4.56	11.98	0.01
2016	3959.17	7786	525	84.69	84.88	85.85	88.64	3.52	4.59	10.54	0.19
2017	2356.85	5050	525	51.54	51.54	51.25	57.65	19.25	20.27	28.19	0.00
2018	2902.74	5677	545	61.51	61.59	60.80	64.81	2.06	21.90	16.51	0.09
2019	-85.83	0	545	0.00	0.00	-1.80	0.00	0.00	100.00	0.00	0.00
2020	-92.66	0	545	0.00	0.00	-1.94	0.00	0.00	100.00	0.00	0.00

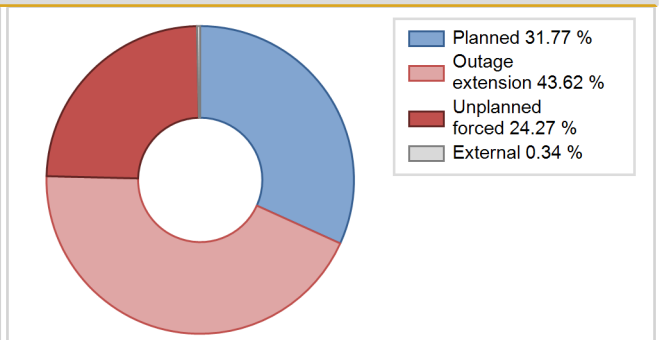
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		8784			1617	
B. Refuelling without maintenance				276	73	
C. Inspection, maintenance or repair combined with refuelling				637	145	
D. Inspection, maintenance or repair without refuelling				884	50	
E. Testing of plant systems or components					8	
H. Nuclear regulatory requirements					4	
J. Grid limitation, failure or grid unavailability						19
L. Human factor related					30	
P. Fire					5	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					44	
Z. Other				65	64	3
Subtotal		8784		1862	2040	22
Total		**8784**			**3924**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		206
12. Reactor I&C Systems		61
13. Reactor Auxiliary Systems		11
14. Safety Systems		1
15. Reactor Cooling Systems		113
16. Steam generation systems		40
21. Fuel Handling and Storage Facilities		226
31. Turbine and auxiliaries		65
32. Feedwater and Main Steam System	8784	979
33. Circulating Water System		36
34. Miscellaneous Systems		2
41. Main Generator Systems		89
42. Electrical Power Supply Systems		34
Total	**8784**	**1863**

Highlights (2020)

Remained on outage all year to address various safety case issues

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2020 Operating Experience

GB-18B DUNGENESS B-2 UNITED KINGDOM

Status at end of year	:	**Operational**
Operator	:	EDF UK (EDF Energy)
Owner	:	EDF UK (EDF Energy)
Reactor Supplier	:	APC (ATOMIC POWER CONSTRUCTION, LTD.)
Turbine Supplier	:	PARSONS (C.A.PARSONS)

Reactor Unit Details

Reactor type and model	:	GCR / AGR
Thermal power	:	1500 MWth
Gross electrical power	:	615 MWe
Reference unit power (net)	:	545 MWe

Key Dates

Construction Date	:	1965-10-01
Grid Date	:	1985-12-29
Commercial Date	:	1989-04-01
Age at end of year	:	35 years

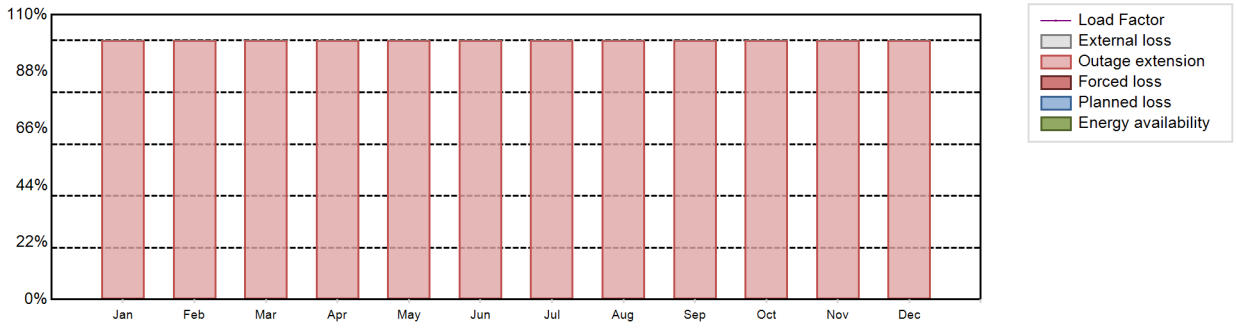
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	3.43
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	673
Fuel material	:	UO2	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	Confinement
Moderator material	:	GRAPHITE	Containment design pressure [MPa]	:	-
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	4	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	4	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	-	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	9.4	HP cylinder inlet steam pressure [MPa]	:	16.3
Active core height/length [m]	:	7.3	Output voltage [kV]	:	11
Number of fissile fuel assemblies/bundles	:	2856	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	14.4	Number of main condensate pumps	:	-
Number of control rod assemblies	:	36	Number of FW pumps for full power operation	:	-
Number of external reactor coolant loops	:	4	Number of on-site safety related diesel generators	:	4
Coolant type	:	CO2	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	-92.66 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	0 %	Unplanned Capability Loss Factor (UCL)	:	100 %
Unit Capability Factor (UCF)	:	0 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	-1.94 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	0 %	Total off-line time	:	8784 hours

Annual Summary



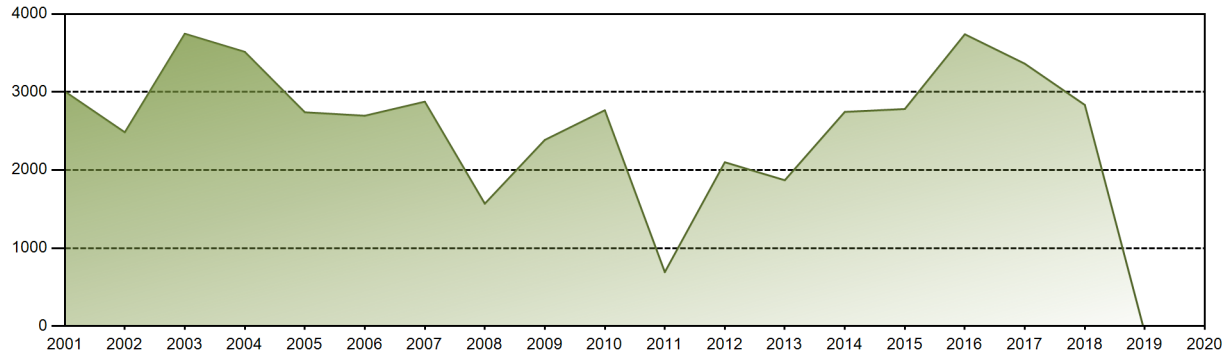
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	-8.58	-7.29	-7.79	-6.60	-7.62	-8.01	-7.67	-7.36	-6.36	-6.78	-6.90	-11.69	-92.66
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LF [%]	-2.12	-1.92	-1.92	-1.68	-1.88	-2.04	-1.89	-1.81	-1.62	-1.67	-1.76	-2.88	-1.94
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 [%]	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
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

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Historical Summary

Lifetime energy generation	:	99543.1 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	24.98 %
Cumulative Energy Availability Factor (EAF)	:	48.65 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	27.5 %
Cumulative Unit Capability Factor (UCF)	:	48.87 %	Cumulative Planned Unavailability Factor (PUF)	:	23.63 %
Cumulative Load Factor (LF)	:	48.45 %	Cumulative Externally cause unavailability (XUF)	:	0.22 %
Cumulative Operating Factor (OF)	:	55.6 %			

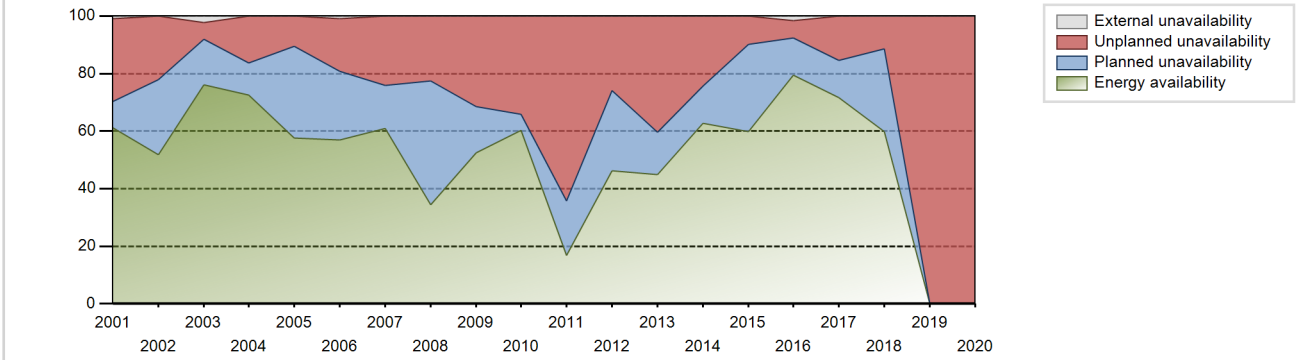
Electricity Production (net) [GWh]



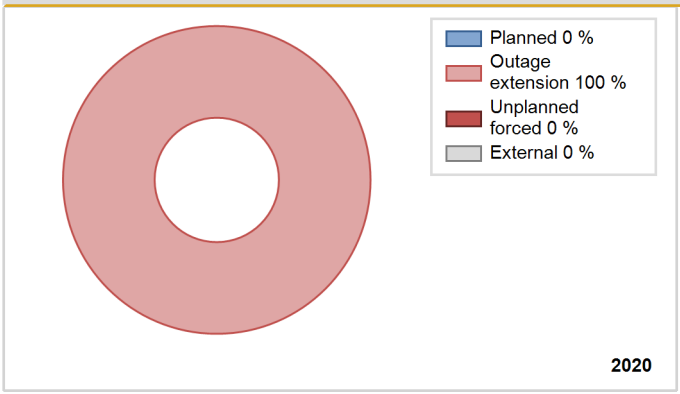
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	232.55	696	412	0.00	0.00	0.00	0.00	99.99	49.54	50.45	0.00
1990	726.00	4060	360	23.08	23.08	23.08	46.47	6.67	1.65	75.27	0.00
1991	1467.22	4295	410	44.78	44.78	40.89	49.16	15.50	8.22	47.00	0.00
1992	2360.35	6525	441	61.92	61.95	59.87	73.28	10.44	7.23	30.82	0.03
1993	2306.70	4672	517	50.00	50.20	51.02	53.48	5.79	3.08	46.72	0.20
1994	2568.27	5075	555	56.99	57.09	52.97	58.09	35.26	31.10	11.81	0.10
1995	773.84	1358	555	16.15	16.15	15.87	15.46	75.16	48.86	34.99	0.00
1996	3614.97	6882	555	74.11	74.15	74.15	78.35	12.39	10.49	15.36	0.04
1997	3327.32	6975	555	68.25	68.52	68.25	79.41	14.30	11.43	20.04	0.27
1998	1897.84	4390	555	39.20	39.20	38.93	49.98	36.89	22.91	37.88	0.00
1999	2123.26	5504	555	30.64	30.64	43.55	62.66	52.62	34.03	35.33	0.00
2000	1814.27	3767	555	37.21	37.21	37.21	42.88	47.18	33.24	29.55	0.00
2001	3007.39	6393	555	61.12	62.14	61.69	72.78	31.60	28.70	9.16	1.02
2002	2483.27	5135	555	51.81	51.81	51.08	58.62	25.68	22.00	26.19	0.00
2003	3747.28	7275	555	76.03	78.31	77.08	83.05	6.95	5.85	15.84	2.28
2004	3514.42	7138	555	72.64	72.64	72.09	81.26	14.73	16.34	11.02	0.00
2005	2739.75	5612	555	57.68	57.68	56.35	64.06	7.05	10.63	31.70	0.00
2006	2695.72	5712	555	56.89	57.91	56.21	65.21	18.98	18.20	23.89	1.03
2007	2875.74	6301	545	60.94	60.94	60.24	71.93	18.34	24.02	15.03	0.00
2008	1568.90	3356	520	34.38	34.38	33.94	38.21	15.58	22.56	43.07	0.00
2009	2385.66	5597	520	52.59	52.59	52.37	63.89	31.06	31.47	15.95	0.00
2010	2766.05	6173	520	60.18	60.18	60.72	70.47	36.19	34.13	5.69	0.00
2011	691.07	2754	520	16.90	16.90	15.17	31.44	54.50	64.27	18.82	0.00
2012	2099.69	4420	520	46.22	46.22	45.97	50.32	10.09	25.94	27.84	0.00
2013	1869.00	4308	520	44.92	44.92	41.03	49.18	41.10	40.30	14.78	0.00
2014	2745.12	6153	520	62.80	62.80	60.26	70.24	25.66	24.24	12.96	0.00
2015	2781.99	5665	525	59.74	59.74	60.49	64.67	8.89	9.87	30.39	0.00
2016	3740.04	7407		79.55	81.13	81.10	84.32	6.29	6.07	12.79	1.58
2017	3362.55	6554	525	71.72	71.72	73.11	74.82	15.60	15.34	12.94	0.00
2018	2834.30	5398	545	59.89	60.02	59.37	61.62	0.00	11.17	28.81	0.13
2019	-85.83	0	545	0.00	0.00	-1.80	0.00	0.00	100.00	0.00	0.00
2020	-92.66	0	545	0.00	0.00	-1.94	0.00	0.00	100.00	0.00	0.00

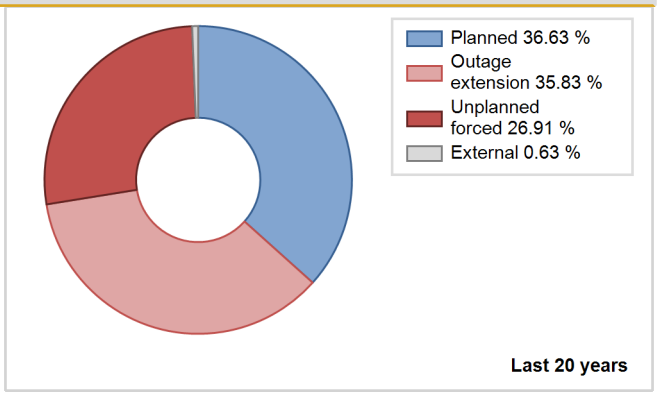
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1989 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					1111	
B. Refuelling without maintenance				328	119	
C. Inspection, maintenance or repair combined with refuelling				898	119	
D. Inspection, maintenance or repair without refuelling				935		
E. Testing of plant systems or components					8	
H. Nuclear regulatory requirements					4	
J. Grid limitation, failure or grid unavailability						20
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						5
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
P. Fire					71	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					38	
Z. Other				98	71	8
Subtotal				2259	1545	36
Total		**0**			**3840**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		10
12. Reactor I&C Systems		54
13. Reactor Auxiliary Systems		1
14. Safety Systems		13
15. Reactor Cooling Systems		21
16. Steam generation systems		50
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		314
31. Turbine and auxiliaries		44
32. Feedwater and Main Steam System		506
33. Circulating Water System		86
34. Miscellaneous Systems		91
41. Main Generator Systems		43
42. Electrical Power Supply Systems		25
Total		**1259**

Highlights (2020)

Remained on outage all year to address various safety case issues

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2020 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

Reactor type and model	:	GCR / AGR
Thermal power	:	1500 MWth
Gross electrical power	:	655 MWe
Reference unit power (net)	:	590 MWe

Key Dates

Construction Date	:	1968-10-01
Grid Date	:	1983-08-01
Commercial Date	:	1989-04-01
Age at end of year	:	37 years

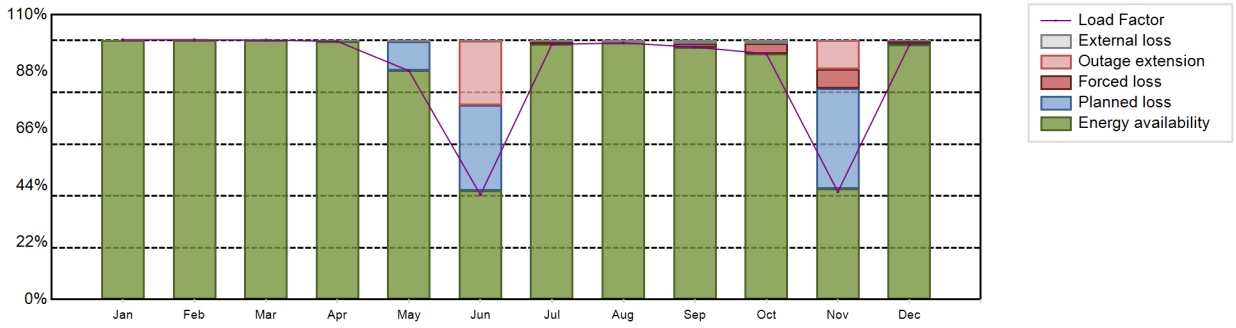
Design Characteristics

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 (2020)

Net Energy Production	:	4581.72 GW(e).h	Forced Loss Rate (FLR)	:	1.36 %
Energy Availability Factor (EAF)	:	88.58 %	Unplanned Capability Loss Factor (UCL)	:	4.17 %
Unit Capability Factor (UCF)	:	88.96 %	Planned Unavailability Factor (PUF)	:	6.87 %
Load Factor (LF)	:	88.41 %	Externally cause unavailability (XUF)	:	0.39 %
Operating Factor (OF)	:	91.79 %	Total off-line time	:	721 hours

Annual Summary



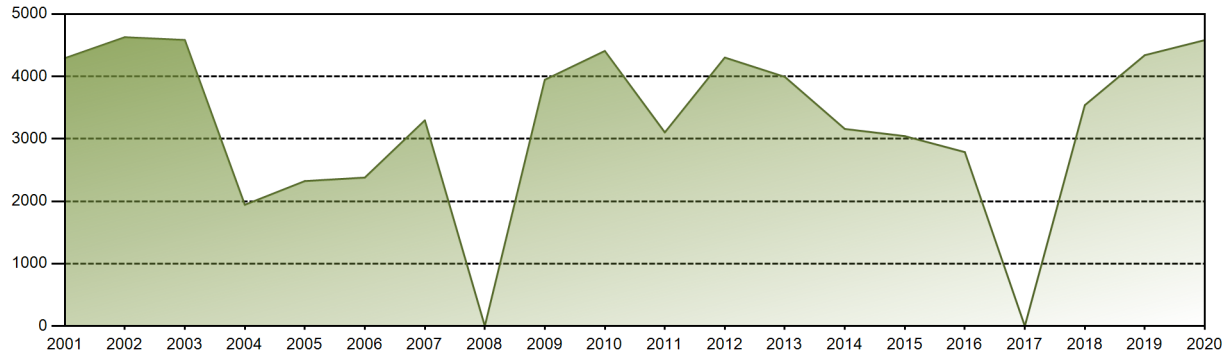
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	440.37	412.02	439.16	423.54	387.78	171.79	432.62	434.97	414.07	417.26	176.76	431.38	4581.72
EAF [%]	100.00	100.00	100.00	99.69	88.49	42.13	98.56	99.09	97.47	94.93	42.70	98.27	88.58
UCF [%]	100.00	100.00	100.00	99.95	88.85	42.26	99.03	100.00	98.66	96.07	42.70	98.47	88.96
LF [%]	100.32	100.34	100.18	99.70	88.34	40.44	98.56	99.09	97.47	94.93	41.61	98.27	88.41
OF [%]	100.00	100.00	100.00	100.00	94.76	50.97	100.00	100.00	100.00	100.00	54.31	100.00	91.79
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.00	1.34	3.93	14.73	1.11	1.36
UCL [%]	0.00	0.00	0.00	0.00	0.00	24.91	0.97	0.00	1.34	3.93	18.39	1.11	4.17
PUF [%]	0.00	0.00	0.00	0.05	11.15	32.84	0.00	0.00	0.01	0.00	38.92	0.43	6.87
XUF [%]	0.00	0.00	0.00	0.26	0.35	0.13	0.47	0.91	1.18	1.14	0.00	0.19	0.39

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Historical Summary

Lifetime energy generation	:	119391.92 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	8.95 %
Cumulative Energy Availability Factor (EAF)	:	70.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	15.01 %
Cumulative Unit Capability Factor (UCF)	:	70.41 %	Cumulative Planned Unavailability Factor (PUF)	:	14.59 %
Cumulative Load Factor (LF)	:	68.75 %	Cumulative Externally cause unavailability (XUF)	:	0.12 %
Cumulative Operating Factor (OF)	:	73.41 %			

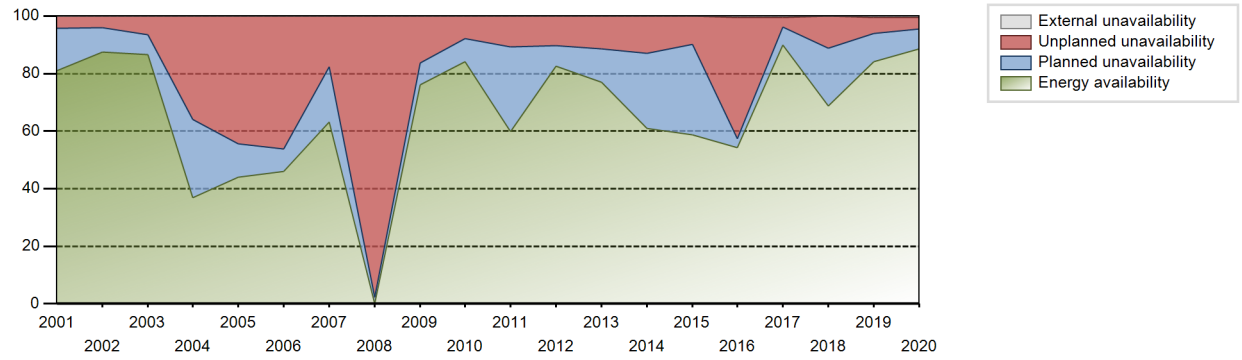
Electricity Production (net) [GWh]



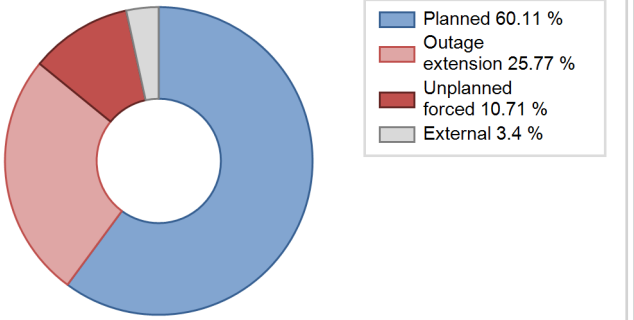
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	1829.47	4683	539	72.77	72.77	39.07	45.19	0.00	0.00	27.23	0.00
1990	1698.68	3486	487	40.12	40.12	39.89	39.90	18.89	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

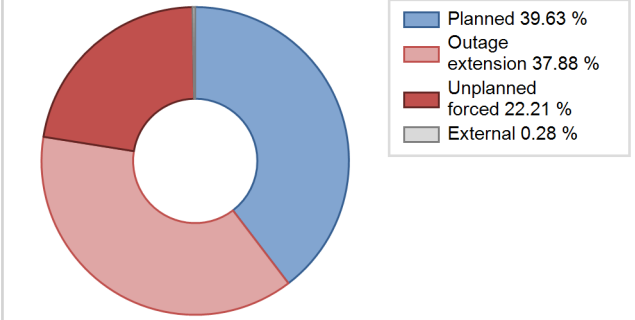
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1989 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		511			1092	
B. Refuelling without maintenance	551			207	17	
C. Inspection, maintenance or repair combined with refuelling				537	9	
D. Inspection, maintenance or repair without refuelling				809		
E. Testing of plant systems or components					14	
G. Major backfitting, refurbishment or upgrading activities without refuelling				68	29	
H. Nuclear regulatory requirements					99	
J. Grid limitation, failure or grid unavailability						6
L. Human factor related					6	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					5	
Z. Other				23	57	
Subtotal	551	511		1644	1328	6
Total	**1062**			**2978**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		411
12. Reactor I&C Systems		19
13. Reactor Auxiliary Systems		31
15. Reactor Cooling Systems		27
16. Steam generation systems		230
17. Safety I&C Systems (excluding reactor I&C)		2
21. Fuel Handling and Storage Facilities	511	53
31. Turbine and auxiliaries		68
32. Feedwater and Main Steam System		76
33. Circulating Water System		57
41. Main Generator Systems		111
42. Electrical Power Supply Systems		43
Total	**511**	**1128**

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2020 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	:	36 years

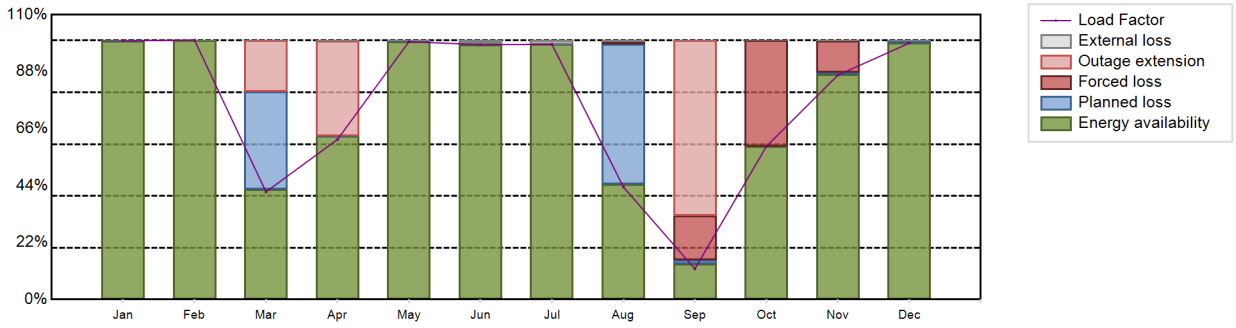
Design Characteristics

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	:	-
Coolant type	:	CO2	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	3919.4 GW(e).h	Forced Loss Rate (FLR)	:	7.28 %
Energy Availability Factor (EAF)	:	75.41 %	Unplanned Capability Loss Factor (UCL)	:	16.17 %
Unit Capability Factor (UCF)	:	75.72 %	Planned Unavailability Factor (PUF)	:	8.11 %
Load Factor (LF)	:	74.99 %	Externally cause unavailability (XUF)	:	0.31 %
Operating Factor (OF)	:	82.33 %	Total off-line time	:	1552 hours

Annual Summary



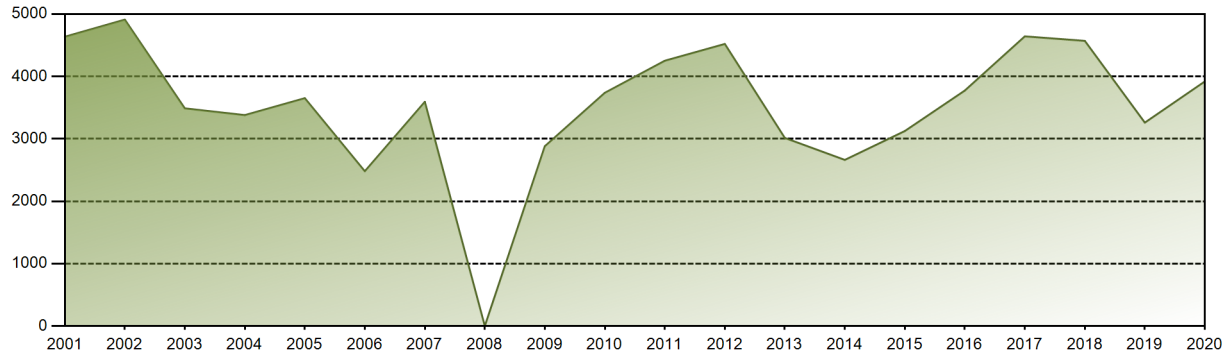
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	442.15	415.04	183.83	264.76	440.82	421.69	436.30	192.34	50.68	262.18	371.25	438.37	3919.40
EAF [%]	99.79	100.00	42.45	63.05	99.58	98.43	98.56	44.52	13.76	59.15	86.90	99.03	75.41
UCF [%]	99.79	100.00	42.45	63.13	99.82	99.50	99.97	44.99	13.76	59.15	87.07	99.26	75.72
LF [%]	99.88	100.22	41.58	61.80	99.58	98.43	98.56	43.45	11.83	59.15	86.66	99.03	74.99
OF [%]	100.00	100.00	43.20	67.78	100.00	100.00	100.00	46.37	36.94	97.99	95.83	100.00	82.33
FLR [%]	0.18	0.00	0.00	0.00	0.00	0.00	0.00	1.86	55.41	40.85	12.22	0.00	7.28
UCL [%]	0.18	0.00	19.70	36.86	0.00	0.00	0.00	0.85	84.67	40.85	12.12	0.00	16.17
PUF [%]	0.03	0.00	37.85	0.01	0.18	0.50	0.03	54.16	1.57	0.00	0.81	0.74	8.11
XUF [%]	0.00	0.00	0.00	0.08	0.25	1.06	1.41	0.47	0.00	0.00	0.16	0.24	0.31

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Historical Summary

Lifetime energy generation	:	114071.8 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	12.72 %
Cumulative Energy Availability Factor (EAF)	:	71.64 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.6 %
Cumulative Unit Capability Factor (UCF)	:	71.79 %	Cumulative Planned Unavailability Factor (PUF)	:	14.61 %
Cumulative Load Factor (LF)	:	70.48 %	Cumulative Externally cause unavailability (XUF)	:	0.16 %
Cumulative Operating Factor (OF)	:	75.07 %			

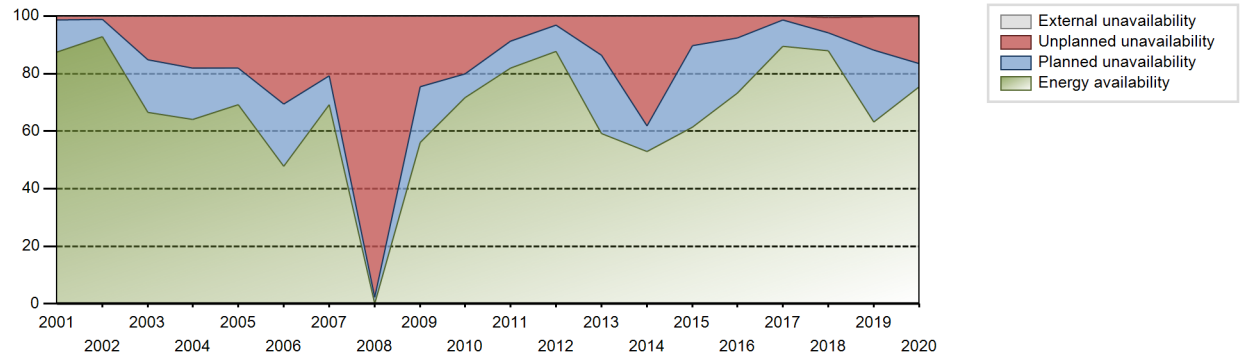
Electricity Production (net) [GWh]



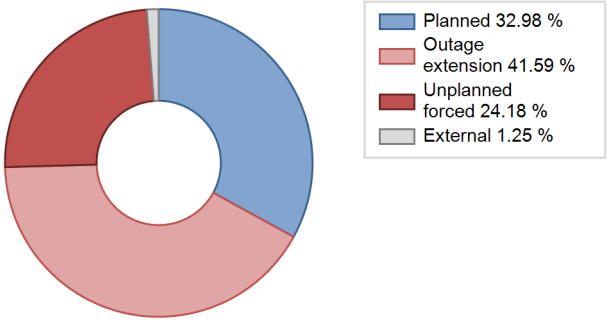
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	2234.82	4689	421	100.00	100.00	80.61	71.03	0.00	0.00	0.00	0.00
1990	3238.38	6796	487	74.14	74.14	76.04	77.79	3.08	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

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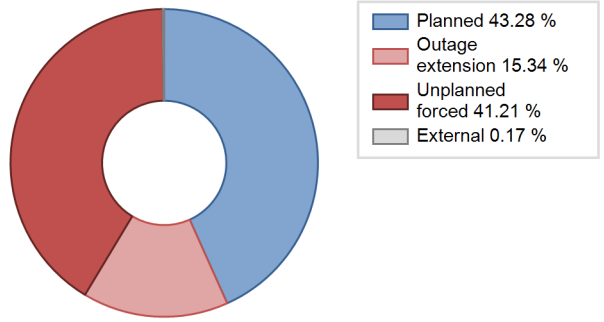
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020			1989 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		1131			1023	
B. Refuelling without maintenance	686			184	8	
C. Inspection, maintenance or repair combined with refuelling				663	32	
D. Inspection, maintenance or repair without refuelling				518		
E. Testing of plant systems or components					5	
G. Major backfitting, refurbishment or upgrading activities without refuelling				66	11	
H. Nuclear regulatory requirements					40	
L. Human factor related					5	
P. Fire					18	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					0	
Z. Other				101	6	
Subtotal	686	1131		1532	1148	
Total	**1817**			**2680**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		347
12. Reactor I&C Systems	45	16
13. Reactor Auxiliary Systems		7
15. Reactor Cooling Systems		69
16. Steam generation systems	442	126
21. Fuel Handling and Storage Facilities	643	46
31. Turbine and auxiliaries		45
32. Feedwater and Main Steam System		124
33. Circulating Water System		56
41. Main Generator Systems		93
42. Electrical Power Supply Systems		19
Total	**1130**	**948**

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2020 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

Reactor type and model	:	GCR / AGR
Thermal power	:	1500 MWth
Gross electrical power	:	625 MWe
Reference unit power (net)	:	485 MWe

Key Dates

Construction Date	:	1970-12-01
Grid Date	:	1983-07-09
Commercial Date	:	1989-04-01
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	:	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

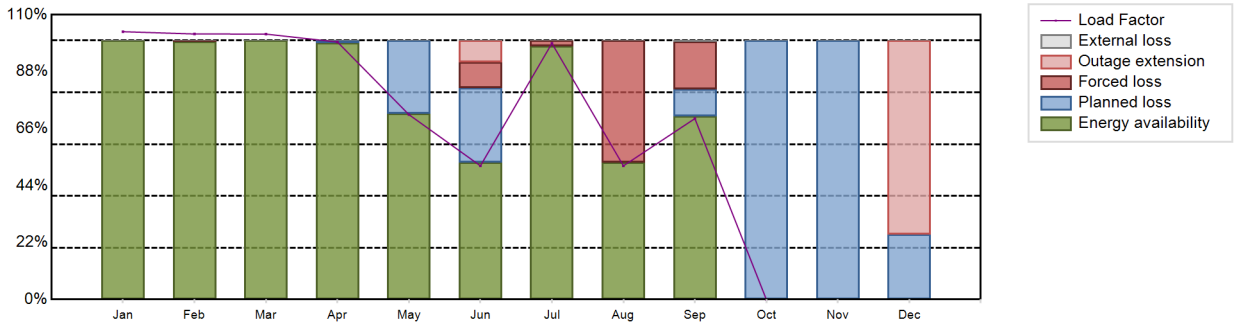
Operating coolant pressure [MPa]	:	4.14
Reactor outlet temperature [°C]	:	650
Number of SG	:	8
Containment type	:	NA
Containment design pressure [MPa]	:	NA
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP cylinder 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 (2020)

Net Energy Production	:	2648.85 GW(e).h
Energy Availability Factor (EAF)	:	61.95 %
Unit Capability Factor (UCF)	:	61.97 %
Load Factor (LF)	:	62.18 %
Operating Factor (OF)	:	64.2 %

Forced Loss Rate (FLR)	:	9.49 %
Unplanned Capability Loss Factor (UCL)	:	13.52 %
Planned Unavailability Factor (PUF)	:	24.5 %
Externally cause unavailability (XUF)	:	0.03 %
Total off-line time	:	3145 hours

Annual Summary



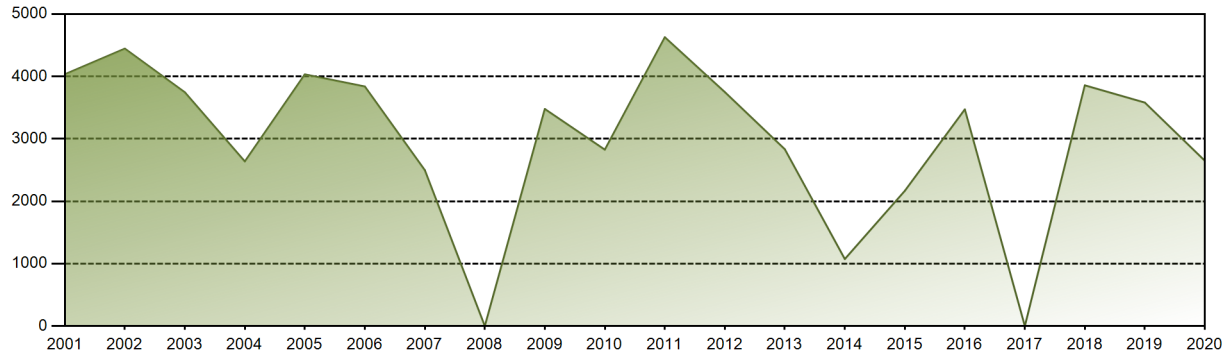
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	373.27	346.20	369.42	347.27	257.69	180.33	357.09	186.32	244.02	0.00	-0.61	-12.15	2648.85
EAF [%]	100.00	99.57	100.00	99.00	71.87	52.97	97.99	52.98	70.71	0.00	0.00	0.00	61.95
UCF [%]	100.00	99.57	100.00	99.00	71.87	52.97	97.99	52.98	71.04	0.00	0.00	0.00	61.97
LF [%]	103.44	102.56	102.51	99.45	71.41	51.64	98.96	51.64	69.88	0.00	-0.17	-3.37	62.18
OF [%]	100.00	100.00	100.00	100.00	77.42	66.11	100.00	53.09	75.69	0.00	0.00	0.00	64.20
FLR [%]	0.00	0.43	0.00	0.00	0.00	15.70	2.01	47.02	20.50	0.00	0.00	0.00	9.49
UCL [%]	0.00	0.43	0.00	0.00	0.00	18.15	2.01	47.02	18.32	0.00	0.00	74.95	13.52
PUF [%]	0.00	0.00	0.00	1.00	28.13	28.88	0.00	0.00	10.64	100.00	100.00	25.05	24.50
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.03

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Historical Summary

Lifetime energy generation	:	110624.69 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.23 %
Cumulative Energy Availability Factor (EAF)	:	68.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	16.64 %
Cumulative Unit Capability Factor (UCF)	:	68.32 %	Cumulative Planned Unavailability Factor (PUF)	:	15.04 %
Cumulative Load Factor (LF)	:	67.33 %	Cumulative Externally cause unavailability (XUF)	:	0.21 %
Cumulative Operating Factor (OF)	:	73.45 %			

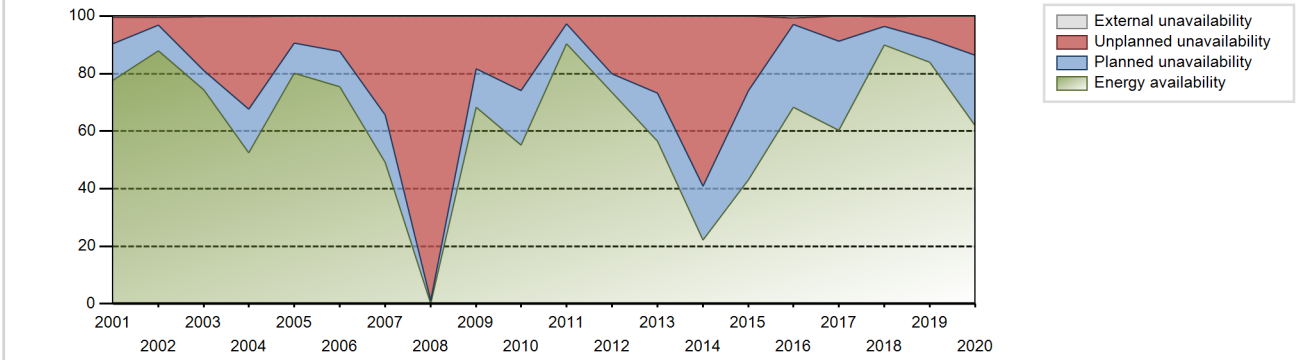
Electricity Production (net) [GWh]



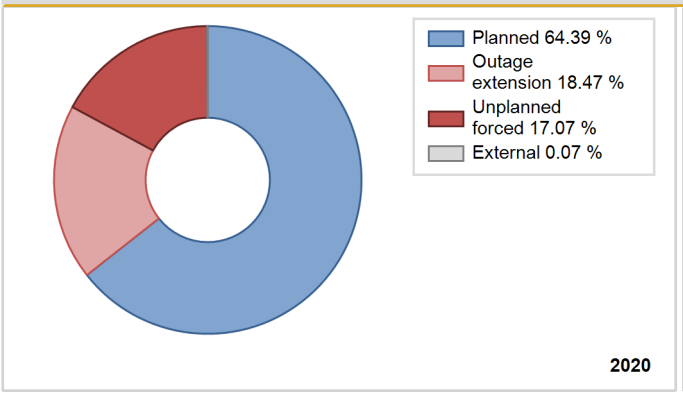
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	3045.30	7113	420	100.00	100.00	84.82	82.53	0.00	0.00	0.00	0.00
1990	1786.74	4096	487	43.38	43.38	41.95	46.89	3.74	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

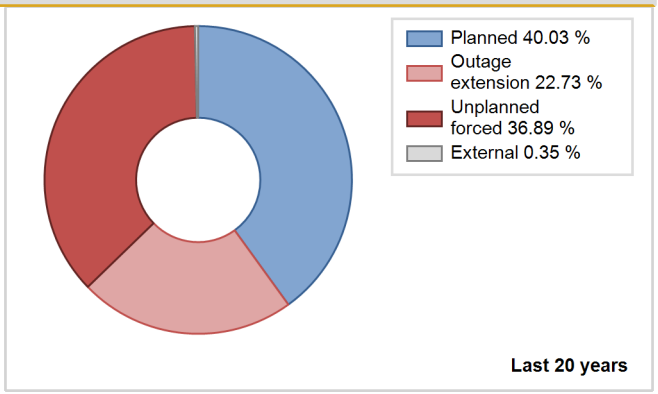
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		758			865	
B. Refuelling without maintenance	376			150	5	
C. Inspection, maintenance or repair combined with refuelling	1722			803	168	
D. Inspection, maintenance or repair without refuelling				517		
E. Testing of plant systems or components					80	
G. Major backfitting, refurbishment or upgrading activities without refuelling				53	5	
H. Nuclear regulatory requirements					57	
J. Grid limitation, failure or grid unavailability						2
L. Human factor related		452			61	
Z. Other				56	31	6
Subtotal	2098	1210		1579	1272	8
Total	**3308**			**2859**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		341
12. Reactor I&C Systems		25
13. Reactor Auxiliary Systems		23
15. Reactor Cooling Systems		37
16. Steam generation systems	558	219
21. Fuel Handling and Storage Facilities	200	23
31. Turbine and auxiliaries	452	52
32. Feedwater and Main Steam System		46
33. Circulating Water System		123
34. Miscellaneous Systems		13
41. Main Generator Systems		71
42. Electrical Power Supply Systems		31
Total	**1210**	**1004**

Highlights (2020)

Carried out a statutory outage

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2020 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

Reactor type and model	:	GCR / AGR
Thermal power	:	1500 MWth
Gross electrical power	:	625 MWe
Reference unit power (net)	:	575 MWe

Key Dates

Construction Date	:	1970-12-01
Grid Date	:	1984-10-11
Commercial Date	:	1989-04-01
Age at end of year	:	36 years

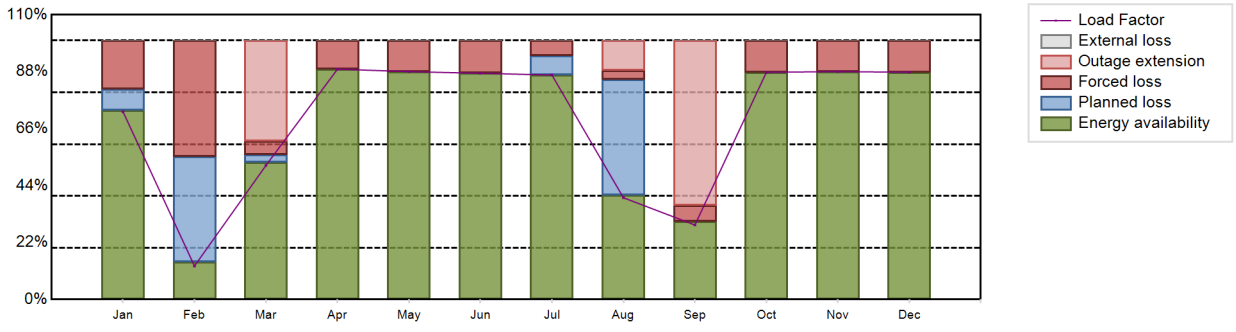
Design Characteristics

Primary Systems		
Reactor vessel centreline orientation	:	Vertical
Fuel material	:	UO2
Refuelling type	:	OFF-line
Moderator material	:	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]	:	15.6
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 (2020)

Net Energy Production	:	3464.2 GW(e).h
Energy Availability Factor (EAF)	:	69.05 %
Unit Capability Factor (UCF)	:	69.05 %
Load Factor (LF)	:	68.59 %
Operating Factor (OF)	:	80.1 %
Forced Loss Rate (FLR)	:	15.74 %
Unplanned Capability Loss Factor (UCL)	:	22.38 %
Planned Unavailability Factor (PUF)	:	8.57 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1748 hours

Annual Summary



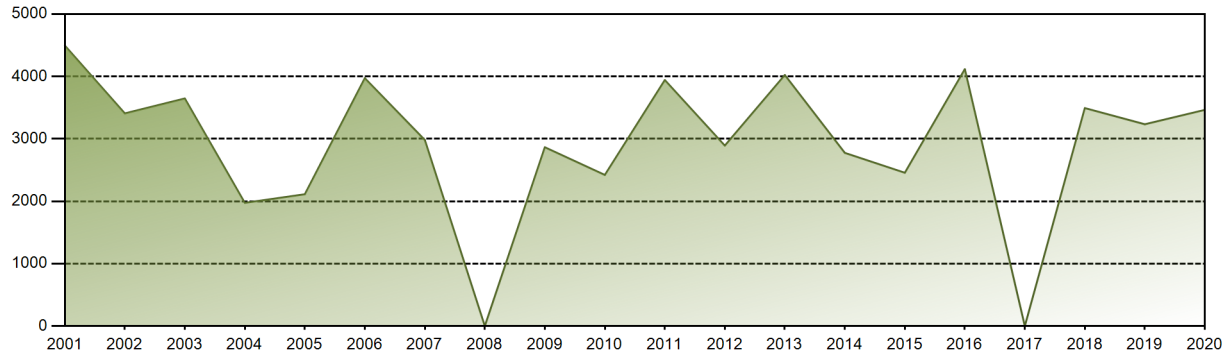
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	310.35	51.77	221.33	368.29	376.52	361.74	370.96	168.22	119.20	375.93	364.39	375.49	3464.20
EAF [%]	73.12	14.50	52.95	88.96	88.01	87.38	86.71	40.33	30.10	87.76	88.02	87.77	69.05
UCF [%]	73.12	14.50	52.95	88.96	88.01	87.38	86.71	40.33	30.10	87.76	88.02	87.77	69.05
LF [%]	72.54	12.94	51.81	88.96	88.01	87.38	86.71	39.32	28.79	87.76	88.02	87.77	68.59
OF [%]	86.02	17.24	62.72	100.00	100.00	100.00	100.00	51.61	40.14	100.00	100.00	100.00	80.10
FLR [%]	20.39	75.55	8.78	11.04	11.99	12.62	6.43	8.00	17.20	12.24	11.98	12.23	15.74
UCL [%]	18.72	44.83	44.07	11.04	11.99	12.62	5.96	14.94	69.90	12.24	11.98	12.23	22.38
PUF [%]	8.16	40.67	2.98	0.00	0.00	0.00	7.32	44.73	0.00	0.00	0.00	0.00	8.57
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

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Historical Summary

Lifetime energy generation	:	106315.05 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	16.19 %
Cumulative Energy Availability Factor (EAF)	:	67.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	18.82 %
Cumulative Unit Capability Factor (UCF)	:	67.73 %	Cumulative Planned Unavailability Factor (PUF)	:	13.45 %
Cumulative Load Factor (LF)	:	66.47 %	Cumulative Externally cause unavailability (XUF)	:	0.45 %
Cumulative Operating Factor (OF)	:	73.37 %			

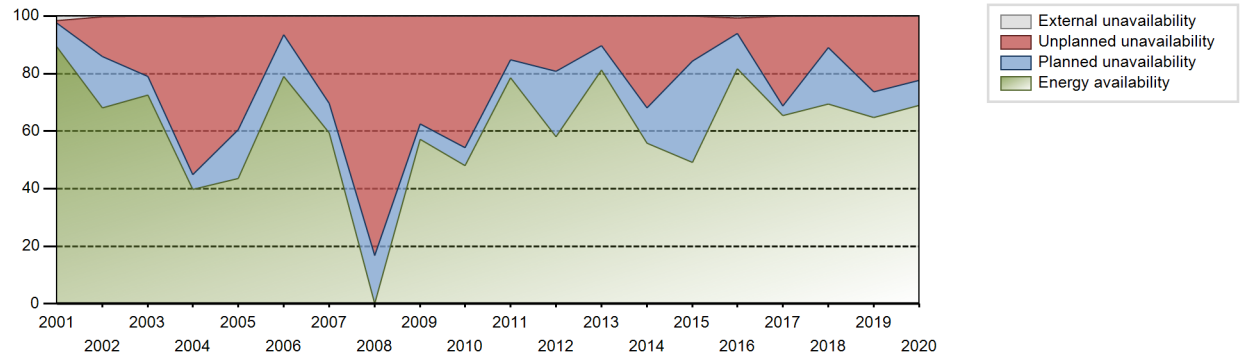
Electricity Production (net) [GWh]



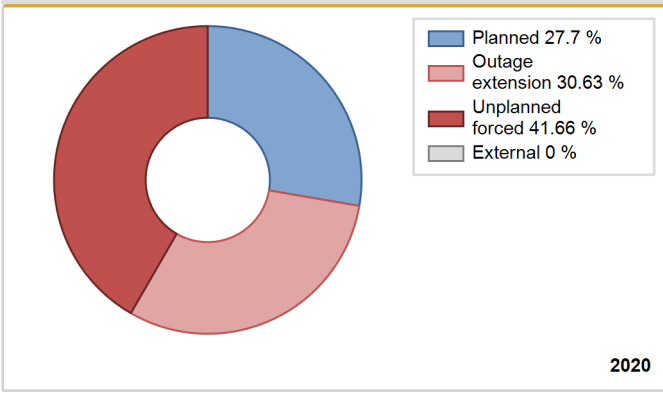
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	2505.64	5507	470	100.00	100.00	90.38	83.43	0.00	0.00	0.00	0.00
1990	3044.18	6690	487	71.98	71.98	71.48	76.58	9.35	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		81.77	82.40	81.50	87.04	4.15	5.50	12.10	0.63
2017	0.00			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

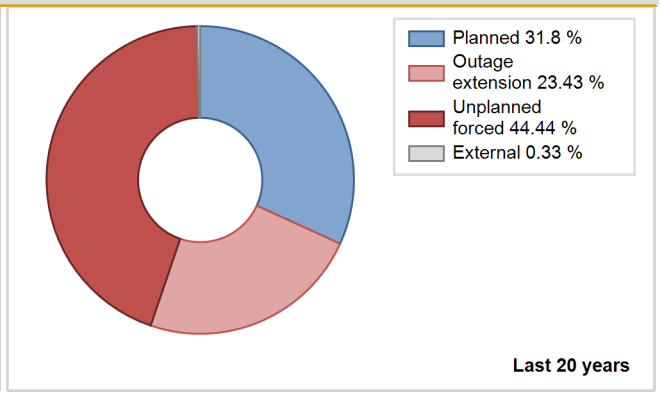
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		1343			845	
B. Refuelling without maintenance	561			189	7	
C. Inspection, maintenance or repair combined with refuelling				692	21	
D. Inspection, maintenance or repair without refuelling				509	226	
E. Testing of plant systems or components				6	20	
G. Major backfitting, refurbishment or upgrading activities without refuelling				18	32	
H. Nuclear regulatory requirements					106	
J. Grid limitation, failure or grid unavailability						11
L. Human factor related					3	
P. Fire					4	
Z. Other				83	54	5
Subtotal	561	1343		1497	1318	16
Total	**1904**			**2831**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		399
12. Reactor I&C Systems		32
13. Reactor Auxiliary Systems		1
14. Safety Systems		15
15. Reactor Cooling Systems		69
16. Steam generation systems	516	189
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities	156	11
31. Turbine and auxiliaries		78
32. Feedwater and Main Steam System		47
33. Circulating Water System	671	130
34. Miscellaneous Systems		4
41. Main Generator Systems		40
42. Electrical Power Supply Systems		73
Total	**1343**	**1089**

Highlights (2020)

Load limited to 90% of RUP to manage fuel clad temperatures

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2020 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

Reactor type and model	:	GCR / AGR
Thermal power	:	1550 MWth
Gross electrical power	:	680 MWe
Reference unit power (net)	:	620 MWe

Key Dates

Construction Date	:	1980-08-01
Grid Date	:	1988-07-12
Commercial Date	:	1989-04-01
Age at end of year	:	32 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]	:	2
Part of the core refuelled [%]	:	3
Average discharge burnup [MWd/t]	:	27000
Active core diameter [m]	:	9.46
Active core height/length [m]	:	8.31
Number of fissile fuel assemblies/bundles	:	332
Fuel linear heat generation rate [kW/m]	:	16.8
Number of control rod assemblies	:	89
Number of external reactor coolant loops	:	NA
Coolant type	:	CO2

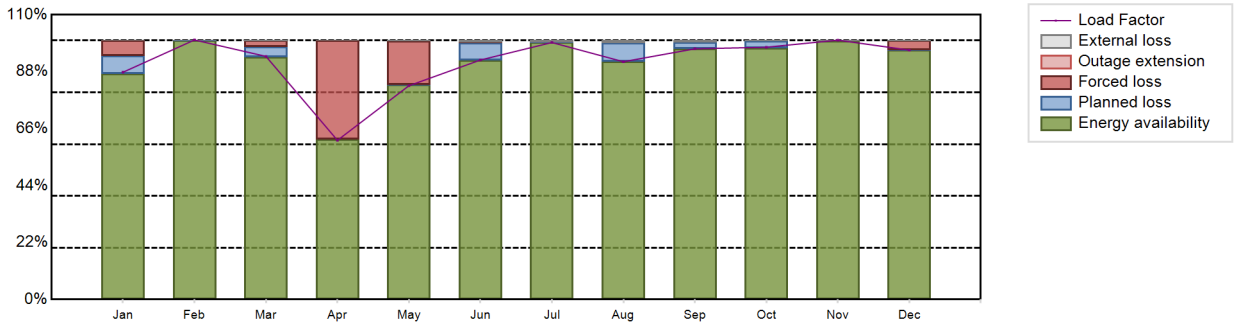
Operating coolant pressure [MPa]	:	4.3
Reactor outlet temperature [°C]	:	635
Number of SG	:	4
Containment type	:	NA
Containment design pressure [MPa]	:	NA
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	15.9
Output voltage [kV]	:	23.5
Primary means of condenser cooling	:	Sea (once-through)
Number of main condensate pumps	:	2
Number of FW pumps for full power operation	:	-
Number of on-site safety related diesel generators	:	-
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	4993.67 GW(e).h
Energy Availability Factor (EAF)	:	91.65 %
Unit Capability Factor (UCF)	:	91.89 %
Load Factor (LF)	:	91.69 %
Operating Factor (OF)	:	97.32 %

Forced Loss Rate (FLR)	:	5.71 %
Unplanned Capability Loss Factor (UCL)	:	5.57 %
Planned Unavailability Factor (PUF)	:	2.55 %
Externally cause unavailability (XUF)	:	0.23 %
Total off-line time	:	235 hours

Annual Summary



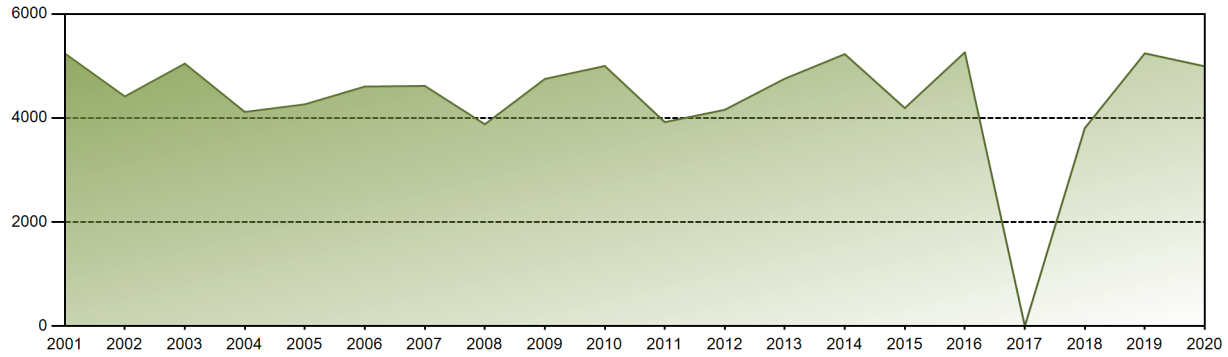
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	404.89	432.62	432.56	274.50	380.90	412.95	457.83	423.69	432.23	450.07	447.14	444.29	4993.67
EAF [%]	87.31	100.00	93.77	61.86	83.05	92.51	99.25	91.85	96.83	97.19	99.97	96.31	91.65
UCF [%]	87.31	100.00	93.77	61.86	83.14	93.04	99.97	92.68	97.43	97.21	99.97	96.31	91.89
LF [%]	87.77	100.25	93.90	61.49	82.58	92.51	99.25	91.85	96.83	97.44	100.17	96.32	91.69
OF [%]	98.92	100.00	100.00	77.92	90.86	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.32
FLR [%]	6.27	0.00	2.36	38.14	16.85	0.33	0.00	0.00	0.00	0.00	0.00	3.57	5.71
UCL [%]	5.84	0.00	2.26	38.14	16.85	0.31	0.00	0.00	0.00	0.00	0.00	3.56	5.57
PUF [%]	6.85	0.00	3.96	0.00	0.02	6.66	0.03	7.32	2.57	2.79	0.03	0.13	2.55
XUF [%]	0.00	0.00	0.00	0.00	0.09	0.53	0.71	0.83	0.60	0.02	0.00	0.00	0.23

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Historical Summary

Lifetime energy generation	:	135714.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.48 %
Cumulative Energy Availability Factor (EAF)	:	80.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.39 %
Cumulative Unit Capability Factor (UCF)	:	80.65 %	Cumulative Planned Unavailability Factor (PUF)	:	13.95 %
Cumulative Load Factor (LF)	:	79.41 %	Cumulative Externally cause unavailability (XUF)	:	0.56 %
Cumulative Operating Factor (OF)	:	84.5 %			

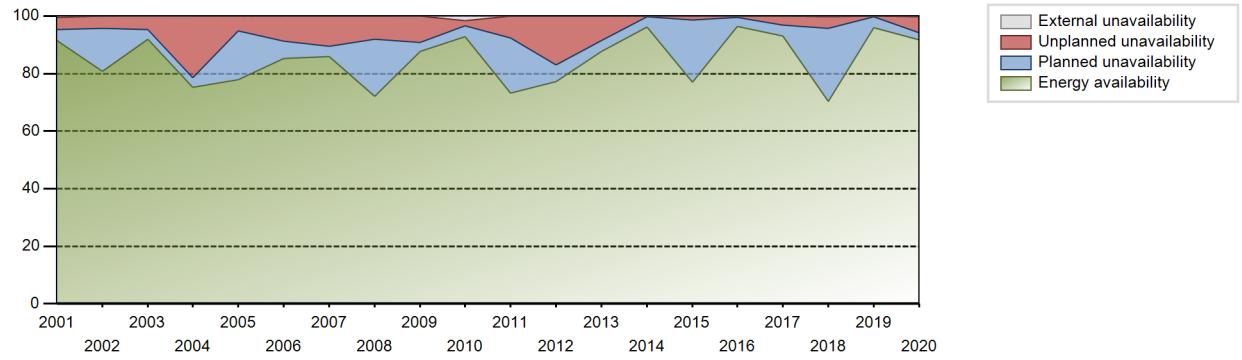
Electricity Production (net) [GWh]



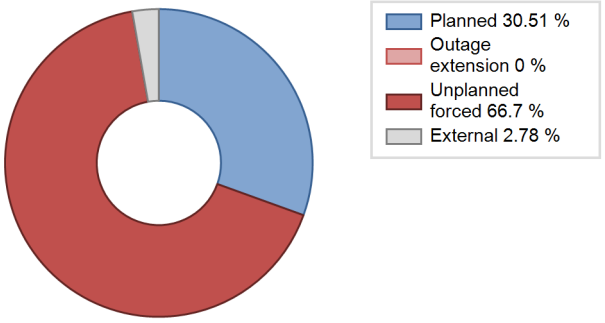
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	2204.46	4454	615	56.92	56.92	22.19	35.13	0.00	0.00	43.08	0.00
1990	1487.04	3509	615	27.75	27.75	27.68	40.17	1.22	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

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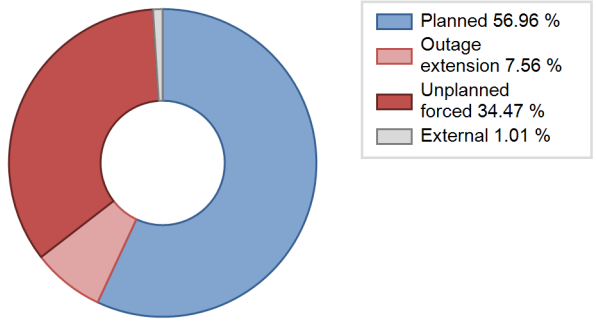
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		236			266	
C. Inspection, maintenance or repair combined with refuelling				621	34	
D. Inspection, maintenance or repair without refuelling				119	4	
E. Testing of plant systems or components				1	5	
J. Grid limitation, failure or grid unavailability						29
L. Human factor related					24	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				92		
Z. Other					0	10
Subtotal		236		833	333	39
Total		**236**			**1205**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		9
15. Reactor Cooling Systems		5
16. Steam generation systems		22
21. Fuel Handling and Storage Facilities		9
31. Turbine and auxiliaries	236	121
32. Feedwater and Main Steam System		94
41. Main Generator Systems		19
42. Electrical Power Supply Systems		22
Total	**236**	**303**

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2020 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

Reactor type and model	:	GCR / AGR
Thermal power	:	1550 MWth
Gross electrical power	:	680 MWe
Reference unit power (net)	:	620 MWe

Key Dates

Construction Date	:	1980-08-01
Grid Date	:	1988-11-11
Commercial Date	:	1989-04-01
Age at end of year	:	32 years

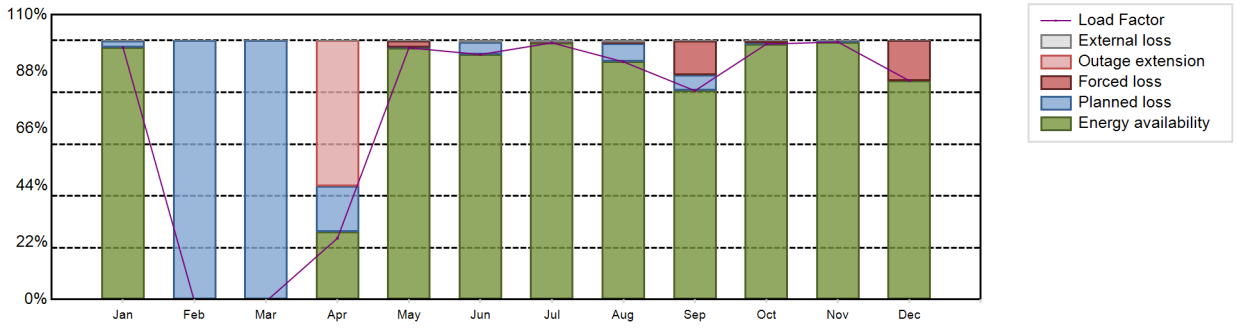
Design Characteristics

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 (2020)

Net Energy Production	:	3948.62 GW(e).h	Forced Loss Rate (FLR)	:	3.6 %
Energy Availability Factor (EAF)	:	72.85 %	Unplanned Capability Loss Factor (UCL)	:	7.35 %
Unit Capability Factor (UCF)	:	73.05 %	Planned Unavailability Factor (PUF)	:	19.61 %
Load Factor (LF)	:	72.5 %	Externally cause unavailability (XUF)	:	0.2 %
Operating Factor (OF)	:	77.21 %	Total off-line time	:	2002 hours

Annual Summary



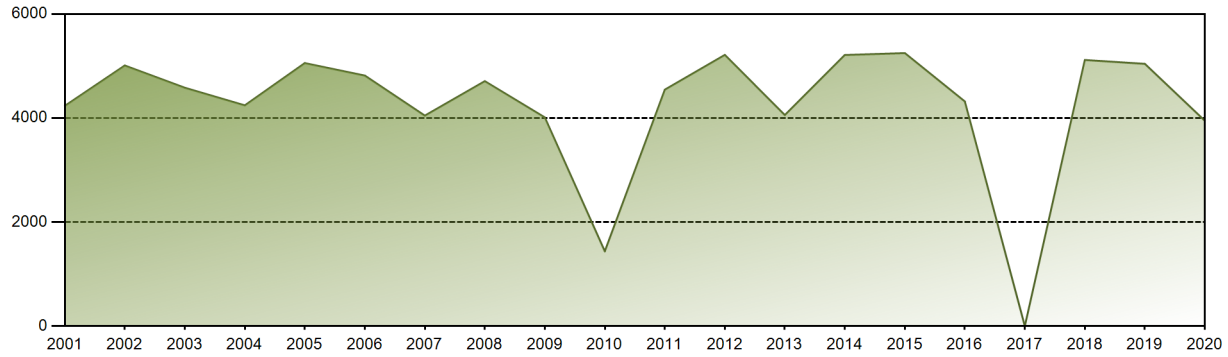
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	448.96	-3.38	-3.45	105.68	448.42	422.34	457.25	423.49	359.93	455.60	444.03	389.74	3948.62
EAF [%]	97.32	0.00	0.00	26.17	97.20	94.61	99.13	91.81	80.80	98.64	99.47	84.49	72.85
UCF [%]	97.32	0.00	0.00	26.19	97.35	95.22	99.78	92.40	80.97	98.82	99.49	84.49	73.05
LF [%]	97.33	-0.78	-0.75	23.67	97.21	94.61	99.13	91.81	80.63	98.64	99.47	84.49	72.50
OF [%]	97.98	0.00	0.00	30.56	100.00	100.00	100.00	100.00	93.33	100.00	100.00	100.00	77.21
FLR [%]	0.00	0.00	0.00	0.00	2.52	0.00	0.22	0.53	14.04	0.71	0.00	15.51	3.60
UCL [%]	0.18	0.00	0.00	56.13	2.52	0.00	0.22	0.49	13.23	0.71	0.00	15.51	7.35
PUF [%]	2.50	100.00	100.00	17.69	0.13	4.78	0.00	7.11	5.81	0.47	0.51	0.00	19.61
XUF [%]	0.00	0.00	0.00	0.01	0.15	0.61	0.66	0.59	0.16	0.19	0.03	0.00	0.20

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Historical Summary

Lifetime energy generation	:	131192.95 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.37 %
Cumulative Energy Availability Factor (EAF)	:	78.32 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.49 %
Cumulative Unit Capability Factor (UCF)	:	79.11 %	Cumulative Planned Unavailability Factor (PUF)	:	13.4 %
Cumulative Load Factor (LF)	:	77.64 %	Cumulative Externally cause unavailability (XUF)	:	0.79 %
Cumulative Operating Factor (OF)	:	82.58 %			

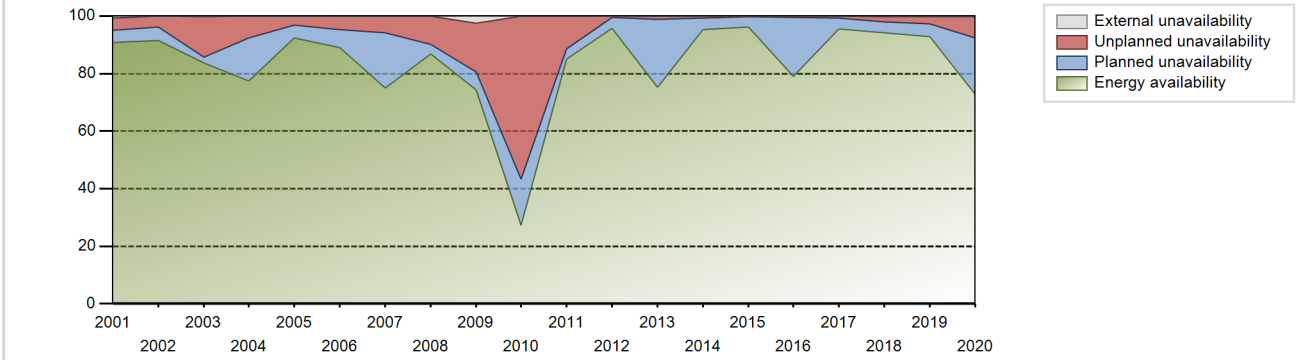
Electricity Production (net) [GWh]



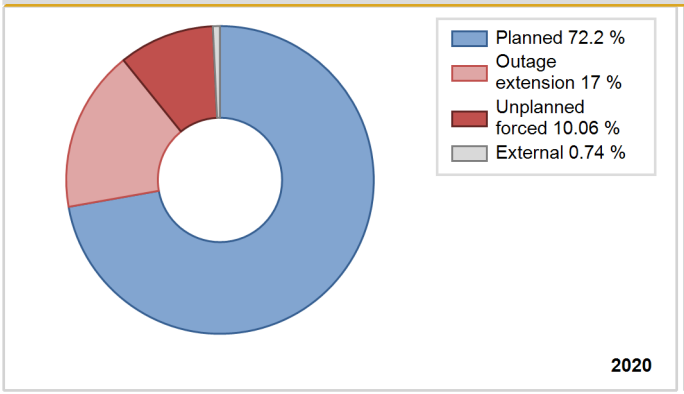
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	3825.57	6989	615	74.41	74.41	63.81	73.90	0.00	0.00	25.59	0.00
1990	783.97	1901	615	14.92	14.92	14.59	21.76	0.00	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

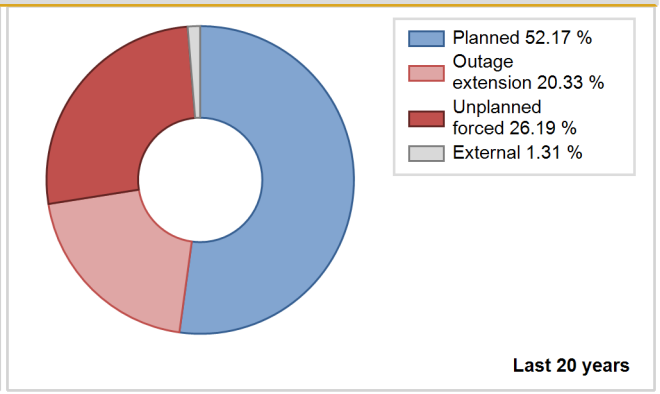
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		522			505	
B. Refuelling without maintenance				8	5	
C. Inspection, maintenance or repair combined with refuelling	1580			646	15	
D. Inspection, maintenance or repair without refuelling				209		
E. Testing of plant systems or components					6	
J. Grid limitation, failure or grid unavailability						29
L. Human factor related					6	
P. Fire					2	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				15		
Z. Other						34
Subtotal	1580	522		878	539	63
Total	**2102**			**1480**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories	100	19
12. Reactor I&C Systems		11
15. Reactor Cooling Systems		1
16. Steam generation systems		15
17. Safety I&C Systems (excluding reactor I&C)		2
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		204
32. Feedwater and Main Steam System	49	32
33. Circulating Water System		140
41. Main Generator Systems	374	84
42. Electrical Power Supply Systems		10
Total	**523**	**523**

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2020 Operating Experience

GB-16A HINKLEY POINT B-1 UNITED KINGDOM

Status at end of year	:	**Operational**
Operator	:	EDF UK (EDF Energy)
Owner	:	EDF UK (EDF Energy)
Reactor Supplier	:	TNPG (THE NUCLEAR POWER GROUP, LTD.)
Turbine Supplier	:	GEC (GENERAL ELECTRIC COMPANY (UK))

Reactor Unit Details

Reactor type and model	:	GCR / AGR
Thermal power	:	1494 MWth
Gross electrical power	:	655 MWe
Reference unit power (net)	:	485 MWe

Key Dates

Construction Date	:	1967-09-01
Grid Date	:	1976-10-30
Commercial Date	:	1978-10-02
Age at end of year	:	44 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]	:	NA
Part of the core refuelled [%]	:	NA
Average discharge burnup [MWd/t]	:	38500
Active core diameter [m]	:	9.1
Active core height/length [m]	:	8.312
Number of fissile fuel assemblies/bundles	:	2464
Fuel linear heat generation rate [kW/m]	:	18.2
Number of control rod assemblies	:	81
Number of external reactor coolant loops	:	4
Coolant type	:	CO2

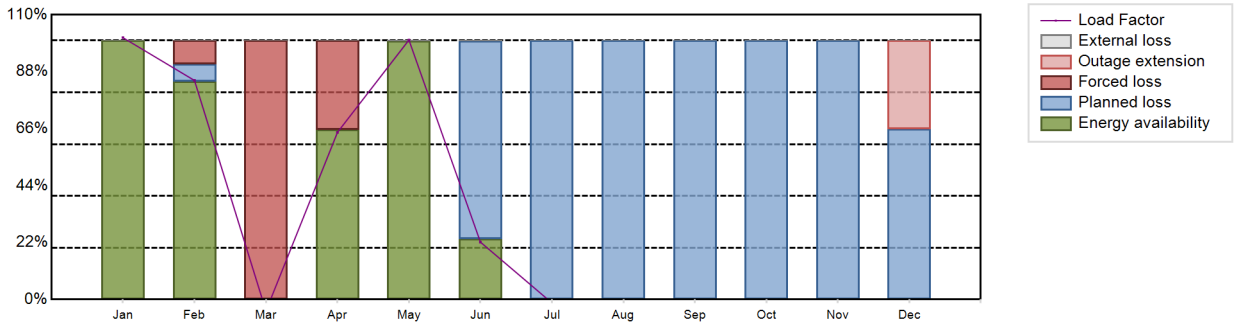
Operating coolant pressure [MPa]	:	4.24
Reactor outlet temperature [°C]	:	645.5
Number of SG	:	4
Containment type	:	NA
Containment design pressure [MPa]	:	NA
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	15.85
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	:	5
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	1275.63 GW(e).h
Energy Availability Factor (EAF)	:	30.9 %
Unit Capability Factor (UCF)	:	30.93 %
Load Factor (LF)	:	29.94 %
Operating Factor (OF)	:	31.88 %

Forced Loss Rate (FLR)	:	27.96 %
Unplanned Capability Loss Factor (UCL)	:	14.89 %
Planned Unavailability Factor (PUF)	:	54.18 %
Externally cause unavailability (XUF)	:	0.02 %
Total off-line time	:	5984 hours

Annual Summary



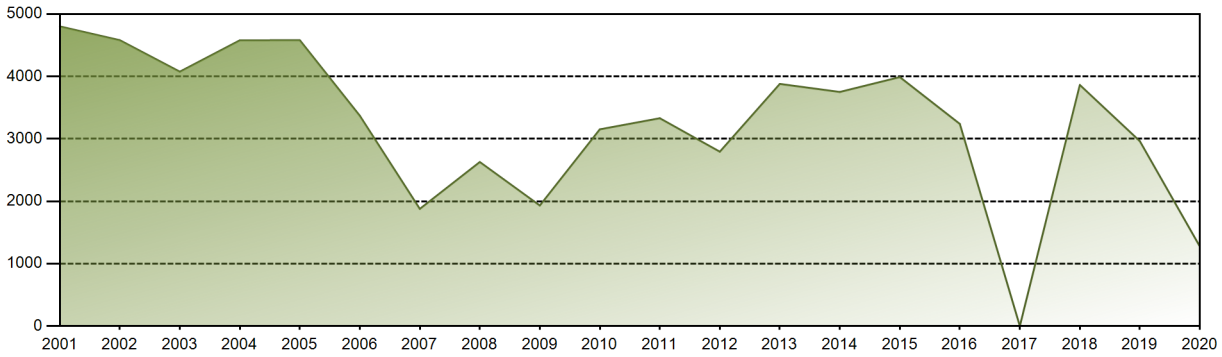
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	364.89	285.58	-15.85	225.44	361.65	77.46	-4.71	-4.31	-3.00	-2.22	-2.09	-7.21	1275.63
EAF [%]	100.00	84.16	0.00	65.64	99.90	23.43	0.00	0.00	0.00	0.00	0.00	0.00	30.90
UCF [%]	100.00	84.16	0.00	65.64	100.00	23.63	0.00	0.00	0.00	0.00	0.00	0.00	30.93
LF [%]	101.12	84.60	-4.40	64.56	100.23	22.18	-1.30	-1.19	-0.86	-0.62	-0.60	-2.00	29.94
OF [%]	100.00	90.95	0.00	69.58	100.00	24.72	0.00	0.00	0.00	0.00	0.00	0.00	31.88
FLR [%]	0.00	9.83	100.00	34.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.96
UCL [%]	0.00	9.18	100.00	34.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.12	14.89
PUF [%]	0.00	6.66	0.00	0.00	0.00	76.37	100.00	100.00	100.00	100.00	100.00	65.88	54.18
XUF [%]	0.00	0.00	0.00	0.00	0.10	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.02

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Historical Summary

Lifetime energy generation	:	147370.32 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.41 %
Cumulative Energy Availability Factor (EAF)	:	75.81 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.56 %
Cumulative Unit Capability Factor (UCF)	:	76.34 %	Cumulative Planned Unavailability Factor (PUF)	:	14.1 %
Cumulative Load Factor (LF)	:	76.86 %	Cumulative Externally cause unavailability (XUF)	:	0.53 %
Cumulative Operating Factor (OF)	:	80.43 %			

Electricity Production (net) [GWh]

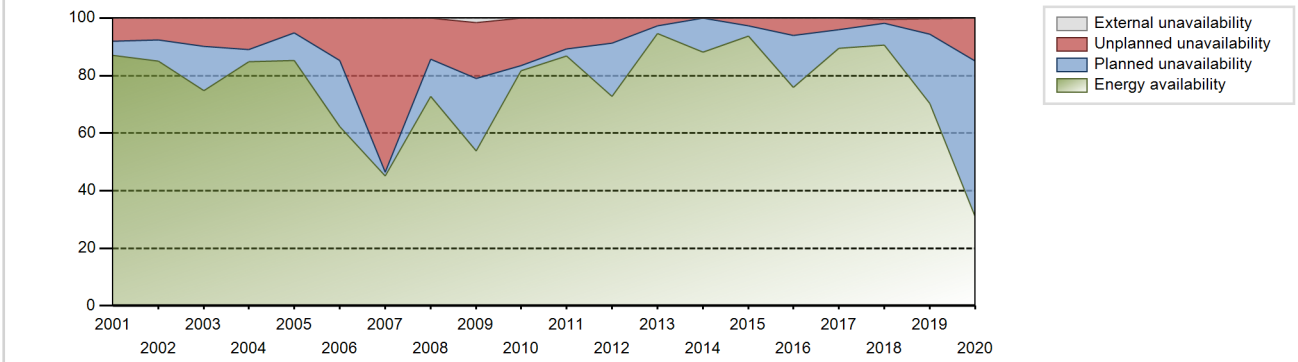


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1978	Data not provided										
1979	3079.80	6646	400	73.47	79.41	88.14	76.08	20.59	20.59	0.00	5.94
1980	2337.16	5394	475	55.37	59.86	56.32	61.74	5.89	3.74	36.39	4.50
1981	3441.60	7118	520	74.27	78.55	74.33	79.94	1.70	1.35	20.10	4.28
1982	2950.76	6000	520	65.36	67.79	64.96	68.68	1.36	0.94	31.28	2.42
1983	4082.98	8127	520	86.62	88.31	89.88	93.03	4.47	4.14	7.56	1.68
1984	3408.22	6589	520	71.56	71.95	75.03	75.42	10.11	8.09	19.96	0.39
1985	4263.02	8167	520	82.20	82.32	93.84	93.49	8.86	8.00	9.68	0.11
1986	3199.19	6110	560	67.24	68.17	65.39	69.94	4.70	3.36	28.47	0.93
1987	1837.99	3554	560	38.79	39.61	36.86	39.91	59.65	58.54	1.85	0.82
1988	2905.41	5370	560	59.14	59.86	59.39	61.47	5.20	3.28	36.86	0.73
1989	4195.30	7878	560	85.50	85.64	85.76	90.18	1.14	0.99	13.37	0.14
1990	3101.98	5732	560	63.37	63.88	63.41	65.61	15.37	11.60	24.51	0.52
1991	4601.89	8430	560	94.35	94.35	94.07	96.50	0.00	0.00	5.65	0.00
1992	3614.47	6565	583	69.78	70.24	69.54	73.73	9.17	7.09	22.67	0.46
1993	4843.29	8587	585	94.56	94.79	94.01	97.50	2.63	2.56	2.66	0.23
1994	4126.20	7342	585	78.32	78.71	80.74	84.04	5.05	4.19	17.10	0.39
1995	4812.46	7910	610	89.63	90.09	89.81	90.05	5.38	5.13	4.79	0.46
1996	4797.27	8418	610	89.74	90.25	89.53	95.83	5.57	5.33	4.43	0.50
1997	4185.70	7341	610	78.27	78.39	78.12	83.57	4.69	3.86	17.75	0.12
1998	4252.57	7740	610	80.89	79.64	79.37	88.11	7.43	6.39	13.97	-1.26
1999	4045.23	7221	610	76.98	75.77	75.50	82.21	21.10	20.26	3.97	-1.21
2000	3850.58	7208	610	71.86	71.86	71.86	82.06	14.66	12.34	15.80	0.00
2001	4801.96	8545	610	86.97	86.97	89.62	97.28	8.57	8.16	4.87	0.00
2002	4580.96	8021	610	84.96	84.98	85.73	91.56	6.79	7.52	7.51	0.01
2003	4076.35	7032	610	74.84	74.84	76.28	80.27	6.49	9.83	15.34	0.00
2004	4578.71	8091	610	84.77	84.77	85.45	92.11	11.39	11.01	4.22	0.00
2005	4580.58	8257	610	85.23	85.23	85.72	94.26	5.24	5.06	9.71	0.00
2006	3370.18	6200	610	62.36	62.36	62.30	70.78	9.67	14.85	22.79	0.00
2007	1877.41	5204	430	45.21	45.24	44.94	59.41	14.64	53.62	1.14	0.03
2008	2628.76	6935	410	72.77	72.77	72.12	78.95	16.47	14.37	12.86	0.01
2009	1931.52	4963	410	53.72	55.40	53.78	56.66	23.30	19.39	25.21	1.67
2010	3152.41	7411	410	81.78	81.80	87.77	84.60	16.71	16.46	1.75	0.01
2011	3329.95	7863	435	86.79	86.79	87.39	89.76	11.05	10.78	2.43	0.00
2012	2793.96	6693	435	72.81	72.81	73.12	76.20	6.36	8.71	18.49	0.00
2013	3880.00	8553	440	94.72	94.72	100.66	97.64	2.63	2.75	2.54	0.00
2014	3751.17	7968	475	88.19	88.19	90.15	90.96	0.02	0.02	11.79	0.00

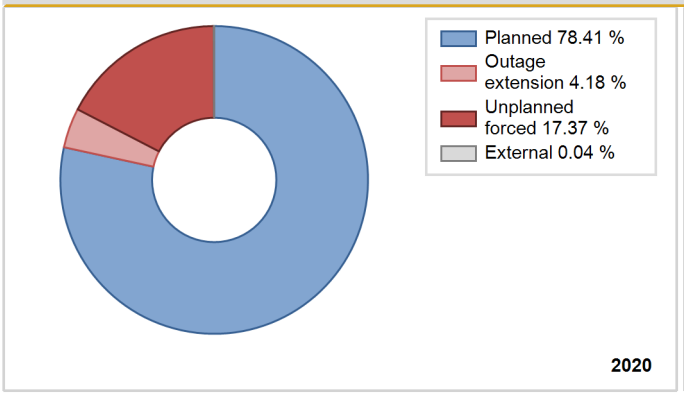
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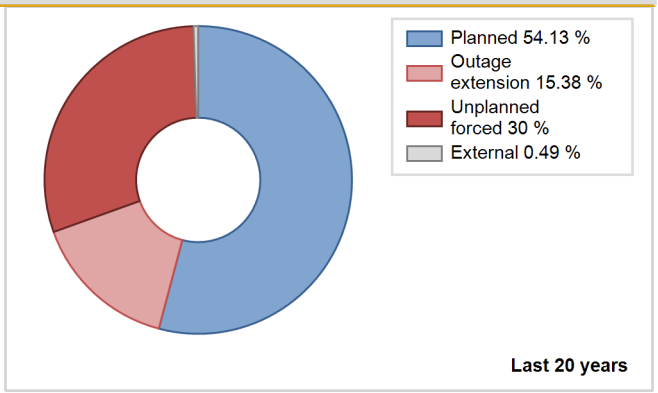
2015	3989.08	8614	480	93.67	93.71	94.87	98.33	2.48	2.66	3.63	0.04
2016	3239.17	6928		75.91	75.91	76.82	78.87	7.28	5.96	18.13	0.00
2017	0.00			89.47	89.52	90.60	91.94	4.23	3.95	6.52	0.05
2018	3863.64	8305	485	90.64	91.13	90.94	94.81	1.34	1.24	7.63	0.49
2019	2963.04	6427	485	70.24	70.56	69.74	73.37	4.24	5.36	24.08	0.32
2020	1275.63	2800	485	30.90	30.93	29.94	31.88	27.96	14.89	54.18	0.02

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020			1978 to 2020		
		Hours Lost			Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure		1025			485	
B.	Refuelling without maintenance				1		
C.	Inspection, maintenance or repair combined with refuelling				251	21	
D.	Inspection, maintenance or repair without refuelling	4704			537		
E.	Testing of plant systems or components					1	
J.	Grid limitation, failure or grid unavailability						2
L.	Human factor related					19	
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.)						3
Z.	Other		254		1	7	1
Subtotal		4704	1279		790	533	7
Total			**5983**			**1330**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1978 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	254	15
12. Reactor I&C Systems		11
15. Reactor Cooling Systems		7
16. Steam generation systems		114
17. Safety I&C Systems (excluding reactor I&C)	1025	24
21. Fuel Handling and Storage Facilities		6
31. Turbine and auxiliaries		142
32. Feedwater and Main Steam System		16
41. Main Generator Systems		80
42. Electrical Power Supply Systems		88
Total	**1279**	**503**

Highlights (2020)

Shut down in June for a graphite core inspection and remains off pending a return to service safety case

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2020 Operating Experience

GB-16B HINKLEY POINT B-2 UNITED KINGDOM

Status at end of year	:	**Operational**
Operator	:	EDF UK (EDF Energy)
Owner	:	EDF UK (EDF Energy)
Reactor Supplier	:	TNPG (THE NUCLEAR POWER GROUP, LTD.)
Turbine Supplier	:	GEC (GENERAL ELECTRIC COMPANY (UK))

Reactor Unit Details

Reactor type and model	:	GCR / AGR
Thermal power	:	1494 MWth
Gross electrical power	:	655 MWe
Reference unit power (net)	:	480 MWe

Key Dates

Construction Date	:	1967-09-01
Grid Date	:	1976-02-05
Commercial Date	:	1976-09-27
Age at end of year	:	44 years

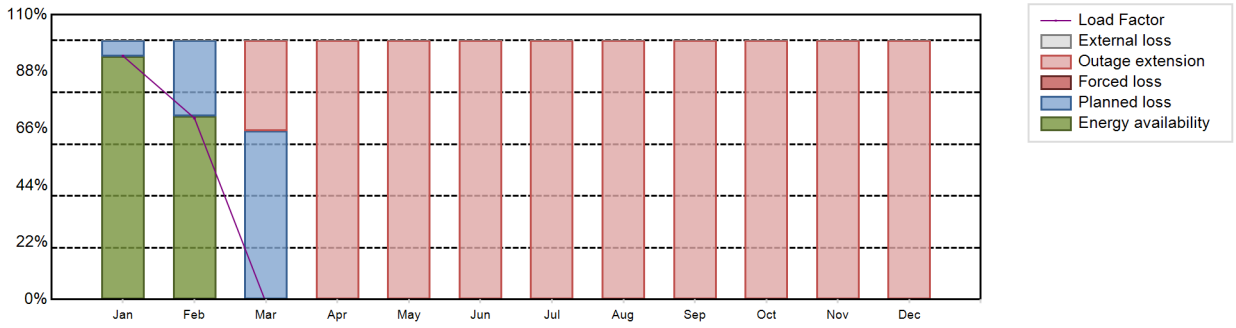
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	4.24
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	645.5
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]	:	NA	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	NA	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	38500	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	9.1	HP cylinder inlet steam pressure [MPa]	:	16
Active core height/length [m]	:	8.312	Output voltage [kV]	:	23
Number of fissile fuel assemblies/bundles	:	2464	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	18.2	Number of main condensate pumps	:	2
Number of control rod assemblies	:	81	Number of FW pumps for full power operation	:	1
Number of external reactor coolant loops	:	4	Number of on-site safety related diesel generators	:	5
Coolant type	:	CO2	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	500.91 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	13.57 %	Unplanned Capability Loss Factor (UCL)	:	78.1 %
Unit Capability Factor (UCF)	:	13.57 %	Planned Unavailability Factor (PUF)	:	8.33 %
Load Factor (LF)	:	11.88 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	14.18 %	Total off-line time	:	7538 hours

Annual Summary



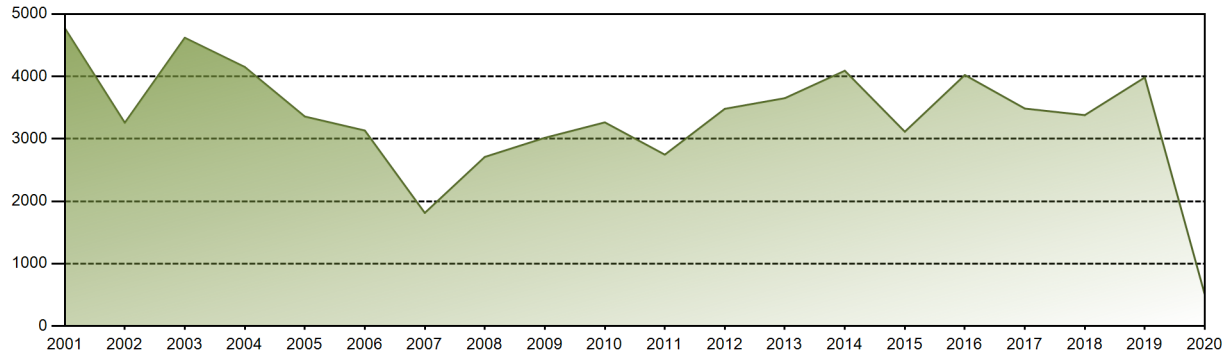
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	335.88	234.01	-4.27	-3.83	-3.38	-9.49	-10.63	-10.69	-9.64	-5.59	-5.63	-5.83	500.91
EAF [%]	94.00	70.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.57
UCF [%]	94.00	70.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.57
LF [%]	94.05	70.05	-1.20	-1.11	-0.95	-2.75	-2.98	-2.99	-2.79	-1.56	-1.63	-1.63	11.88
OF [%]	100.00	72.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.18
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	34.94	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	78.10
PUF [%]	6.00	29.28	65.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.33
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

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Historical Summary

Lifetime energy generation	:	143677.63 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	10.77 %
Cumulative Energy Availability Factor (EAF)	:	74.3 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.2 %
Cumulative Unit Capability Factor (UCF)	:	75.22 %	Cumulative Planned Unavailability Factor (PUF)	:	13.58 %
Cumulative Load Factor (LF)	:	73.54 %	Cumulative Externally cause unavailability (XUF)	:	0.93 %
Cumulative Operating Factor (OF)	:	78.28 %			

Electricity Production (net) [GWh]

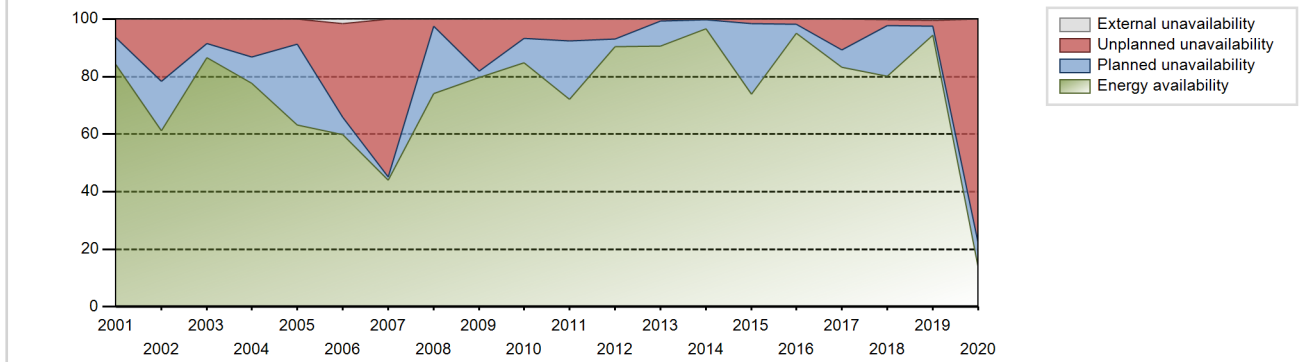


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	Data not provided										
1977	1044.00	2756	400	74.58	74.58	29.88	31.55	23.23	22.56	2.86	0.00
1978	Data not provided										
1979	1499.67	3512	400	38.16	43.97	42.92	40.20	4.51	2.08	53.96	5.81
1980	3008.94	6390	475	69.31	71.35	72.51	73.15	9.08	7.13	21.53	2.04
1981	2488.82	5054	520	54.68	57.09	53.75	56.76	20.99	15.16	27.75	2.41
1982	3155.05	6834	520	69.75	73.64	69.45	78.23	16.51	14.56	11.80	3.89
1983	3454.48	6839	520	74.14	75.59	76.04	78.29	3.14	2.45	21.95	1.45
1984	4393.54	8228	520	89.39	89.56	96.72	94.18	5.95	5.67	4.77	0.17
1985	3229.92	5950	520	66.72	66.73	71.10	68.11	6.71	4.80	28.48	0.00
1986	3497.25	7257	560	75.11	81.23	72.48	84.23	13.47	12.64	6.13	6.12
1987	2971.07	6333	560	60.64	68.32	59.59	71.13	5.34	3.85	27.83	7.68
1988	4268.17	8467	560	86.64	91.11	87.25	96.92	4.05	3.85	5.05	4.47
1989	2484.57	4896	560	65.35	65.59	50.79	56.04	0.44	0.29	34.11	0.24
1990	4463.54	8565	560	91.24	92.36	91.24	98.04	1.75	1.65	5.99	1.12
1991	2353.52	4432	560	57.40	57.40	48.11	50.73	17.01	11.76	30.84	0.00
1992	3901.97	7225	583	76.27	76.60	75.07	81.14	21.22	20.63	2.76	0.33
1993	3743.03	6575	597	71.38	71.72	71.71	75.26	11.07	8.93	19.35	0.34
1994	4852.23	8602	610	91.08	91.51	91.05	98.47	3.05	2.88	5.60	0.43
1995	4518.09	7411	610	84.59	84.59	84.32	84.37	10.90	10.35	5.06	0.00
1996	3119.85	5615	610	59.14	58.94	58.23	63.92	16.82	11.92	29.14	-0.20
1997	4512.87	7958	610	84.95	84.50	84.22	90.60	11.86	11.37	4.13	-0.45
1998	4738.89	8641	610	88.34	88.71	88.44	98.37	5.34	5.01	6.28	0.38
1999	4082.29	7402	610	75.83	76.90	76.19	84.27	5.45	4.43	18.67	1.08
2000	4189.37	7851	610	78.90	78.90	78.19	89.38	15.92	14.94	6.16	0.00
2001	4772.43	8406	610	84.12	84.12	89.07	95.70	7.28	6.60	9.28	0.00
2002	3257.33	6163	610	61.23	61.23	60.96	70.35	24.50	21.58	17.19	0.00
2003	4619.46	8575	610	86.52	86.52	86.45	97.89	8.89	8.44	5.03	0.00
2004	4150.52	8163	610	77.73	77.73	77.46	92.93	13.83	13.25	9.02	0.00
2005	3357.19	6544	610	63.28	63.28	62.83	74.70	10.01	8.79	27.94	0.00
2006	3132.91	6051	610	59.78	61.46	59.36	69.08	31.08	32.37	6.17	1.68
2007	1812.88	4806	430	44.04	44.04	43.85	54.86	55.44	54.78	1.18	0.00
2008	2709.85	6821	410	74.06	74.06	74.34	77.65	3.13	2.54	23.41	0.00
2009	3016.26	7268	430	79.63	79.63	81.00	82.97	18.39	18.10	2.27	0.00
2010	3263.25	7693	430	84.78	84.80	86.63	87.82	4.37	6.62	8.58	0.02
2011	2746.32	6580	435	72.05	72.05	72.07	75.11	6.03	7.58	20.37	0.00
2012	3480.49	8264	435	90.43	90.43	91.09	94.08	5.41	6.85	2.72	0.00

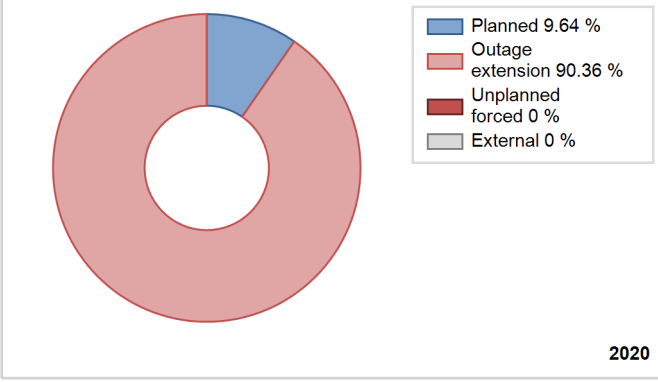
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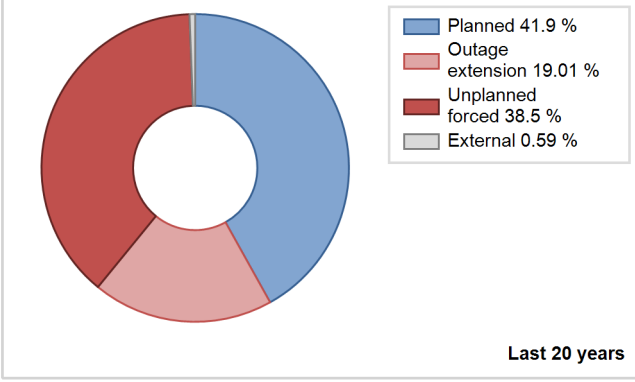
2013	3651.26	8196	440	90.52	90.52	94.73	93.56	0.66	0.63	8.85	0.00
2014	4091.01	8760	470	96.73	96.73	99.36	100.00	0.02	0.17	3.10	0.00
2015	3113.74	6722	475	73.96	73.96	74.83	76.74	0.00	1.52	24.51	0.00
2016	4022.36	8649		95.04	95.04	96.40	98.46	1.83	1.78	3.18	0.00
2017	3485.07	7509		83.14	83.24	83.76	85.72	11.29	10.59	6.17	0.10
2018	3379.89	7222	480	80.15	80.46	80.38	82.44	0.31	1.92	17.62	0.31
2019	3983.59	8652	480	94.44	95.01	94.74	98.77	1.58	1.84	3.15	0.56
2020	500.91	1246	480	13.57	13.57	11.88	14.18	0.00	78.10	8.33	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1976 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					591	
C. Inspection, maintenance or repair combined with refuelling				235	17	
D. Inspection, maintenance or repair without refuelling	677			192		
E. Testing of plant systems or components				3	8	
H. Nuclear regulatory requirements					47	
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					2	
Z. Other		6861		1	168	
Subtotal	677	6861		431	833	2
Total	**7538**			**1266**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1976 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	6861	195
12. Reactor I&C Systems		22
15. Reactor Cooling Systems		16
16. Steam generation systems		200
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		6
31. Turbine and auxiliaries		126
32. Feedwater and Main Steam System		123
33. Circulating Water System		1
34. Miscellaneous Systems		3
41. Main Generator Systems		53
42. Electrical Power Supply Systems		12
Total	**6861**	**758**

Highlights (2020)

Shut down in February for a graphite core inspection and remains off pending a return to service safety case

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2020 Operating Experience

GB-17A HUNTERSTON B-1 UNITED KINGDOM

Status at end of year	:	**Operational**
Operator	:	EDF UK (EDF Energy)
Owner	:	EDF UK (EDF Energy)
Reactor Supplier	:	TNPG (THE NUCLEAR POWER GROUP, LTD.)
Turbine Supplier	:	PARSONS (C.A.PARSONS)

Reactor Unit Details

Reactor type and model	:	GCR / AGR
Thermal power	:	1496 MWth
Gross electrical power	:	644 MWe
Reference unit power (net)	:	490 MWe

Key Dates

Construction Date	:	1967-11-01
Grid Date	:	1976-02-06
Commercial Date	:	1976-02-06
Age at end of year	:	44 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 [%]	:	NA
Average discharge burnup [MWd/t]	:	38500
Active core diameter [m]	:	9.11
Active core height/length [m]	:	8.312
Number of fissile fuel assemblies/bundles	:	2464
Fuel linear heat generation rate [kW/m]	:	18.2
Number of control rod assemblies	:	81
Number of external reactor coolant loops	:	4
Coolant type	:	CO2

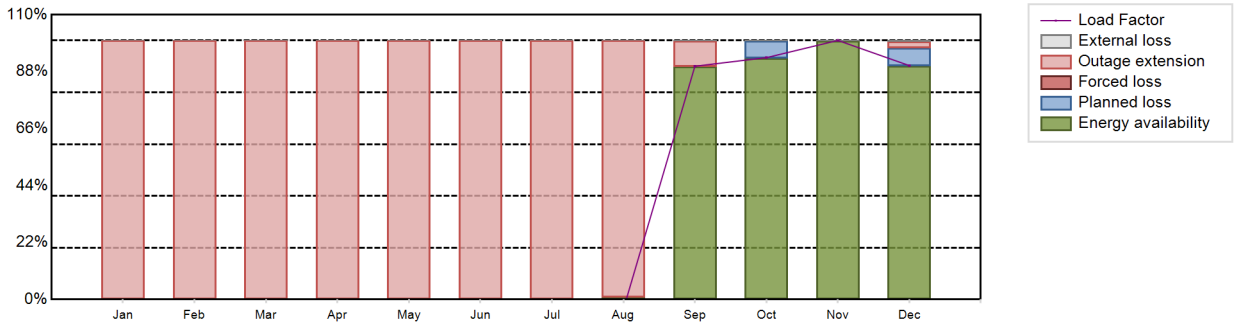
Operating coolant pressure [MPa]	:	4.24
Reactor outlet temperature [°C]	:	648.5
Number of SG	:	4
Containment type	:	NA
Containment design pressure [MPa]	:	NA
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	16.28
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	:	5
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	1253.87 GW(e).h
Energy Availability Factor (EAF)	:	31.2 %
Unit Capability Factor (UCF)	:	31.25 %
Load Factor (LF)	:	29.13 %
Operating Factor (OF)	:	33.62 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	67.59 %
Planned Unavailability Factor (PUF)	:	1.16 %
Externally cause unavailability (XUF)	:	0.05 %
Total off-line time	:	5831 hours

Annual Summary



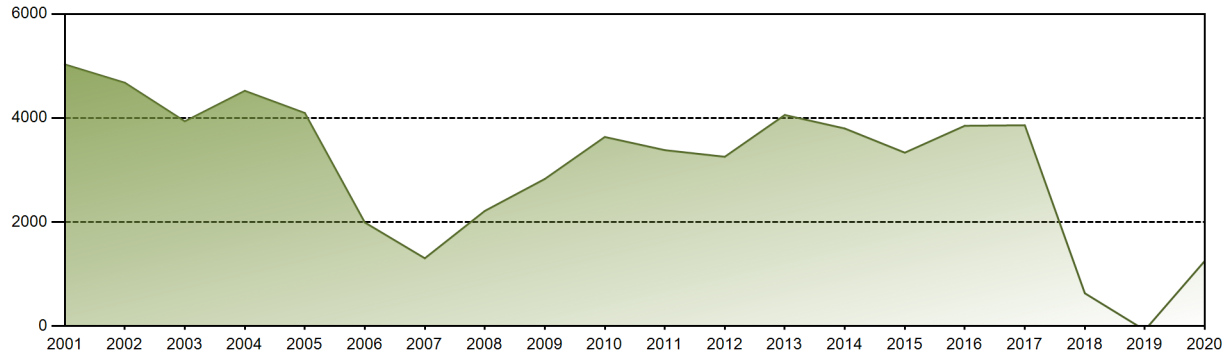
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	-8.81	-10.63	-13.53	-7.16	-15.00	-9.32	-9.35	-13.63	317.86	341.01	353.04	329.39	1253.87
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	89.98	93.24	99.91	90.24	31.20
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	90.03	93.33	100.00	90.64	31.25
LF [%]	-2.42	-3.12	-3.72	-2.03	-4.12	-2.64	-2.56	-3.74	90.10	93.42	100.07	90.35	29.13
OF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	100.00	100.00	100.00	100.00	33.62
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 [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.06	9.97	0.00	0.00	2.37	67.59
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.67	0.00	7.00	1.16
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.09	0.39	0.05

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Historical Summary

Lifetime energy generation	:	141872.73 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	10.8 %
Cumulative Energy Availability Factor (EAF)	:	69.39 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	15.24 %
Cumulative Unit Capability Factor (UCF)	:	69.67 %	Cumulative Planned Unavailability Factor (PUF)	:	15.09 %
Cumulative Load Factor (LF)	:	68.46 %	Cumulative Externally cause unavailability (XUF)	:	0.28 %
Cumulative Operating Factor (OF)	:	73.63 %			

Electricity Production (net) [GWh]

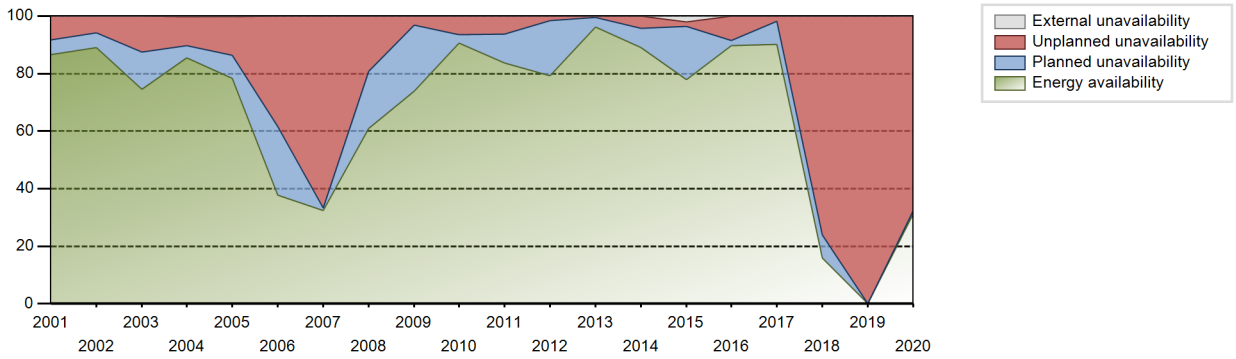


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	1349.00	4293	459	35.97	35.97	35.70	52.15	45.70	30.26	33.77	0.00
1977	1709.20	4313	500	40.07	40.07	39.13	49.37	31.14	18.12	41.81	0.00
1978	2158.40	5375	500	49.37	49.37	49.41	61.53	22.27	14.14	36.49	0.00
1979	2250.00	5259	500	52.25	52.25	51.51	60.20	21.61	14.41	33.34	0.00
1980	1486.00	3750	500	34.44	34.44	34.02	42.93	52.72	38.40	27.15	0.00
1981	1794.80	3941	500	40.77	40.77	40.31	44.26	59.23	59.23	0.00	0.00
1982	3484.10	7408	515	77.27	77.27	77.43	84.79	21.45	21.10	1.62	0.00
1983	2912.00	6107	520	63.13	63.13	64.10	69.91	16.91	12.85	24.02	0.00
1984	4214.00	8080	550	85.45	85.45	87.70	92.49	6.87	6.30	8.25	0.00
1985	3644.20	6655	575	71.06	71.06	72.55	76.18	7.42	5.69	23.25	0.00
1986	4571.20	8268	575	89.12	89.12	91.00	94.64	5.33	5.01	5.87	0.00
1987	3268.40	6358	575	63.73	63.73	63.84	71.41	6.88	4.71	31.57	0.00
1988	4492.30	8568	575	89.25	89.25	89.43	98.08	3.92	3.65	7.11	0.00
1989	2959.70	5467	575	58.22	58.22	58.92	62.58	5.01	3.07	38.71	0.00
1990	4744.10	8585	575	92.66	92.66	94.44	98.27	0.78	0.72	6.61	0.00
1991	2033.80	3827	575	40.12	40.12	40.49	43.81	4.42	1.86	58.02	0.00
1992	4315.70	8771	575	84.40	92.03	84.29	98.51	1.74	1.63	6.34	7.63
1993	2928.90	5581	575	58.25	59.48	58.31	63.89	6.86	4.38	36.14	1.23
1994	4698.10	8545	582	92.42	92.84	92.31	97.81	0.62	0.58	6.59	0.41
1995	3829.98	6917	585	74.23	74.23	72.49	76.58	2.68	2.05	23.72	0.00
1996	1643.70	2839	585	98.49	98.49	31.99	32.32	0.00	0.00	1.51	0.00
1997	3833.99	7035	595	73.63	73.63	73.36	80.09	6.49	5.11	21.26	0.00
1998	4835.44	8584	595	92.79	92.79	92.52	97.72	3.65	3.52	3.69	0.00
1999	4811.50	8591	595	92.33	92.33	92.06	97.80	2.79	2.65	5.01	0.00
2000	4035.56	7497	595	77.21	77.21	77.21	85.35	10.03	8.61	14.18	0.00
2001	5030.39	8598	595	86.64	86.64	96.25	97.88	8.80	8.36	5.00	0.00
2002	4678.54	8356	595	89.08	89.15	89.76	95.39	5.36	5.70	5.15	0.07
2003	3936.46	7225	595	74.64	74.68	75.52	82.48	11.81	12.47	12.85	0.04
2004	4522.73	8271	595	85.56	85.77	86.53	94.16	10.45	10.01	4.22	0.22
2005	4096.42	8207	595	78.42	78.78	78.59	93.69	14.36	13.31	7.91	0.36
2006	1991.38	3838	595	37.79	37.79	37.49	43.81	24.89	38.39	23.82	0.00
2007	1303.35	4315	420	32.49	32.49	31.87	49.26	37.76	66.70	0.81	0.00
2008	2213.36	5894	410	60.85	60.85	61.09	67.10	19.07	19.29	19.86	0.00
2009	2827.96	6969	430	73.89	73.91	75.95	79.55	2.37	3.08	23.01	0.02
2010	3635.46	8409	430	90.52	90.53	96.51	95.99	5.71	6.38	3.08	0.01
2011	3382.26	7698	460	83.63	83.64	83.94	87.88	5.87	6.31	10.05	0.01
2012	3254.96	7350	460	79.30	79.33	80.56	83.67	0.08	1.50	19.17	0.03

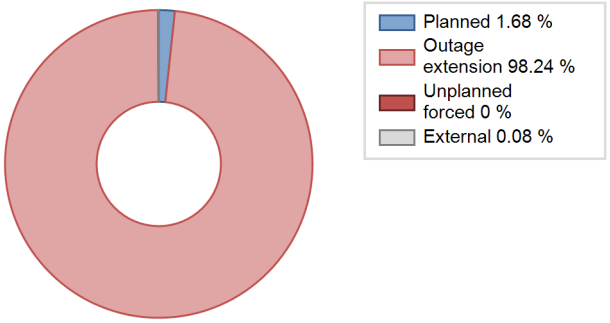
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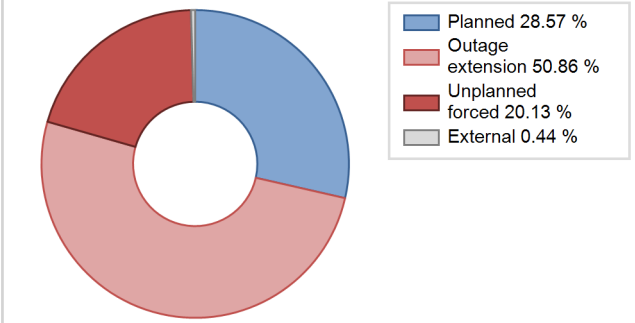
2013	4058.32	8760	460	96.25	96.25	100.71	100.00	0.03	0.51	3.24	0.00
2014	3798.18	8103	475	88.97	88.97	91.28	92.50	4.62	4.31	6.72	0.00
2015	3333.82	7047	480	77.93	79.89	79.29	80.45	0.99	1.56	18.55	1.96
2016	3851.10	8120		89.60	89.60	91.34	92.44	8.59	8.42	1.98	0.00
2017	3860.89	8104		90.06	90.06	91.82	92.51	1.87	1.72	8.22	0.00
2018	631.33	1488	490	15.99	15.99	14.71	16.99	11.78	76.14	7.87	0.00
2019	-78.20	0	490	0.00	0.00	-1.82	0.00	0.00	100.00	0.00	0.00
2020	1253.87	2953	490	31.20	31.25	29.13	33.62	0.00	67.59	1.16	0.05

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1976 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					461	
C.	Inspection, maintenance or repair combined with refuelling				339	18	
D.	Inspection, maintenance or repair without refuelling				644	11	
E.	Testing of plant systems or components				59	6	
H.	Nuclear regulatory requirements					339	
J.	Grid limitation, failure or grid unavailability						4
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						3
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
S.	Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				2	2	
Z.	Other		6215		69	149	
Subtotal			6215		1113	988	11
Total			**6215**			**2112**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1976 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	6215	479
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		4
14. Safety Systems		1
15. Reactor Cooling Systems		50
16. Steam generation systems		195
21. Fuel Handling and Storage Facilities		3
31. Turbine and auxiliaries		84
32. Feedwater and Main Steam System		33
33. Circulating Water System		15
34. Miscellaneous Systems		8
35. All other I&C Systems		2
41. Main Generator Systems		44
42. Electrical Power Supply Systems		21
Total	**6215**	**957**

Highlights (2020)

Started the year on outage for graphite core safety case work and re-started in August

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2020 Operating Experience

GB-17B HUNTERSTON B-2 UNITED KINGDOM

Status at end of year	:	**Operational**
Operator	:	EDF UK (EDF Energy)
Owner	:	EDF UK (EDF Energy)
Reactor Supplier	:	TNPG (THE NUCLEAR POWER GROUP, LTD.)
Turbine Supplier	:	PARSONS (C.A.PARSONS)

Reactor Unit Details

Reactor type and model	:	GCR / AGR
Thermal power	:	1496 MWth
Gross electrical power	:	644 MWe
Reference unit power (net)	:	495 MWe

Key Dates

Construction Date	:	1967-11-01
Grid Date	:	1977-03-31
Commercial Date	:	1977-03-31
Age at end of year	:	43 years

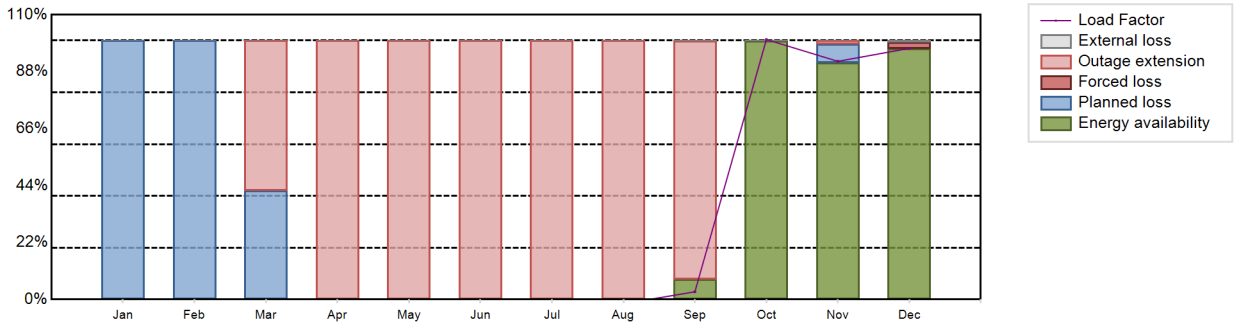
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	4.24
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	648.5
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]	:	NA	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	NA	Turbine speed [rpm]	:	3000
Average discharge burnup [MWd/t]	:	38500	Number of LP cylinders per turbine	:	3
Active core diameter [m]	:	9.11	HP cylinder inlet steam pressure [MPa]	:	16.28
Active core height/length [m]	:	8.312	Output voltage [kV]	:	23
Number of fissile fuel assemblies/bundles	:	2464	Primary means of condenser cooling	:	Sea (once-through)
Fuel linear heat generation rate [kW/m]	:	18.2	Number of main condensate pumps	:	2
Number of control rod assemblies	:	81	Number of FW pumps for full power operation	:	1
Number of external reactor coolant loops	:	4	Number of on-site safety related diesel generators	:	5
Coolant type	:	CO2	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	1022.14 GW(e).h	Forced Loss Rate (FLR)	:	0.82 %
Energy Availability Factor (EAF)	:	24.8 %	Unplanned Capability Loss Factor (UCL)	:	54.57 %
Unit Capability Factor (UCF)	:	24.88 %	Planned Unavailability Factor (PUF)	:	20.55 %
Load Factor (LF)	:	23.51 %	Externally cause unavailability (XUF)	:	0.08 %
Operating Factor (OF)	:	26 %	Total off-line time	:	6500 hours

Annual Summary



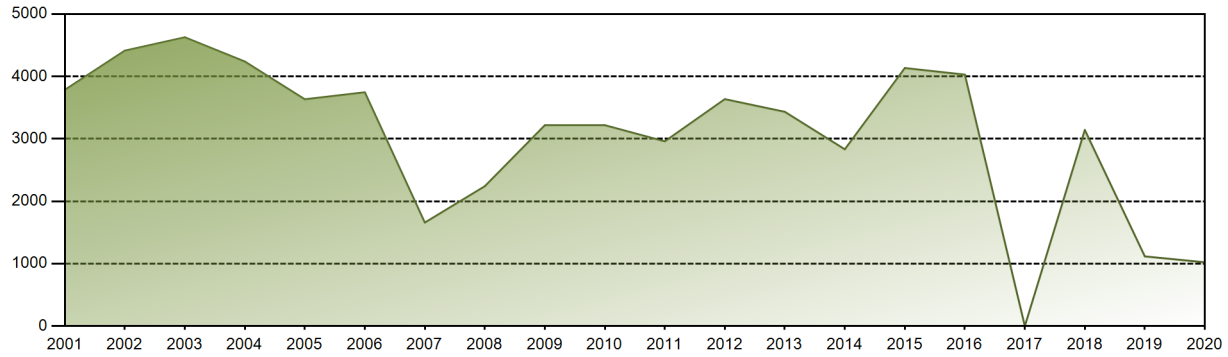
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	-4.76	-3.65	-6.47	-6.20	-5.74	-5.58	-5.45	-6.11	10.67	370.30	327.86	357.26	1022.14
EAF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.86	99.81	91.30	96.91	24.80
UCF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.90	100.00	91.30	97.57	24.88
LF [%]	-1.29	-1.06	-1.76	-1.74	-1.56	-1.57	-1.48	-1.66	2.99	100.41	91.99	97.01	23.51
OF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.42	100.00	100.00	100.00	26.00
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.43	0.82
UCL [%]	0.00	0.00	58.01	100.00	100.00	100.00	100.00	100.00	92.10	0.00	1.30	2.43	54.57
PUF [%]	100.00	100.00	41.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.39	0.00	20.55
XUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.19	0.00	0.66	0.08

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Historical Summary

Lifetime energy generation	:	138927.11 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.2 %
Cumulative Energy Availability Factor (EAF)	:	71.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	15.33 %
Cumulative Unit Capability Factor (UCF)	:	71.39 %	Cumulative Planned Unavailability Factor (PUF)	:	13.28 %
Cumulative Load Factor (LF)	:	69.57 %	Cumulative Externally cause unavailability (XUF)	:	0.1 %
Cumulative Operating Factor (OF)	:	73.99 %			

Electricity Production (net) [GWh]

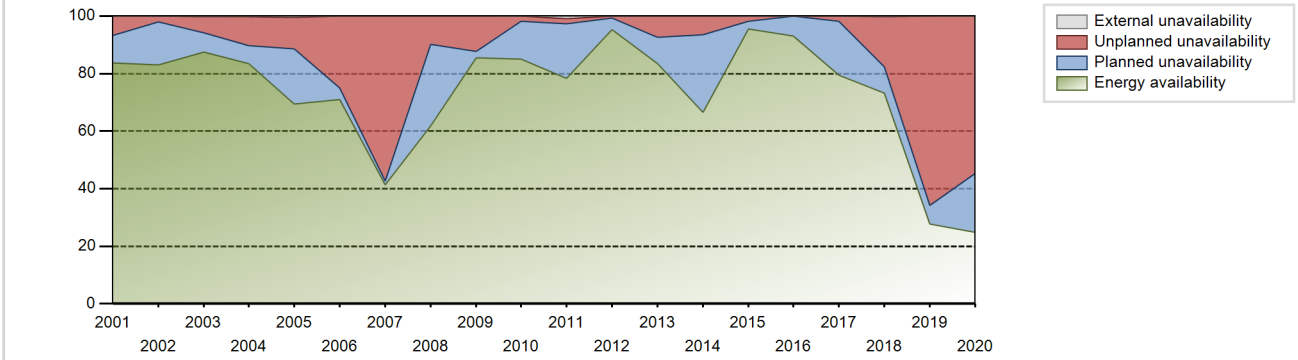


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	1047.70	3071	500	32.47	32.47	31.63	46.35	58.11	45.04	22.49	0.00
1978	0.00	0	500	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00
1979	0.00	0	500	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00
1980	2544.00	5147	500	58.92	58.92	58.24	58.92	20.97	15.64	25.45	0.00
1981	3019.90	7219	500	68.17	68.17	67.83	81.08	31.83	31.83	0.00	0.00
1982	2706.20	5596	515	59.82	59.82	60.14	64.05	20.24	15.18	25.00	0.00
1983	4153.00	8524	520	88.41	88.41	91.42	97.57	7.22	6.88	4.70	0.00
1984	3287.00	6365	550	67.71	67.71	68.41	72.86	10.42	7.88	24.41	0.00
1985	4507.70	8303	575	88.71	88.73	89.74	95.04	6.47	6.14	5.13	0.02
1986	3616.10	6496	575	70.84	70.84	71.99	74.36	9.76	7.66	21.50	0.00
1987	4623.40	8710	575	90.47	90.77	90.30	97.82	4.70	4.47	4.76	0.30
1988	3115.50	5754	575	61.26	61.26	62.02	65.87	3.33	2.11	36.62	0.00
1989	4728.00	8643	575	93.51	93.51	94.12	98.94	1.99	1.90	4.58	0.00
1990	3231.25	5858	575	63.78	63.78	64.33	67.06	1.47	0.95	35.27	0.00
1991	4727.80	8707	575	94.04	94.65	94.12	99.67	1.37	1.31	4.04	0.61
1992	1969.70	3733	575	39.20	39.20	38.47	41.92	1.90	0.76	60.04	0.00
1993	4322.10	8128	575	86.13	86.67	86.04	93.04	2.05	1.81	11.51	0.54
1994	3784.72	6949	582	74.68	74.91	74.36	79.54	2.23	1.71	23.38	0.24
1995	4671.30	8315	585	90.07	90.07	87.94	91.57	3.09	2.87	7.06	0.00
1996	1276.60	2377	585	91.85	91.85	24.84	27.06	1.46	1.36	6.78	0.00
1997	4559.72	8200	595	87.52	87.52	87.24	93.35	8.92	8.57	3.91	0.00
1998	4518.00	8149	595	86.72	86.72	86.44	92.77	9.35	8.95	4.34	0.00
1999	4101.97	7302	595	78.76	78.76	78.48	83.13	9.78	8.53	12.71	0.00
2000	3241.62	6411	595	62.02	62.02	62.02	72.98	31.06	27.95	10.03	0.00
2001	3785.00	6485	595	83.71	83.71	72.42	73.83	7.48	6.77	9.52	0.00
2002	4413.06	7721	595	83.07	83.07	84.67	88.14	1.08	1.94	14.98	0.00
2003	4627.26	8381	595	87.51	87.77	88.78	95.67	5.96	5.56	6.67	0.26
2004	4238.69	7799	595	83.47	83.71	81.10	88.79	7.67	9.94	6.35	0.24
2005	3633.64	7017	595	69.41	69.99	69.71	80.10	7.67	10.79	19.21	0.58
2006	3745.99	6753	595	71.04	71.04	70.97	77.09	25.69	24.97	3.98	0.00
2007	1658.38	4642	420	41.29	41.29	40.66	52.99	58.11	57.28	1.43	0.00
2008	2240.71	6054	410	61.92	61.92	61.84	68.92	11.75	9.74	28.34	0.00
2009	3217.65	8065	430	85.39	85.39	86.41	92.07	11.62	12.20	2.41	0.00
2010	3218.67	7876	430	85.07	85.13	85.45	89.91	1.07	1.87	13.00	0.06
2011	2959.85	7211	430	78.34	79.18	78.58	82.32	0.89	1.79	19.03	0.84
2012	3635.82	8784	430	95.39	95.41	96.26	100.00	0.44	0.72	3.87	0.02
2013	3432.84	7601	430	83.37	83.37	91.13	86.77	0.07	7.38	9.25	0.00

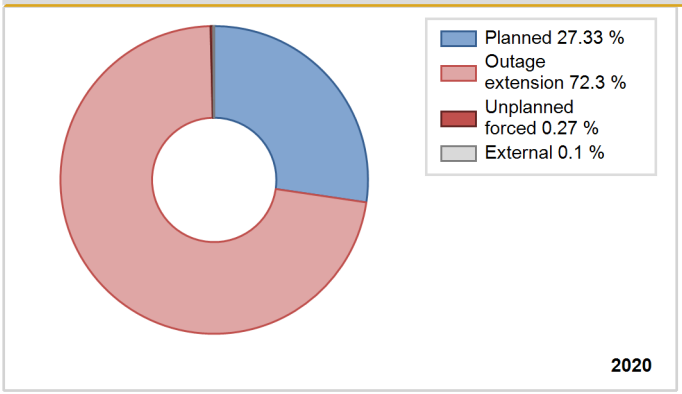
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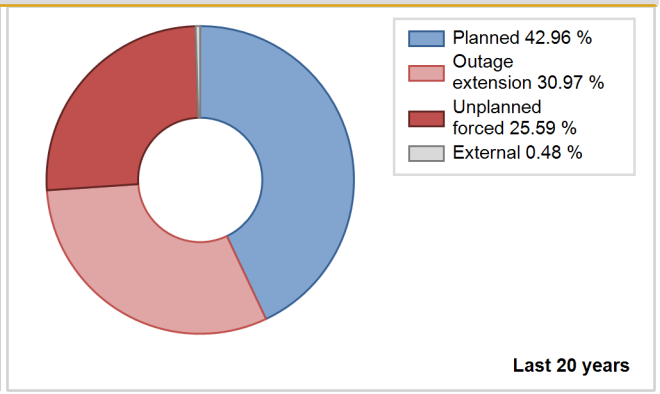
2014	2832.36	6114	485	66.46	66.46	66.67	69.79	1.95	6.50	27.04	0.00
2015	4134.20	8640	485	95.44	95.53	97.31	98.63	1.75	1.70	2.76	0.09
2016	4028.95	8399		92.99	93.01	94.57	95.62	0.06	0.06	6.94	0.02
2017	0.00			79.48	79.48	80.53	82.04	0.48	1.81	18.71	0.00
2018	3142.06	6599	495	73.19	73.48	72.46	75.33	0.00	17.24	9.27	0.30
2019	1116.54	2572	495	27.77	27.78	25.75	29.36	0.00	65.81	6.41	0.01
2020	1022.14	2284	495	24.80	24.88	23.51	26.00	0.82	54.57	20.55	0.08

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					732	
B.	Refuelling without maintenance				0		
C.	Inspection, maintenance or repair combined with refuelling				310	19	
D.	Inspection, maintenance or repair without refuelling	1752			628	49	
E.	Testing of plant systems or components				1	2	
H.	Nuclear regulatory requirements					130	
J.	Grid limitation, failure or grid unavailability						3
K.	Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						5
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		4799		20	112	1
Subtotal		1752	4799		959	1049	10
Total			**6551**			**2018**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	4799	291
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		6
14. Safety Systems		0
15. Reactor Cooling Systems		25
16. Steam generation systems		98
21. Fuel Handling and Storage Facilities		0
31. Turbine and auxiliaries		55
32. Feedwater and Main Steam System		503
33. Circulating Water System		3
34. Miscellaneous Systems		18
35. All other I&C Systems		1
41. Main Generator Systems		6
42. Electrical Power Supply Systems		12
Total	**4799**	**1024**

Highlights (2020)

Started the year on outage for graphite core safety case work and re-started in September

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2020 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	:	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]	:	-
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

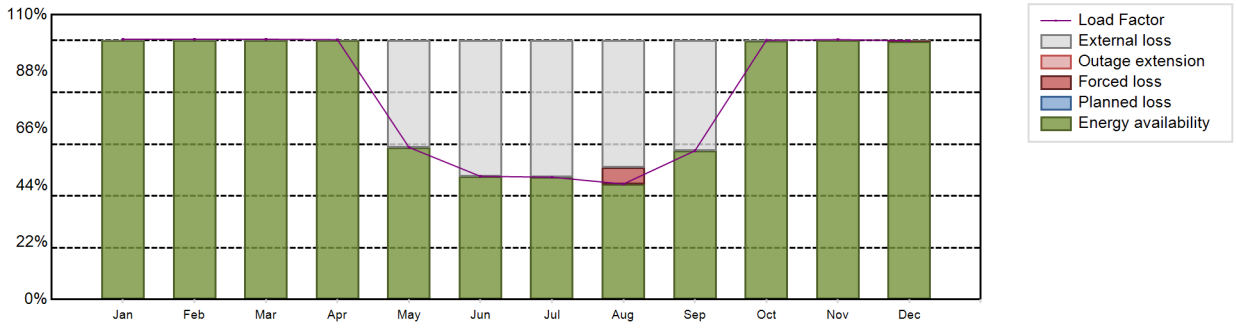
Operating coolant pressure [MPa]	:	15.01
Reactor outlet temperature [°C]	:	323.4
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	0.35
Secondary systems		
Number of turbine-generators per unit/reactor	:	2
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
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 (2020)

Net Energy Production	:	8393.47 GW(e).h
Energy Availability Factor (EAF)	:	79.54 %
Unit Capability Factor (UCF)	:	99.43 %
Load Factor (LF)	:	79.76 %
Operating Factor (OF)	:	99.53 %

Forced Loss Rate (FLR)	:	0.57 %
Unplanned Capability Loss Factor (UCL)	:	0.57 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	19.89 %
Total off-line time	:	41 hours

Annual Summary



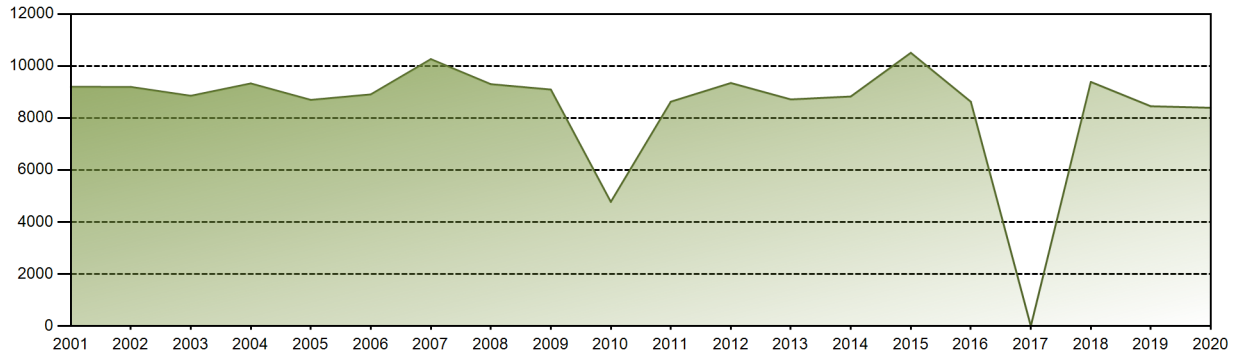
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	896.06	837.98	894.71	865.56	523.92	410.39	421.13	397.59	495.42	893.82	865.89	890.99	8393.47
EAF [%]	100.00	100.00	100.00	100.00	58.75	47.58	47.25	44.63	57.44	99.97	100.00	99.71	79.54
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.56	100.00	100.00	100.00	99.71	99.43
LF [%]	100.53	100.50	100.52	100.35	58.78	47.58	47.25	44.61	57.44	100.15	100.39	99.96	79.76
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.49	100.00	100.00	100.00	100.00	99.53
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.44	0.00	0.00	0.00	0.29	0.57
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.44	0.00	0.00	0.00	0.29	0.57
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	41.25	52.42	52.75	48.92	42.56	0.03	0.00	0.00	19.89

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Historical Summary

Lifetime energy generation	:	199587.49 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.66 %
Cumulative Energy Availability Factor (EAF)	:	84.39 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.54 %
Cumulative Unit Capability Factor (UCF)	:	85.25 %	Cumulative Planned Unavailability Factor (PUF)	:	8.21 %
Cumulative Load Factor (LF)	:	83.68 %	Cumulative Externally cause unavailability (XUF)	:	0.86 %
Cumulative Operating Factor (OF)	:	86.65 %			

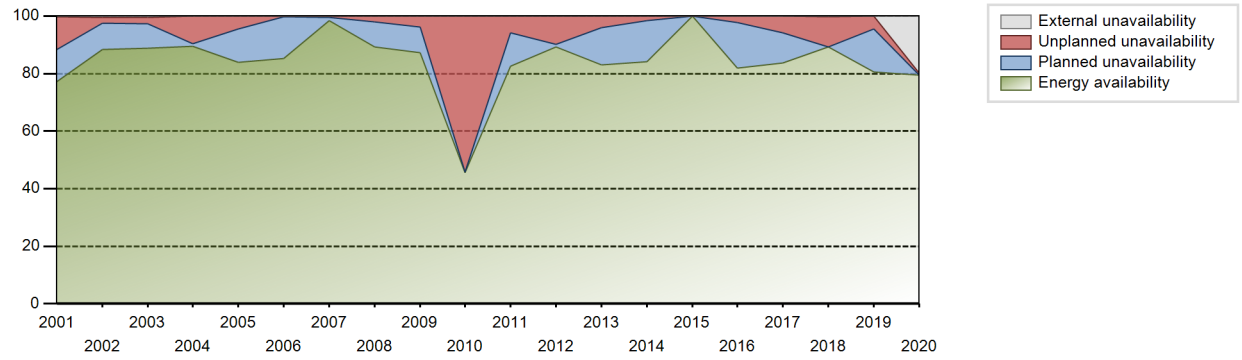
Electricity Production (net) [GWh]



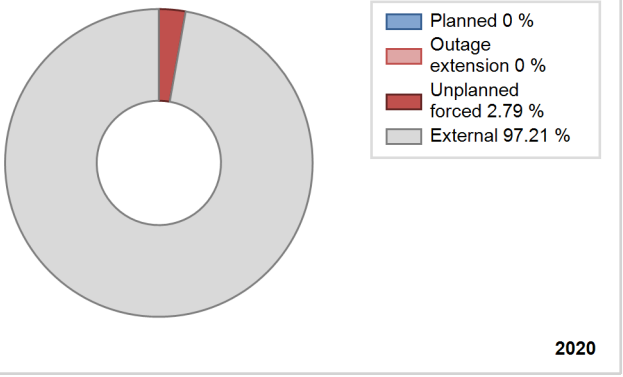
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1995	0.00	0	1188	99.79	100.00	0.00	0.00	0.00	0.00	0.00	0.21
1996	8488.47	7367	1188	81.38	81.34	81.34	83.87	5.51	4.74	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

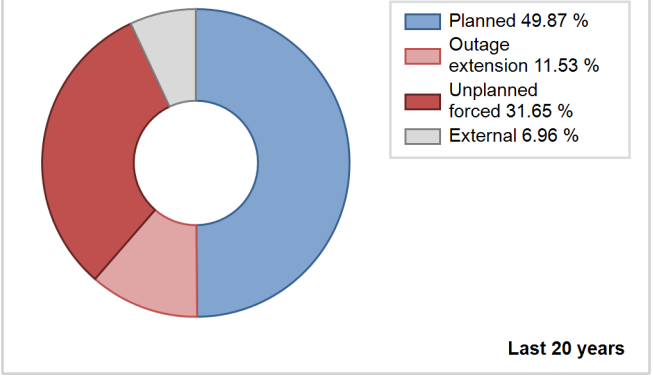
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1995 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					405	
C. Inspection, maintenance or repair combined with refuelling				680	56	
D. Inspection, maintenance or repair without refuelling				1		
E. Testing of plant systems or components					3	
L. Human factor related		41			3	
Subtotal		41		681	467	
Total		**41**			**1148**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1995 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		15
14. Safety Systems		34
15. Reactor Cooling Systems		191
16. Steam generation systems		53
31. Turbine and auxiliaries		2
32. Feedwater and Main Steam System		14
34. Miscellaneous Systems		0
41. Main Generator Systems		59
42. Electrical Power Supply Systems	41	14
Total	**41**	**400**

Highlights (2020)

Operated at around 50% RUP between May and August at request of Grid Operator

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2020 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

Reactor type and model	:	GCR / AGR
Thermal power	:	1623 MWth
Gross electrical power	:	682 MWe
Reference unit power (net)	:	595 MWe

Key Dates

Construction Date	:	1980-08-01
Grid Date	:	1988-05-25
Commercial Date	:	1988-05-25
Age at end of year	:	32 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]	:	2
Part of the core refuelled [%]	:	3
Average discharge burnup [MWd/t]	:	27000
Active core diameter [m]	:	9.46
Active core height/length [m]	:	8.31
Number of fissile fuel assemblies/bundles	:	332
Fuel linear heat generation rate [kW/m]	:	16.8
Number of control rod assemblies	:	89
Number of external reactor coolant loops	:	NA
Coolant type	:	CO2

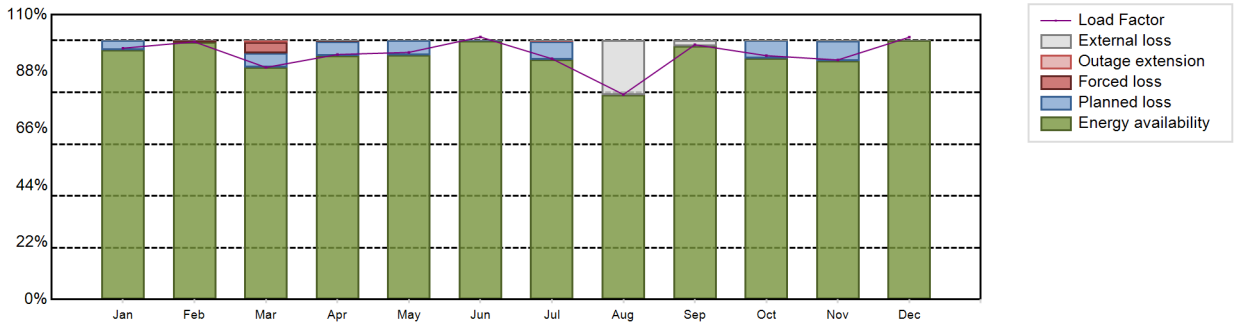
Operating coolant pressure [MPa]	:	4.3
Reactor outlet temperature [°C]	:	635
Number of SG	:	4
Containment type	:	NA
Containment design pressure [MPa]	:	NA
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	15.9
Output voltage [kV]	:	23.5
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 (2020)

Net Energy Production	:	4946.16 GW(e).h
Energy Availability Factor (EAF)	:	94 %
Unit Capability Factor (UCF)	:	95.95 %
Load Factor (LF)	:	94.64 %
Operating Factor (OF)	:	100 %

Forced Loss Rate (FLR)	:	0.48 %
Unplanned Capability Loss Factor (UCL)	:	0.54 %
Planned Unavailability Factor (PUF)	:	3.51 %
Externally cause unavailability (XUF)	:	1.96 %
Total off-line time	:	0 hours

Annual Summary



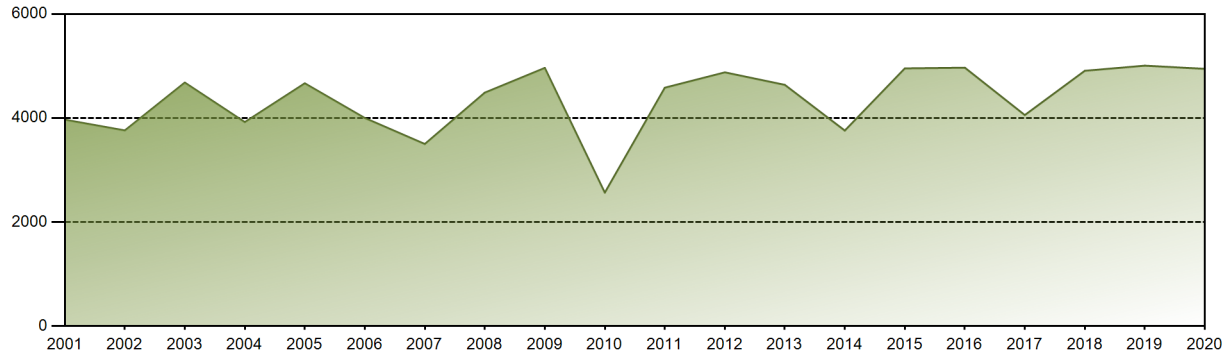
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	429.68	412.05	396.24	405.36	422.56	434.35	411.62	350.57	421.45	417.44	396.37	448.48	4946.16
EAF [%]	96.29	99.32	89.63	94.15	94.43	99.82	92.63	78.91	97.97	93.24	92.17	100.00	94.00
UCF [%]	96.29	99.32	89.63	94.17	94.43	99.82	92.66	100.00	100.00	93.25	92.17	100.00	95.95
LF [%]	97.06	99.50	89.63	94.62	95.45	101.39	92.98	79.19	98.38	94.17	92.52	101.31	94.64
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	0.68	4.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.48
UCL [%]	0.00	0.68	4.84	0.47	0.00	0.00	0.29	0.00	0.00	0.00	0.16	0.00	0.54
PUF [%]	3.71	0.00	5.53	5.36	5.57	0.18	7.05	0.00	0.00	6.75	7.66	0.00	3.51
XUF [%]	0.00	0.00	0.00	0.02	0.00	0.00	0.03	21.09	2.03	0.00	0.00	0.00	1.96

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Historical Summary

Lifetime energy generation	:	128935.07 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.6 %
Cumulative Energy Availability Factor (EAF)	:	77.96 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.51 %
Cumulative Unit Capability Factor (UCF)	:	79.58 %	Cumulative Planned Unavailability Factor (PUF)	:	13.91 %
Cumulative Load Factor (LF)	:	75.27 %	Cumulative Externally cause unavailability (XUF)	:	1.62 %
Cumulative Operating Factor (OF)	:	83.47 %			

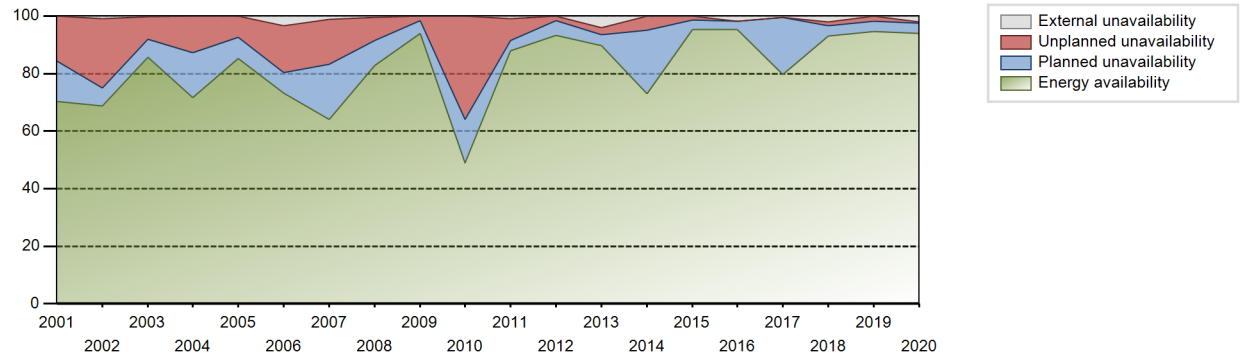
Electricity Production (net) [GWh]



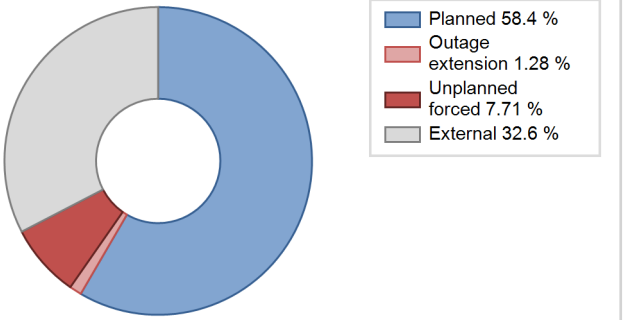
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	2287.10	4330	638	69.41	92.32	68.07	82.99	7.68	7.68	0.00	22.91
1989	2162.10	4582	625	39.47	53.23	39.60	52.45	4.16	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

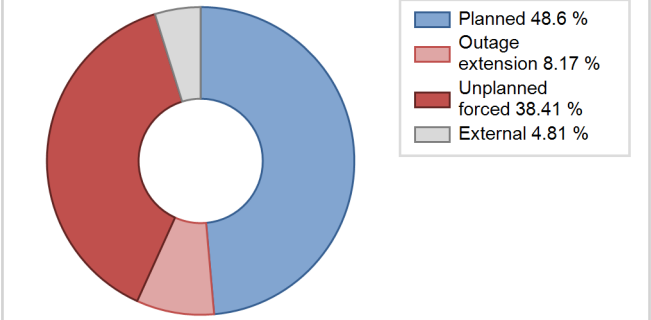
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					223	
B. Refuelling without maintenance				21		
C. Inspection, maintenance or repair combined with refuelling				559	22	
D. Inspection, maintenance or repair without refuelling				154		
E. Testing of plant systems or components					1	
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					30	
M. Governmental requirements or court decisions						10
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						18
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					9	
Z. Other				77	24	45
Subtotal				811	309	75
Total		**0**			**1195**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1988 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		12
12. Reactor I&C Systems		20
14. Safety Systems		4
15. Reactor Cooling Systems		53
16. Steam generation systems		6
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		8
33. Circulating Water System		27
41. Main Generator Systems		57
42. Electrical Power Supply Systems		60
Total		**267**

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2020 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

Reactor type and model	:	GCR / AGR
Thermal power	:	1623 MWth
Gross electrical power	:	682 MWe
Reference unit power (net)	:	605 MWe

Key Dates

Construction Date	:	1980-08-01
Grid Date	:	1989-02-03
Commercial Date	:	1989-02-03
Age at end of year	:	31 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]	:	2
Part of the core refuelled [%]	:	3
Average discharge burnup [MWd/t]	:	27000
Active core diameter [m]	:	9.46
Active core height/length [m]	:	8.31
Number of fissile fuel assemblies/bundles	:	332
Fuel linear heat generation rate [kW/m]	:	16.8
Number of control rod assemblies	:	89
Number of external reactor coolant loops	:	NA
Coolant type	:	CO2

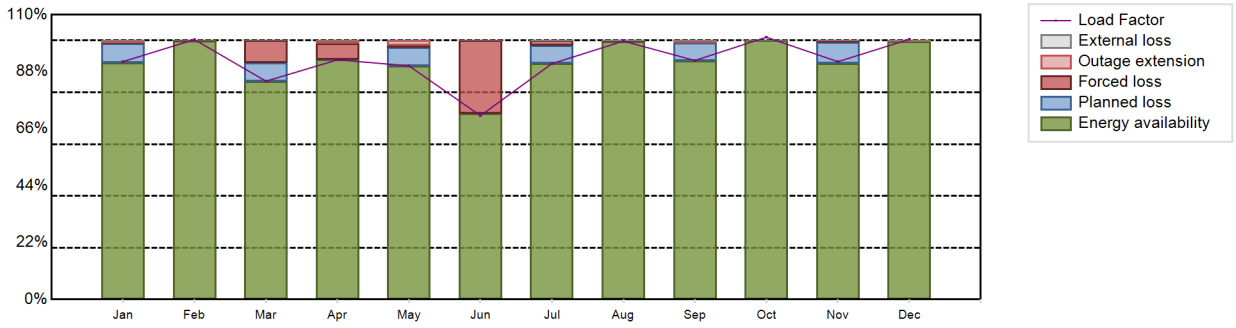
Operating coolant pressure [MPa]	:	4.3
Reactor outlet temperature [°C]	:	635
Number of SG	:	4
Containment type	:	NA
Containment design pressure [MPa]	:	NA
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	3000
Number of LP cylinders per turbine	:	3
HP cylinder inlet steam pressure [MPa]	:	15.9
Output voltage [kV]	:	23.5
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 (2020)

Net Energy Production	:	4904.72 GW(e).h
Energy Availability Factor (EAF)	:	92.01 %
Unit Capability Factor (UCF)	:	92.04 %
Load Factor (LF)	:	92.29 %
Operating Factor (OF)	:	98.08 %

Forced Loss Rate (FLR)	:	4.03 %
Unplanned Capability Loss Factor (UCL)	:	4.26 %
Planned Unavailability Factor (PUF)	:	3.7 %
Externally cause unavailability (XUF)	:	0.03 %
Total off-line time	:	169 hours

Annual Summary



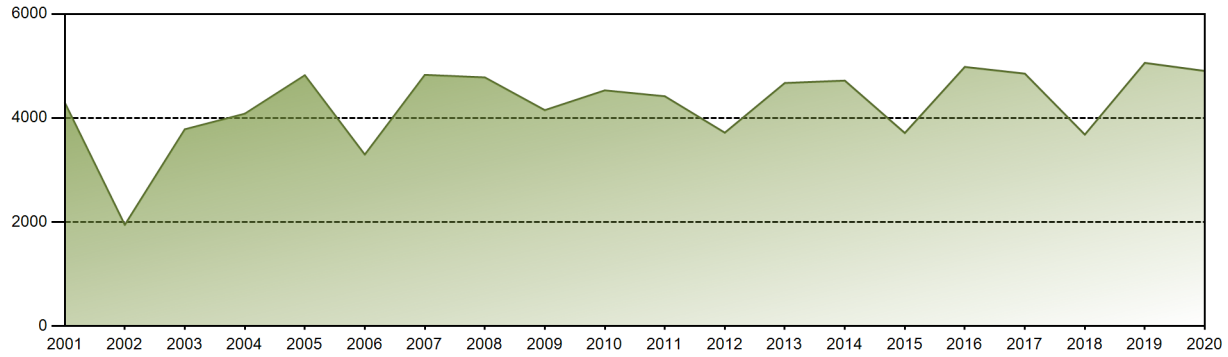
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	413.60	422.72	379.07	403.24	406.23	309.37	409.99	449.24	402.13	456.62	400.18	452.34	4904.72
EAF [%]	91.53	99.78	84.33	92.54	90.19	71.70	91.08	99.72	92.29	100.00	91.09	99.71	92.01
UCF [%]	91.55	99.78	84.33	92.56	90.19	71.70	91.09	99.82	92.44	100.00	91.09	99.73	92.04
LF [%]	91.89	100.39	84.33	92.57	90.25	71.02	91.08	99.80	92.32	101.31	91.87	100.49	92.29
OF [%]	100.00	100.00	100.00	100.00	100.00	76.53	100.00	100.00	100.00	100.00	100.00	100.00	98.08
FLR [%]	0.31	0.22	9.11	6.38	0.89	28.30	1.96	0.16	0.00	0.00	0.40	0.00	4.03
UCL [%]	1.16	0.22	8.46	7.35	2.58	28.30	1.82	0.16	0.67	0.00	0.56	0.22	4.26
PUF [%]	7.29	0.00	7.22	0.10	7.23	0.00	7.09	0.03	6.88	0.00	8.35	0.05	3.70
XUF [%]	0.02	0.00	0.00	0.01	0.00	0.00	0.01	0.09	0.15	0.00	0.00	0.02	0.03

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Historical Summary

Lifetime energy generation	:	126181.73 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.86 %
Cumulative Energy Availability Factor (EAF)	:	77.35 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.76 %
Cumulative Unit Capability Factor (UCF)	:	78.38 %	Cumulative Planned Unavailability Factor (PUF)	:	13.86 %
Cumulative Load Factor (LF)	:	74.82 %	Cumulative Externally cause unavailability (XUF)	:	1.04 %
Cumulative Operating Factor (OF)	:	83.11 %			

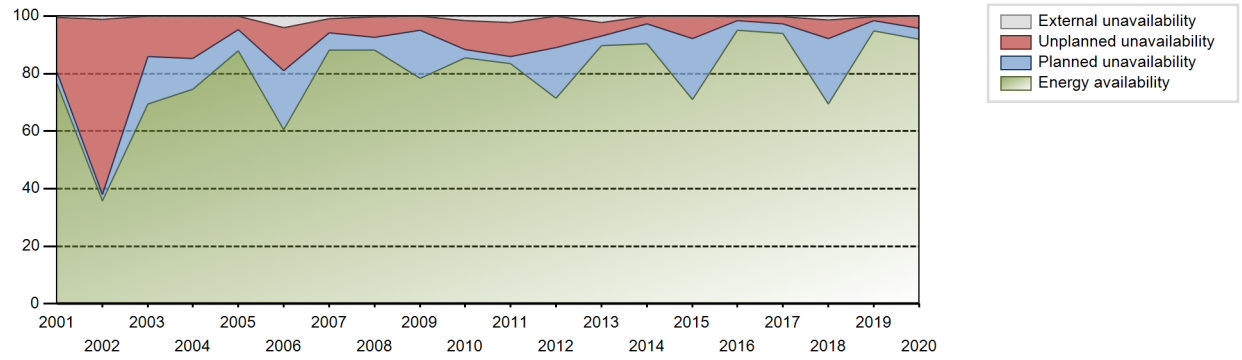
Electricity Production (net) [GWh]



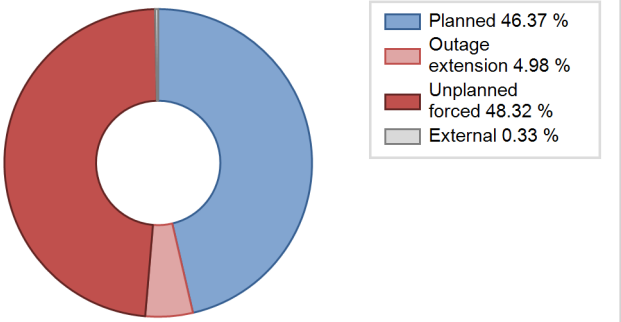
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	3633.80	7068	625	74.21	87.39	73.28	89.08	4.32	3.94	8.67	13.18
1990	1948.30	4211	625	36.08	36.08	35.68	48.20	6.46	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

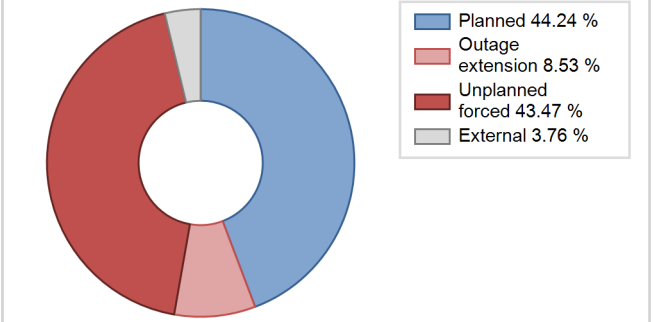
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure		169			292	
C. Inspection, maintenance or repair combined with refuelling				576	39	
D. Inspection, maintenance or repair without refuelling				170		
E. Testing of plant systems or components					5	
G. Major backfitting, refurbishment or upgrading activities without refuelling				14	15	
L. Human factor related					3	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						26
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				5		
Z. Other					10	19
Subtotal		169		765	364	45
Total		**169**			**1174**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1989 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		23
12. Reactor I&C Systems		17
13. Reactor Auxiliary Systems		6
15. Reactor Cooling Systems		167
16. Steam generation systems		37
17. Safety I&C Systems (excluding reactor I&C)		13
21. Fuel Handling and Storage Facilities		3
31. Turbine and auxiliaries		9
32. Feedwater and Main Steam System	169	15
33. Circulating Water System		26
34. Miscellaneous Systems		2
41. Main Generator Systems		5
42. Electrical Power Supply Systems		18
Total	**169**	**341**

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2020 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	:	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]	:	-
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

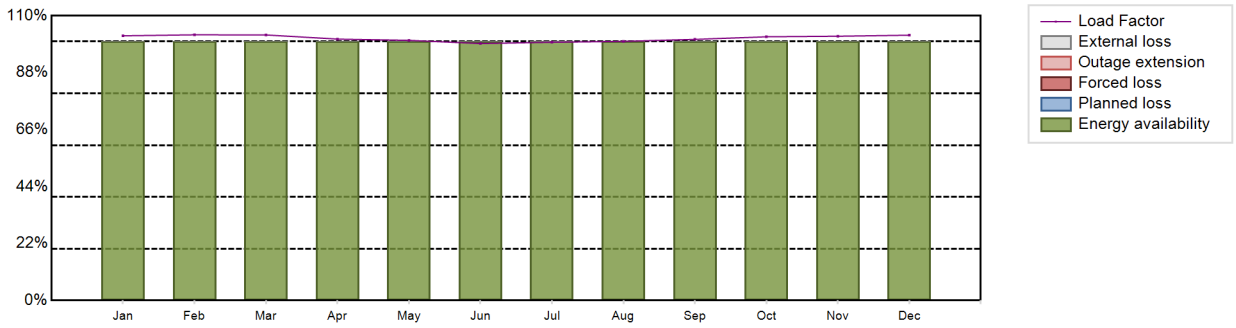
Operating coolant pressure [MPa]	:	15.3
Reactor outlet temperature [°C]	:	318
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.415
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	7436.38 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	101.27 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



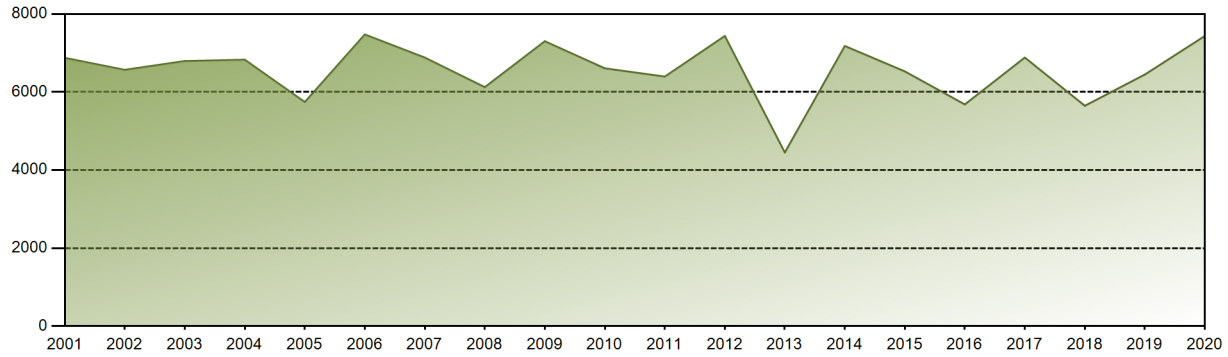
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	635.97	597.07	638.00	607.73	624.96	597.36	620.37	622.51	607.12	633.57	614.38	637.34	7436.38
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	102.25	102.61	102.57	100.96	100.48	99.24	99.74	100.09	100.86	101.86	102.07	102.47	101.27
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	254205.5 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.79 %
Cumulative Energy Availability Factor (EAF)	:	81.45 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.03 %
Cumulative Unit Capability Factor (UCF)	:	81.82 %	Cumulative Planned Unavailability Factor (PUF)	:	13.15 %
Cumulative Load Factor (LF)	:	78.18 %	Cumulative Externally cause unavailability (XUF)	:	0.37 %
Cumulative Operating Factor (OF)	:	81.92 %			

Electricity Production (net) [GWh]

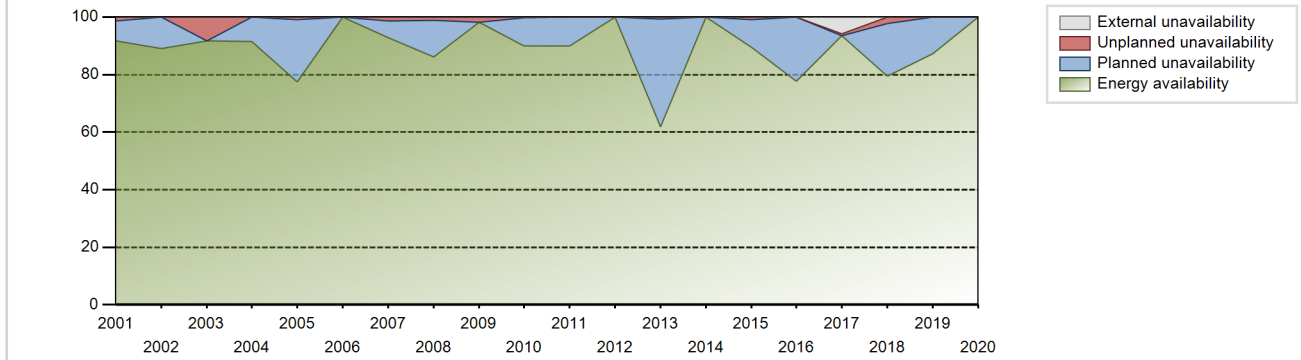


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	Data not provided										
1975	4898.40	6661	797	67.71	67.71	70.16	76.04	10.27	7.75	24.54	0.00
1976	3888.00	4966	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

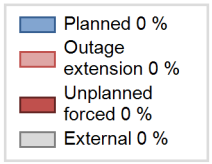
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2011	6395.49	7872	842	89.87	89.87	86.71	89.86	0.00	0.00	10.13	0.00
2012	7436.06	8784	842	100.00	100.00	100.54	100.00	0.00	0.00	0.00	0.00
2013	4448.74	5415	836	61.79	61.79	60.74	61.81	1.22	0.76	37.45	0.00
2014	7180.53	8760	836	100.00	100.00	98.05	100.00	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

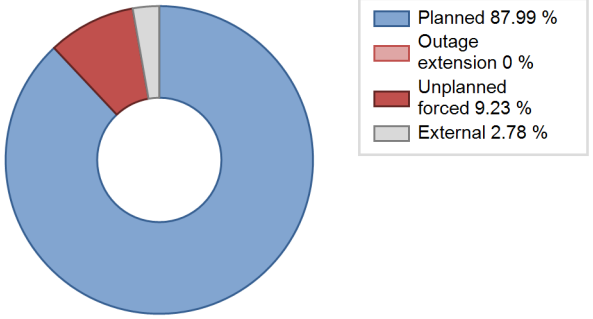
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					467	
C. Inspection, maintenance or repair combined with refuelling				845		
D. Inspection, maintenance or repair without refuelling				103		
E. Testing of plant systems or components				3	2	
F. Major backfitting, refurbishment or upgrading activities with refuelling				41		
H. Nuclear regulatory requirements					36	
J. Grid limitation, failure or grid unavailability						1
L. Human factor related					5	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						15
P. Fire					3	
Z. Other				45	1	
Subtotal				1037	514	16
Total	**0**			**1567**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		64
12. Reactor I&C Systems		28
13. Reactor Auxiliary Systems		11
14. Safety Systems		27
15. Reactor Cooling Systems		37
16. Steam generation systems		41
17. Safety I&C Systems (excluding reactor I&C)		16
31. Turbine and auxiliaries		103
32. Feedwater and Main Steam System		52
33. Circulating Water System		7
34. Miscellaneous Systems		3
35. All other I&C Systems		1
41. Main Generator Systems		65
42. Electrical Power Supply Systems		29
Total		**484**

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2020 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	:	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]	:	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

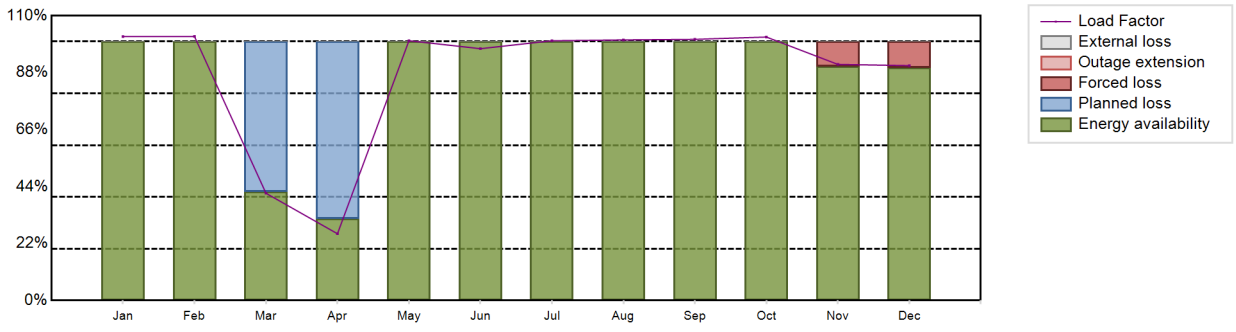
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	323
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.38
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7626.67 GW(e).h
Energy Availability Factor (EAF)	:	87.84 %
Unit Capability Factor (UCF)	:	87.84 %
Load Factor (LF)	:	87.88 %
Operating Factor (OF)	:	87.83 %

Forced Loss Rate (FLR)	:	1.84 %
Unplanned Capability Loss Factor (UCL)	:	1.64 %
Planned Unavailability Factor (PUF)	:	10.52 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1069 hours

Annual Summary



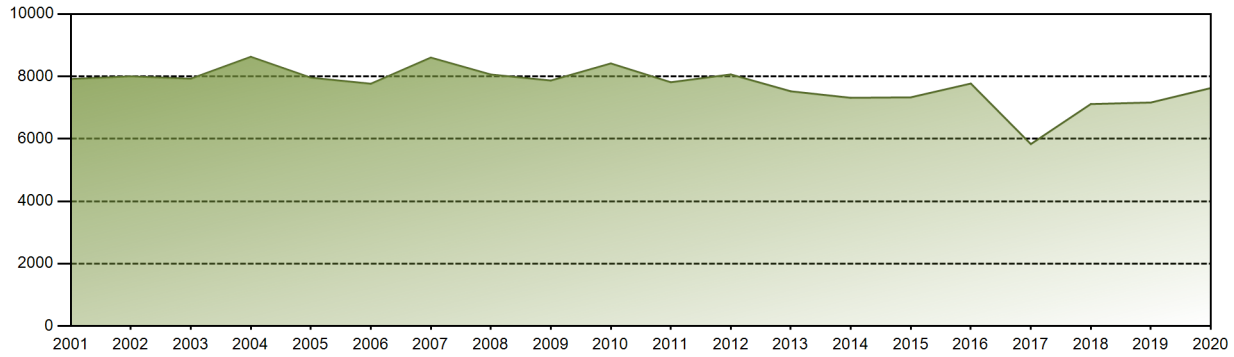
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	749.52	701.23	304.61	183.44	737.52	691.88	737.39	739.84	717.60	747.98	648.77	666.89	7626.67
EAF [%]	100.00	100.00	41.94	31.64	100.00	100.00	100.00	100.00	100.00	100.00	90.46	89.84	87.84
UCF [%]	100.00	100.00	41.94	31.64	100.00	100.00	100.00	100.00	100.00	100.00	90.46	89.84	87.84
LF [%]	101.97	101.98	41.44	25.79	100.33	97.26	100.32	100.65	100.88	101.76	91.20	90.72	87.88
OF [%]	100.00	100.00	41.80	31.67	100.00	100.00	100.00	100.00	100.00	100.00	90.56	89.78	87.83
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.54	10.16	1.84
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.54	10.16	1.64
PUF [%]	0.00	0.00	58.06	68.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.52
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

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Historical Summary

Lifetime energy generation	:	308139.2 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.5 %
Cumulative Energy Availability Factor (EAF)	:	84.15 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.19 %
Cumulative Unit Capability Factor (UCF)	:	84.28 %	Cumulative Planned Unavailability Factor (PUF)	:	10.53 %
Cumulative Load Factor (LF)	:	84.1 %	Cumulative Externally cause unavailability (XUF)	:	0.13 %
Cumulative Operating Factor (OF)	:	83.86 %			

Electricity Production (net) [GWh]

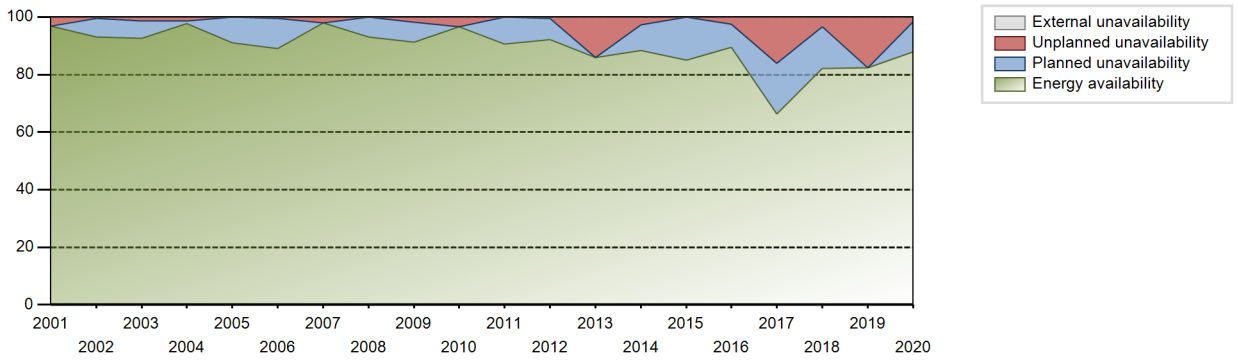


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	3646.60	4913	884	73.39	80.25	60.50	72.74	19.75	19.75	0.00	6.85
1981	4323.60	5622	858	65.23	65.23	57.52	64.18	10.27	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

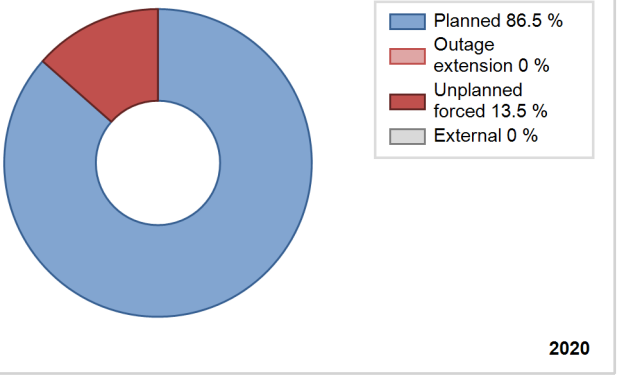
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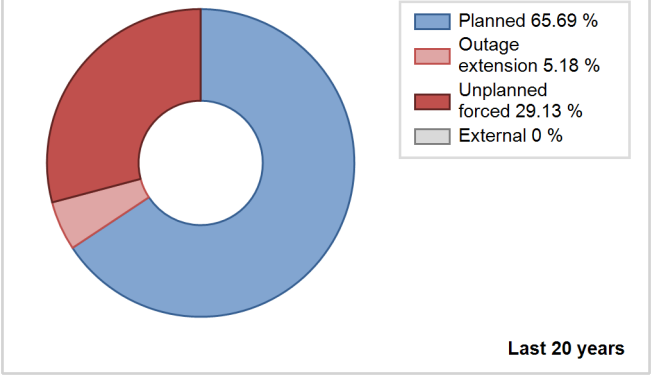
2017	5831.07	6325	993	66.37	66.37	67.03	72.20	7.51	16.19	17.45	0.00
2018	7114.93	7196	988	82.14	82.14	82.21	82.15	3.98	3.41	14.45	0.00
2019	7163.64	7216	988	82.39	82.39	82.77	82.37	17.61	17.61	0.00	0.00
2020	7626.67	7715	988	87.84	87.84	87.88	87.83	1.84	1.64	10.52	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					470	
B. Refuelling without maintenance	924			23		
C. Inspection, maintenance or repair combined with refuelling				830		
D. Inspection, maintenance or repair without refuelling				99		
E. Testing of plant systems or components				10	18	
H. Nuclear regulatory requirements				17	24	
J. Grid limitation, failure or grid unavailability						20
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
P. Fire					19	
Z. Other		144			4	
Subtotal	924	144		979	545	20
Total	**1068**			**1544**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		5
12. Reactor I&C Systems		52
13. Reactor Auxiliary Systems		15
14. Safety Systems		72
15. Reactor Cooling Systems		147
16. Steam generation systems		58
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		36
32. Feedwater and Main Steam System		43
33. Circulating Water System		2
34. Miscellaneous Systems		27
41. Main Generator Systems		8
42. Electrical Power Supply Systems		49
Total		**515**

Highlights (2020)

2 hour shutdown using OP-2203.053 Rapid Power Reduction due to 2E-2B FW heater leak.

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2020 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	:	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]	:	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

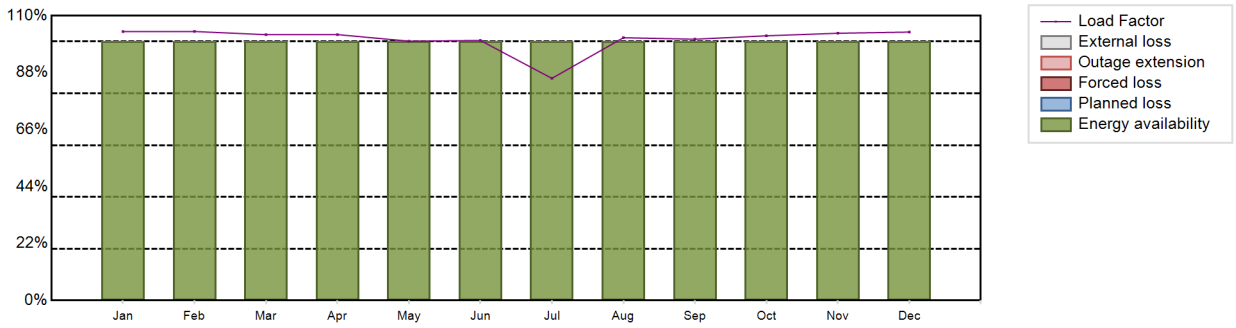
Operating coolant pressure [MPa]	:	15.82
Reactor outlet temperature [°C]	:	322
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.38
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	8047.73 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	100.9 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



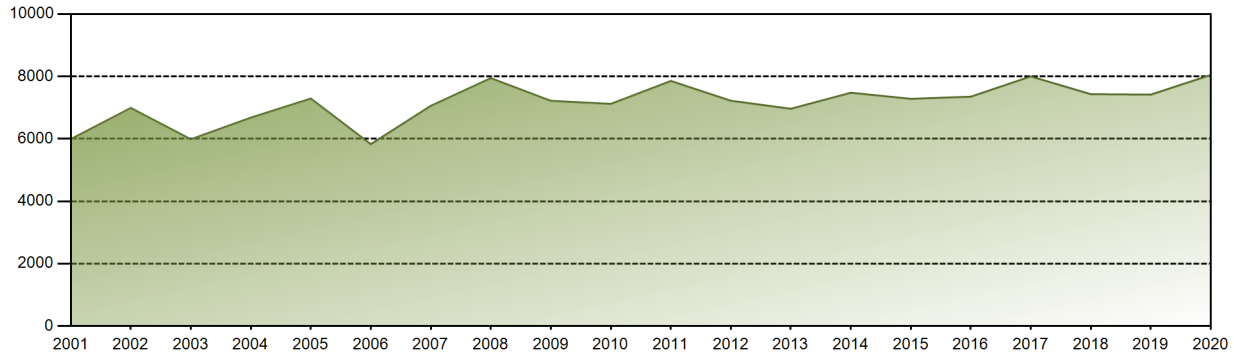
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	701.64	656.67	693.62	671.45	676.65	656.58	579.62	685.71	659.84	690.73	674.79	700.43	8047.73
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	103.86	103.91	102.67	102.71	100.16	100.43	85.80	101.50	100.93	102.25	103.22	103.68	100.90
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	251573.78 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.75 %
Cumulative Energy Availability Factor (EAF)	:	78.52 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.49 %
Cumulative Unit Capability Factor (UCF)	:	78.52 %	Cumulative Planned Unavailability Factor (PUF)	:	12.99 %
Cumulative Load Factor (LF)	:	76.13 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	78.25 %			

Electricity Production (net) [GWh]

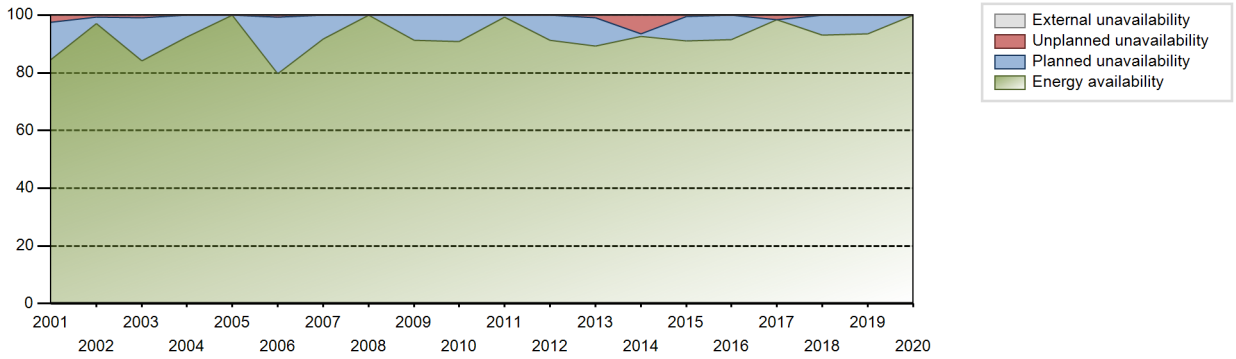


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	504.50	821	834	100.00	100.00	16.12	37.18	0.00	0.00	0.00	0.00
1977	2870.30	4312	843	39.24	39.24	38.87	49.22	49.37	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

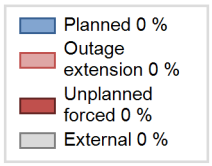
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2013	6963.06	7825	921	89.35	89.35	88.86	89.32	0.91	0.82	9.83	0.00
2014	7477.39	8116	921	92.65	92.65	92.68	92.65	6.56	6.51	0.84	0.00
2015	7282.19	7971	921	91.00	91.00	90.26	90.99	0.47	0.43	8.57	0.00
2016	7351.14	8031	921	91.43	91.43	90.87	91.43	0.00	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

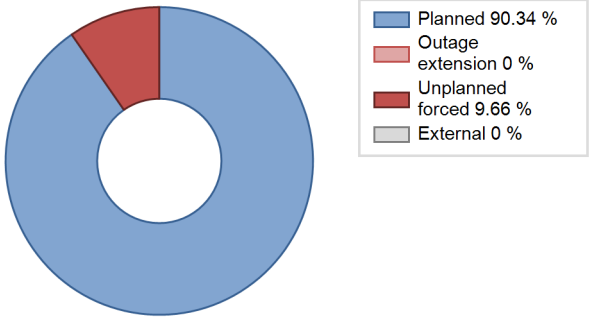
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1976 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					519	
B. Refuelling without maintenance				14		
C. Inspection, maintenance or repair combined with refuelling				993	4	
D. Inspection, maintenance or repair without refuelling				85		
E. Testing of plant systems or components				7	15	
H. Nuclear regulatory requirements					88	
L. Human factor related					11	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						2
Z. Other				16	140	
Subtotal				1115	777	2
Total		**0**			**1894**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1976 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		37
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		25
14. Safety Systems		31
15. Reactor Cooling Systems		280
16. Steam generation systems		2
17. Safety I&C Systems (excluding reactor I&C)		5
31. Turbine and auxiliaries		18
32. Feedwater and Main Steam System		111
34. Miscellaneous Systems		43
35. All other I&C Systems		1
41. Main Generator Systems		16
42. Electrical Power Supply Systems		128
Total		**703**

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2020 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	:	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]	:	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

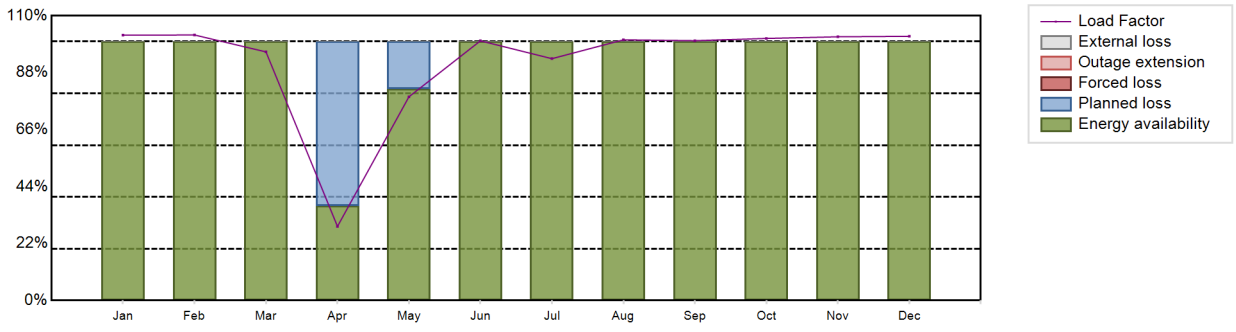
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	322
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.38
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	7345.66 GW(e).h
Energy Availability Factor (EAF)	:	93.25 %
Unit Capability Factor (UCF)	:	93.25 %
Load Factor (LF)	:	92.4 %
Operating Factor (OF)	:	93.24 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	6.75 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	594 hours

Annual Summary



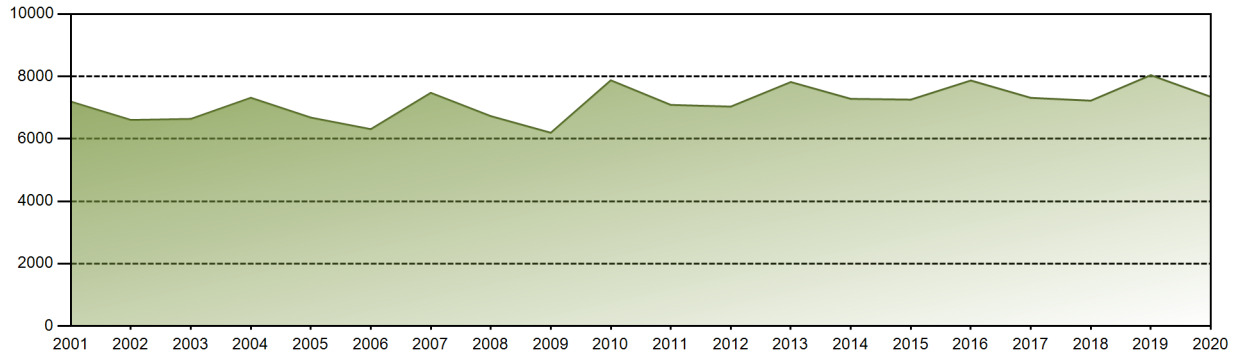
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	690.10	646.00	646.64	186.53	529.80	653.54	628.97	677.89	653.84	681.58	663.72	687.05	7345.66
EAF [%]	100.00	100.00	100.00	36.67	81.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.25
UCF [%]	100.00	100.00	100.00	36.67	81.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.25
LF [%]	102.49	102.56	96.04	28.63	78.69	100.30	93.41	100.68	100.34	101.23	101.86	102.04	92.40
OF [%]	100.00	100.00	99.87	36.67	81.59	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.24
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	63.33	18.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.75
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

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Historical Summary

Lifetime energy generation	:	162091.55 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.39 %
Cumulative Energy Availability Factor (EAF)	:	88.77 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.07 %
Cumulative Unit Capability Factor (UCF)	:	88.77 %	Cumulative Planned Unavailability Factor (PUF)	:	7.16 %
Cumulative Load Factor (LF)	:	86.81 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	88.23 %			

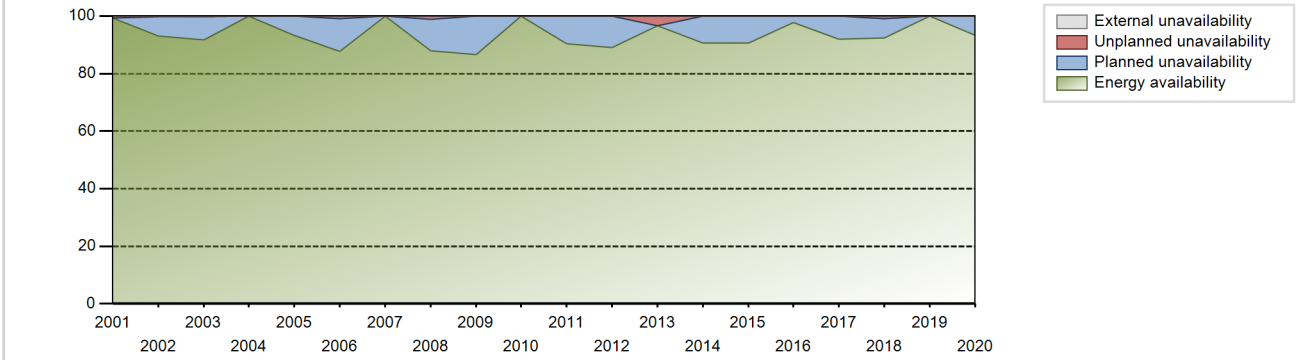
Electricity Production (net) [GWh]



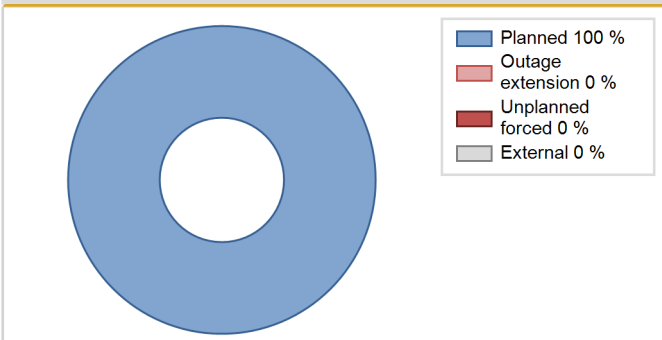
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	738.10	950	822	100.00	100.00	93.42	100.00	0.00	0.00	0.00	0.00
1988	6477.06	8224	833	93.78	93.78	88.52	93.62	2.42	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

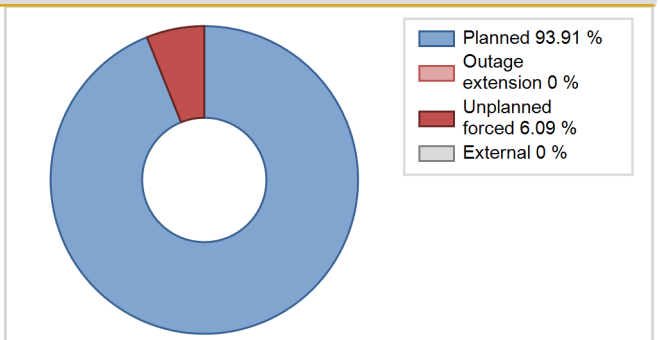
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					309	
B. Refuelling without maintenance	593			18		
C. Inspection, maintenance or repair combined with refuelling				595	2	
D. Inspection, maintenance or repair without refuelling				18		
E. Testing of plant systems or components				1	13	
L. Human factor related					4	
Z. Other					42	
Subtotal	593			632	370	
Total	**593**			**1002**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		30
14. Safety Systems		12
15. Reactor Cooling Systems		168
16. Steam generation systems		17
17. Safety I&C Systems (excluding reactor I&C)		5
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		6
34. Miscellaneous Systems		19
35. All other I&C Systems		3
41. Main Generator Systems		14
42. Electrical Power Supply Systems		22
Total		**333**

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Highlights (2020)
21st Refueling Outage (2R21)

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2020 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

Reactor type and model	:	PWR / WH 4LP (DRYAMB)
Thermal power	:	3645 MWth
Gross electrical power	:	1270 MWe
Reference unit power (net)	:	1194 MWe

Key Dates

Construction Date	:	1975-08-01
Grid Date	:	1987-07-12
Commercial Date	:	1988-07-29
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 [%]	:	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

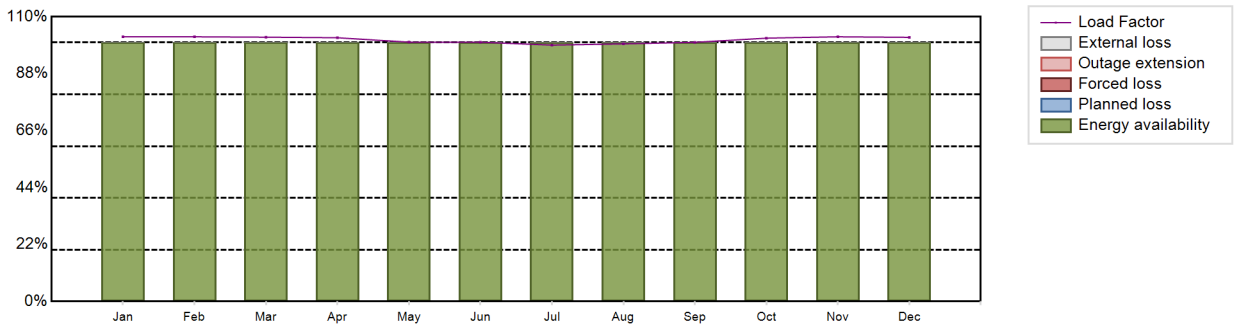
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	326
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.42
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.63
Output voltage [kV]	:	-
Primary means of condenser cooling	:	Cooling 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 (2020)

Net Energy Production	:	10604.45 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	101.11 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



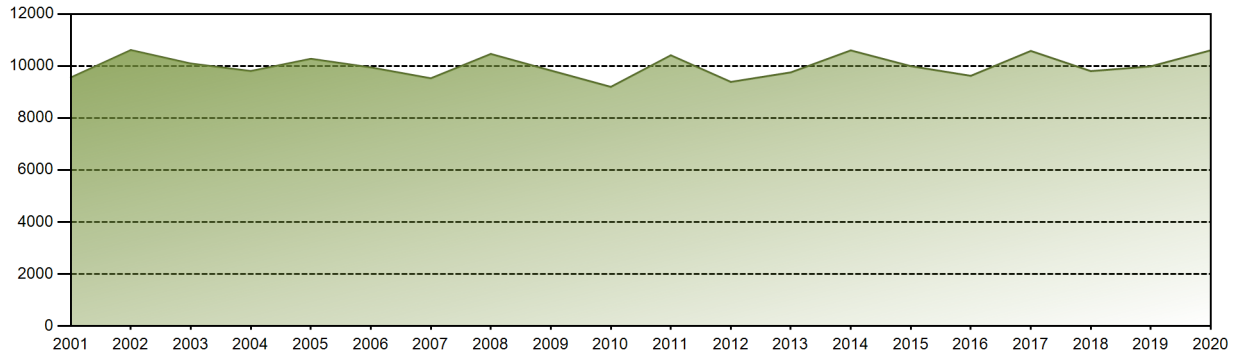
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	908.15	849.61	906.87	875.78	889.91	860.94	879.77	884.03	860.54	903.55	878.94	906.34	10604.45
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	102.23	102.24	102.09	101.87	100.18	100.15	99.04	99.52	100.10	101.71	102.24	102.03	101.11
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	295005.1 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.58 %
Cumulative Energy Availability Factor (EAF)	:	90.45 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.4 %
Cumulative Unit Capability Factor (UCF)	:	90.46 %	Cumulative Planned Unavailability Factor (PUF)	:	7.14 %
Cumulative Load Factor (LF)	:	89.45 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	90.17 %			

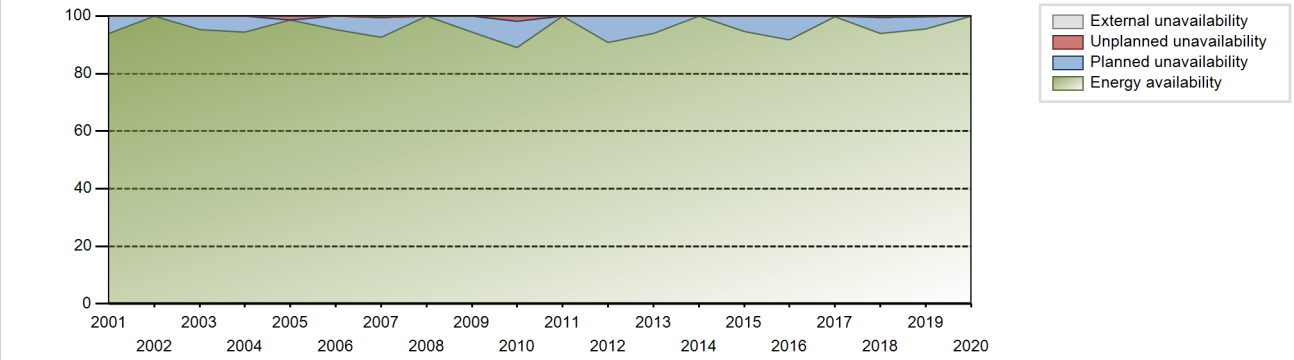
Electricity Production (net) [GWh]



Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
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

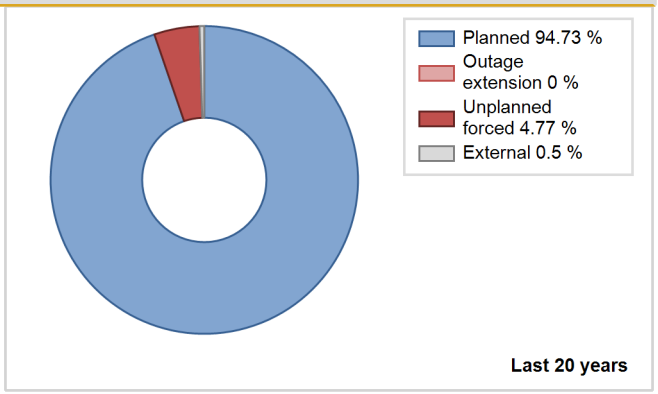
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					195	
C. Inspection, maintenance or repair combined with refuelling				559		
D. Inspection, maintenance or repair without refuelling				81		
E. Testing of plant systems or components				1		
H. Nuclear regulatory requirements					14	
J. Grid limitation, failure or grid unavailability						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				0	2	
Subtotal				641	216	4
Total		**0**			**861**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		3
14. Safety Systems		3
15. Reactor Cooling Systems		5
16. Steam generation systems		15
17. Safety I&C Systems (excluding reactor I&C)		22
31. Turbine and auxiliaries		1
32. Feedwater and Main Steam System		21
34. Miscellaneous Systems		13
41. Main Generator Systems		102
42. Electrical Power Supply Systems		8
Total		**197**

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2020 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	:	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]	:	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

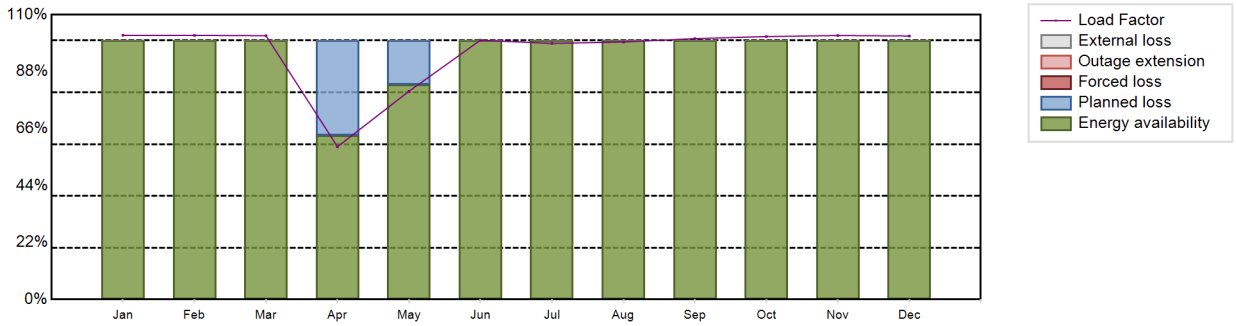
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	326
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.42
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	9767.22 GW(e).h
Energy Availability Factor (EAF)	:	95.57 %
Unit Capability Factor (UCF)	:	95.57 %
Load Factor (LF)	:	95.86 %
Operating Factor (OF)	:	95.56 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	4.43 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	390 hours

Annual Summary



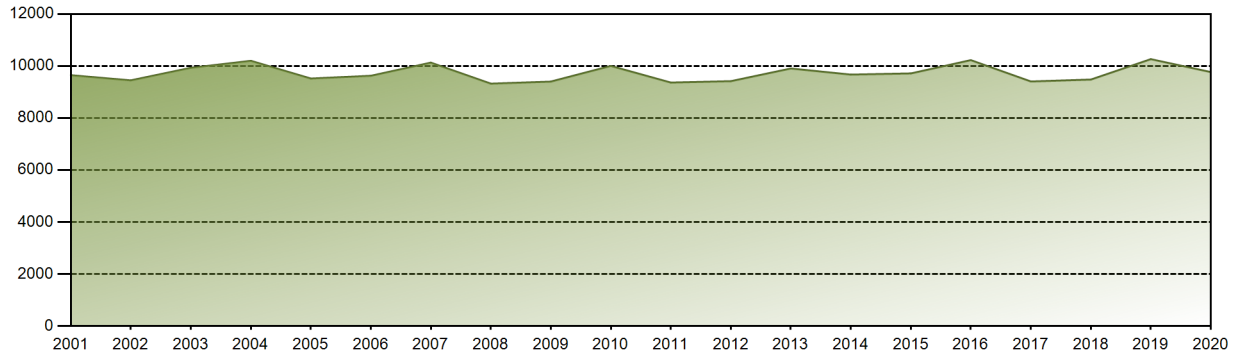
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	880.65	823.75	879.37	492.89	694.11	836.43	853.58	858.53	841.45	876.50	851.61	878.35	9767.22
EAF [%]	100.00	100.00	100.00	63.47	83.04	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.57
UCF [%]	100.00	100.00	100.00	63.47	83.04	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.57
LF [%]	102.04	102.03	101.89	59.02	80.43	100.15	98.90	99.48	100.75	101.56	101.97	101.77	95.86
OF [%]	100.00	100.00	99.87	63.47	83.06	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.56
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	36.53	16.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.43
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

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Historical Summary

Lifetime energy generation	:	302075.35 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.38 %
Cumulative Energy Availability Factor (EAF)	:	92.43 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.3 %
Cumulative Unit Capability Factor (UCF)	:	92.45 %	Cumulative Planned Unavailability Factor (PUF)	:	6.26 %
Cumulative Load Factor (LF)	:	90.99 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	92.28 %			

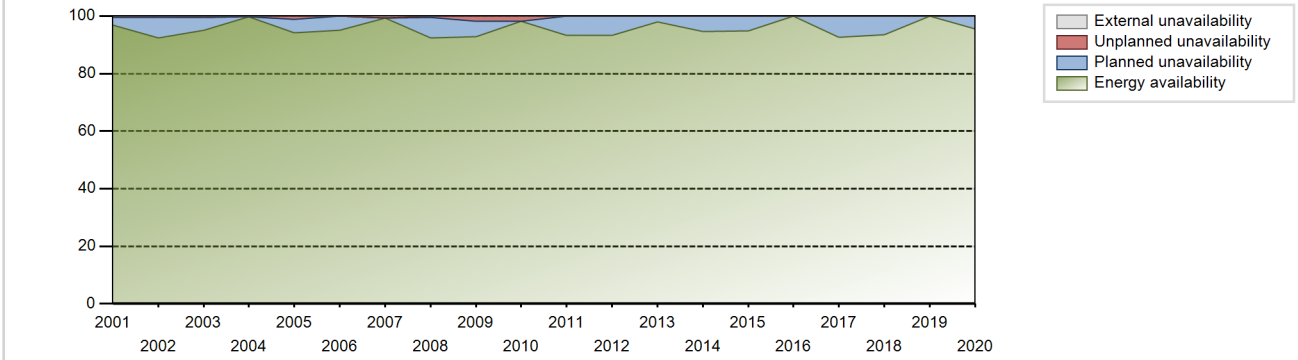
Electricity Production (net) [GWh]



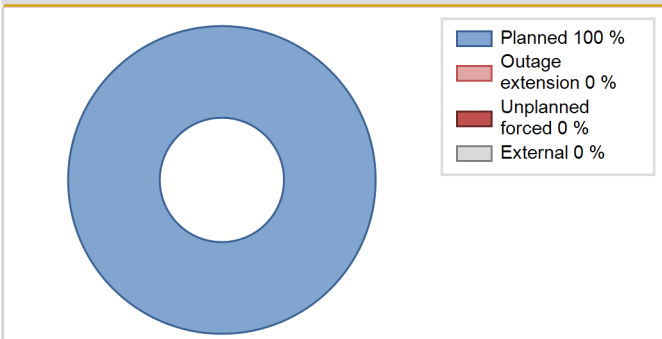
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	1350.94	1476	1097	87.43	87.43	72.73	87.30	12.57	12.57	0.00	0.00
1989	7142.04	7581	1120	86.89	86.89	72.79	86.54	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

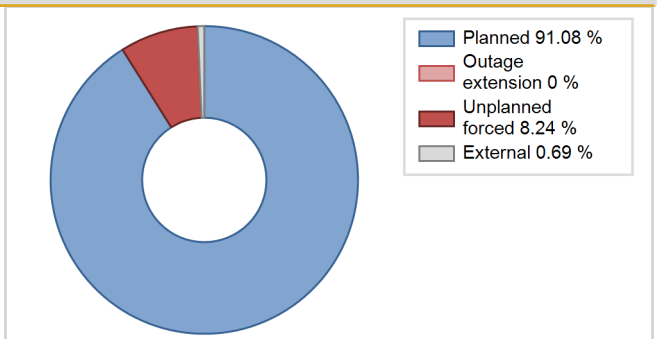
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					103	
B. Refuelling without maintenance	389			12		
C. Inspection, maintenance or repair combined with refuelling				489		
D. Inspection, maintenance or repair without refuelling				56		
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					9	
Subtotal	389			557	120	3
Total	**389**			**680**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 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		11
34. Miscellaneous Systems		1
35. All other I&C Systems		3
41. Main Generator Systems		13
42. Electrical Power Supply Systems		40
Total		**104**

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Highlights (2020)

Refueling Outage 21 (A2R21)

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	3458 MWth
Gross electrical power	:	1256 MWe
Reference unit power (net)	:	1200 MWe

Key Dates

Construction Date	:	1967-05-01
Grid Date	:	1973-10-15
Commercial Date	:	1974-08-01
Age at end of year	:	47 years

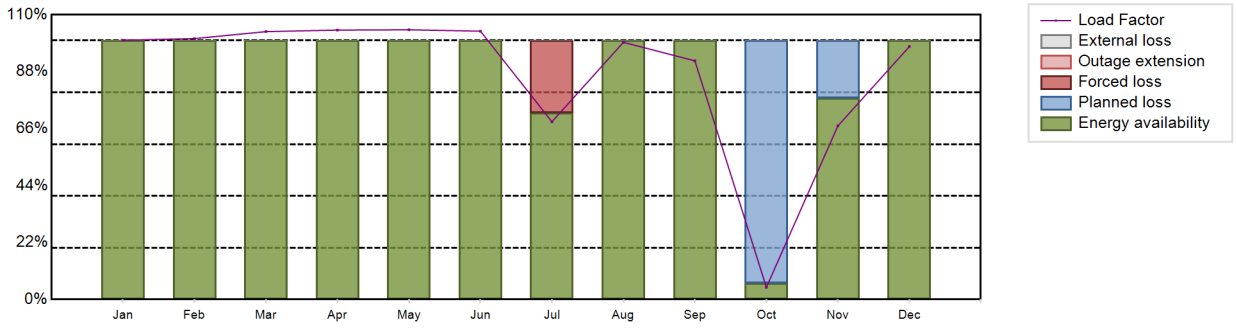
Design Characteristics

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 [%]	:	28
Average discharge burnup [MWd/t]	:	38000
Active core diameter [m]	:	4.8
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	154
Fuel linear heat generation rate [kW/m]	:	18.25
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.2
Reactor outlet temperature [°C]	:	285
Number of SG	:	NA
Containment type	:	-
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	:	-
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	:	none

Annual Production Results (2020)

Net Energy Production	:	9174.12 GW(e).h
Energy Availability Factor (EAF)	:	87.86 %
Unit Capability Factor (UCF)	:	87.86 %
Load Factor (LF)	:	87.03 %
Operating Factor (OF)	:	87.86 %
Forced Loss Rate (FLR)	:	2.63 %
Unplanned Capability Loss Factor (UCL)	:	2.37 %
Planned Unavailability Factor (PUF)	:	9.76 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1066 hours

Annual Summary



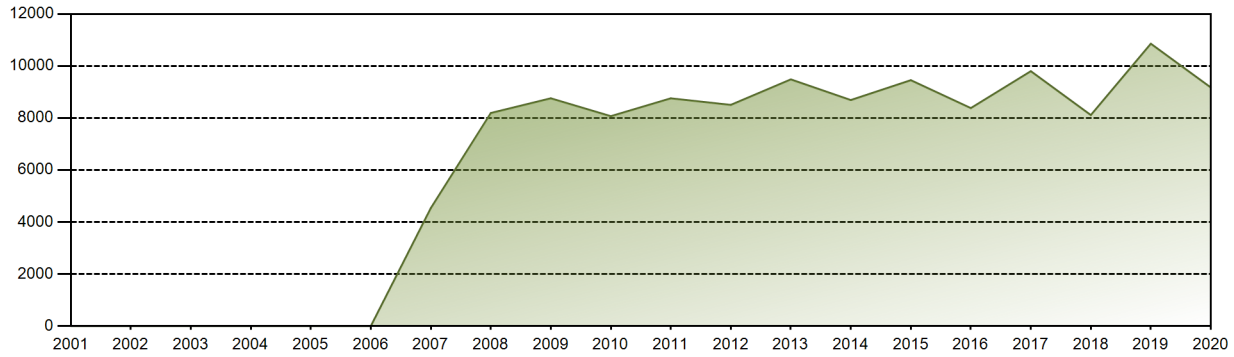
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	894.14	841.58	923.78	899.02	930.17	895.46	612.86	886.88	796.45	42.16	579.40	872.22	9174.12
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	71.99	100.00	100.00	6.32	77.70	100.00	87.86
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	71.99	100.00	100.00	6.32	77.70	100.00	87.86
LF [%]	100.15	100.76	103.47	104.05	104.19	103.64	68.64	99.34	92.18	4.72	67.06	97.69	87.03
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	72.04	100.00	100.00	6.32	77.78	100.00	87.86
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	28.01	0.00	0.00	0.00	0.00	0.00	2.63
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	28.01	0.00	0.00	0.00	0.00	0.00	2.37
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.68	22.30	0.00	9.76
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

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Historical Summary

Lifetime energy generation	:	181837.75 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	11.19 %
Cumulative Energy Availability Factor (EAF)	:	77.26 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.76 %
Cumulative Unit Capability Factor (UCF)	:	77.53 %	Cumulative Planned Unavailability Factor (PUF)	:	12.71 %
Cumulative Load Factor (LF)	:	75.45 %	Cumulative Externally cause unavailability (XUF)	:	0.27 %
Cumulative Operating Factor (OF)	:	79.08 %			

Electricity Production (net) [GWh]

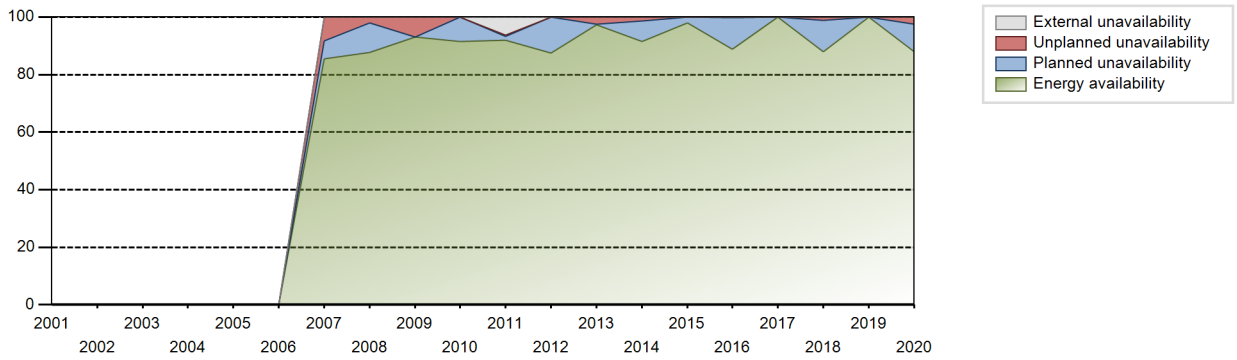


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	5168.70	6523	1065	85.76	85.76	70.71	84.80	1.41	1.23	13.02	0.00
1975	1378.50	1535	1065	14.79	14.79	14.78	17.52	84.64	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 - Long-term shutdown										
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

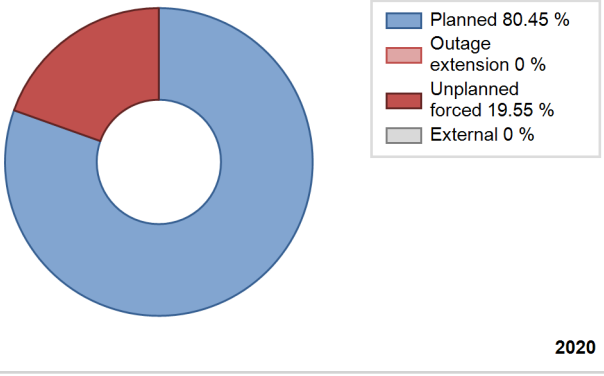
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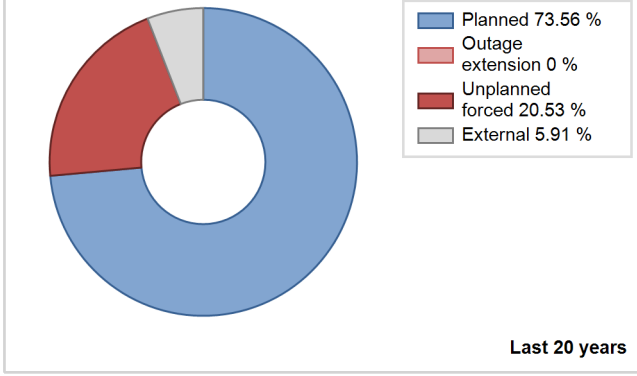
2011	8757.41	8048	1101	91.95	98.21	90.80	91.87	0.49	0.48	1.31	6.26
2012	8505.98	7691	1101	87.57	87.57	87.95	87.56	0.00	0.00	12.43	0.00
2013	9485.99	8516	1101	97.22	97.22	98.34	97.20	2.49	2.48	0.30	0.00
2014	8691.41	8021	1101	91.56	91.56	90.12	91.56	1.42	1.32	7.11	0.00
2015	9455.32	8575	1101	97.88	97.88	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					269	
B. Refuelling without maintenance	858			35		
C. Inspection, maintenance or repair combined with refuelling				1102	89	
D. Inspection, maintenance or repair without refuelling				3714		
E. Testing of plant systems or components				12	17	
H. Nuclear regulatory requirements				362	2869	
J. Grid limitation, failure or grid unavailability						24
L. Human factor related					9	
P. Fire					544	
Z. Other		208			11	
Subtotal	858	208		5225	3808	24
Total	**1066**			**9057**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		11
13. Reactor Auxiliary Systems		15
14. Safety Systems		17
15. Reactor Cooling Systems		79
31. Turbine and auxiliaries		63
32. Feedwater and Main Steam System		26
34. Miscellaneous Systems		26
41. Main Generator Systems		10
42. Electrical Power Supply Systems		28
Total		**278**

Highlights (2020)

Refueling Outage U1R13 Refueling

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	3458 MWth
Gross electrical power	:	1259 MWe
Reference unit power (net)	:	1200 MWe

Key Dates

Construction Date	:	1967-05-01
Grid Date	:	1974-08-28
Commercial Date	:	1975-03-01
Age at end of year	:	46 years

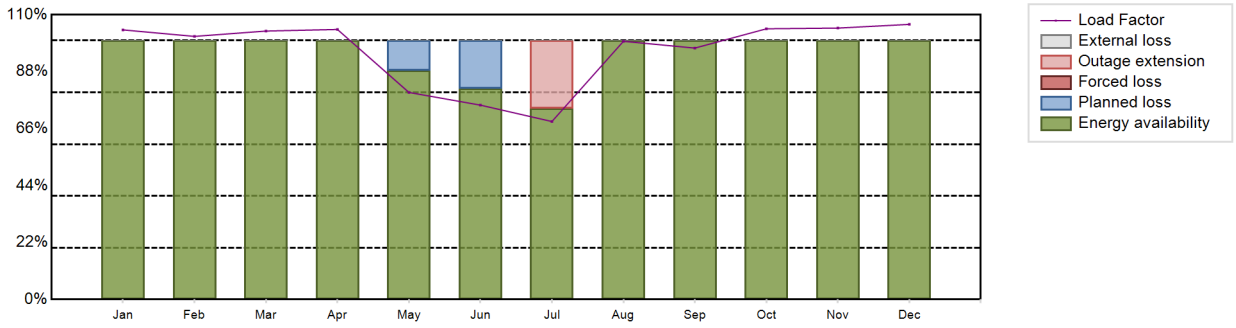
Design Characteristics

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 (2020)

Net Energy Production	:	10098.92 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	95.27 %	Unplanned Capability Loss Factor (UCL)	:	2.22 %
Unit Capability Factor (UCF)	:	95.27 %	Planned Unavailability Factor (PUF)	:	2.5 %
Load Factor (LF)	:	95.81 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	95.26 %	Total off-line time	:	416 hours

Annual Summary



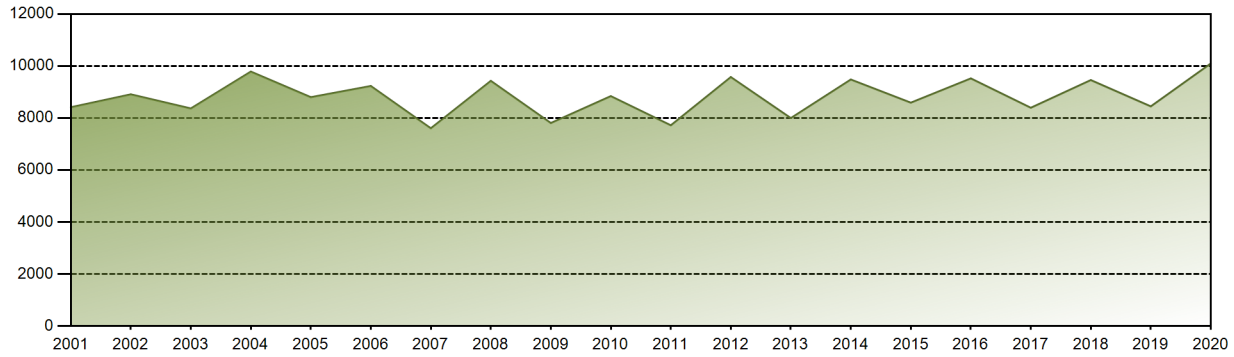
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	929.70	848.77	925.68	901.14	714.04	648.68	613.76	890.35	839.04	933.45	905.70	948.62	10098.92
EAF [%]	100.00	100.00	100.00	100.00	88.37	81.47	73.77	100.00	100.00	100.00	100.00	100.00	95.27
UCF [%]	100.00	100.00	100.00	100.00	88.37	81.47	73.77	100.00	100.00	100.00	100.00	100.00	95.27
LF [%]	104.13	101.63	103.68	104.30	79.98	75.08	68.75	99.73	97.11	104.55	104.83	106.25	95.81
OF [%]	100.00	100.00	99.87	100.00	88.31	81.53	73.79	100.00	100.00	100.00	100.00	100.00	95.26
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	26.23	0.00	0.00	0.00	0.00	0.00	2.22
PUF [%]	0.00	0.00	0.00	0.00	11.63	18.53	0.00	0.00	0.00	0.00	0.00	0.00	2.50
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

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Historical Summary

Lifetime energy generation	:	310815.58 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.71 %
Cumulative Energy Availability Factor (EAF)	:	83.1 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.05 %
Cumulative Unit Capability Factor (UCF)	:	83.3 %	Cumulative Planned Unavailability Factor (PUF)	:	10.65 %
Cumulative Load Factor (LF)	:	80.25 %	Cumulative Externally cause unavailability (XUF)	:	0.2 %
Cumulative Operating Factor (OF)	:	83.9 %			

Electricity Production (net) [GWh]

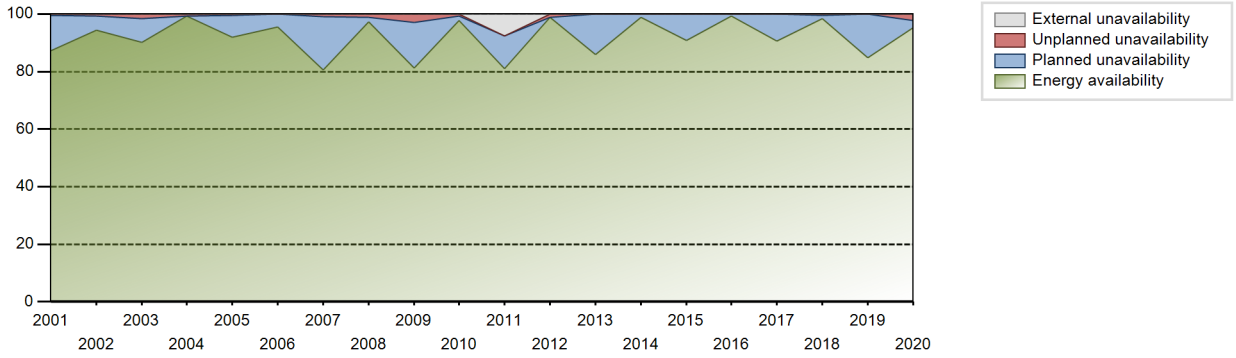


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	1425.70	1578	1065	7.04	7.04	7.04	7.04	92.96	92.96	0.00	0.00
1976	1567.20	2547	1065	16.78	16.78	16.75	29.00	78.21	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 - Long-term shutdown										
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

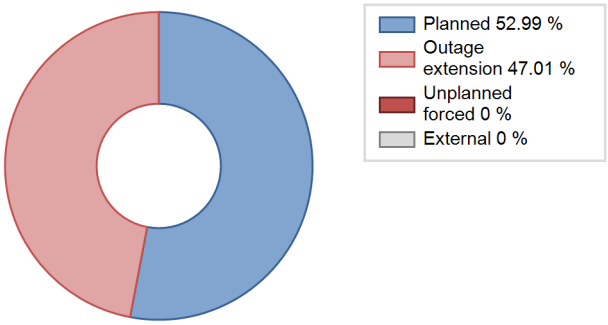
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2012	9576.00	8685	1104	98.88	98.88	98.75	98.87	1.12	1.12	0.00	0.00
2013	7997.82	7527	1104	85.93	85.93	82.69	85.91	0.00	0.00	14.07	0.00
2014	9481.43	8657	1104	98.83	98.83	98.04	98.82	0.00	0.00	1.17	0.00
2015	8591.32	7947	1104	90.72	90.72	88.84	90.72	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

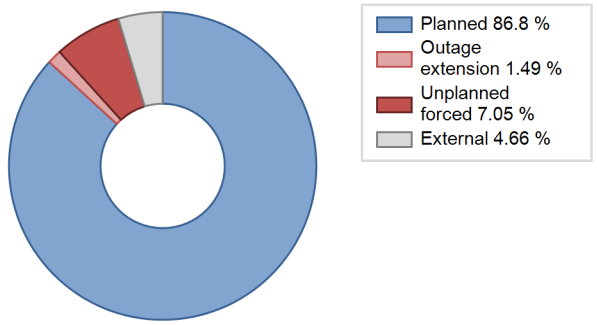
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					174	
C. Inspection, maintenance or repair combined with refuelling				954	55	
D. Inspection, maintenance or repair without refuelling	220			99		
E. Testing of plant systems or components				7	3	
H. Nuclear regulatory requirements					1160	
J. Grid limitation, failure or grid unavailability						17
L. Human factor related					20	
P. Fire					325	
Z. Other			195		2	5
Subtotal	220		195	1060	1739	22
Total	**415**			**2821**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		5
12. Reactor I&C Systems		28
13. Reactor Auxiliary Systems		10
14. Safety Systems		9
15. Reactor Cooling Systems		25
31. Turbine and auxiliaries		45
32. Feedwater and Main Steam System		9
34. Miscellaneous Systems		5
35. All other I&C Systems		1
41. Main Generator Systems		16
42. Electrical Power Supply Systems		22
Total		**175**

Highlights (2020)

Outage to Repair Drywell Leak

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	3458 MWth
Gross electrical power	:	1260 MWe
Reference unit power (net)	:	1210 MWe

Key Dates

Construction Date	:	1968-07-01
Grid Date	:	1976-09-12
Commercial Date	:	1977-03-01
Age at end of year	:	44 years

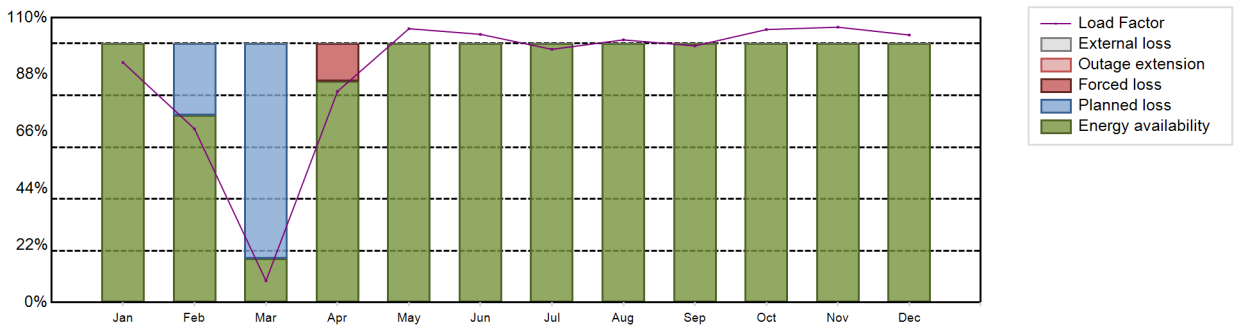
Design Characteristics

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 (2020)

Net Energy Production	:	9501.81 GW(e).h	Forced Loss Rate (FLR)	:	1.31 %
Energy Availability Factor (EAF)	:	89.61 %	Unplanned Capability Loss Factor (UCL)	:	1.19 %
Unit Capability Factor (UCF)	:	89.61 %	Planned Unavailability Factor (PUF)	:	9.21 %
Load Factor (LF)	:	89.4 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	89.59 %	Total off-line time	:	914 hours

Annual Summary



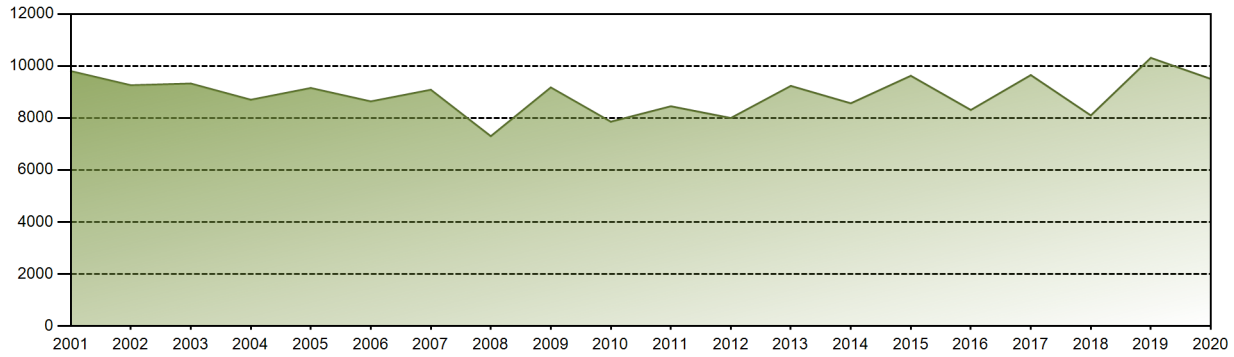
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	834.67	565.01	75.33	710.05	952.01	902.40	880.19	913.19	863.47	949.02	926.39	930.06	9501.81
EAF [%]	100.00	72.42	17.08	85.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	89.61
UCF [%]	100.00	72.42	17.08	85.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	89.61
LF [%]	92.72	67.09	8.37	81.50	105.75	103.58	97.77	101.44	99.11	105.42	106.33	103.31	89.40
OF [%]	100.00	72.41	16.94	85.56	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	89.59
FLR [%]	0.00	0.00	0.00	14.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31
UCL [%]	0.00	0.00	0.00	14.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.19
PUF [%]	0.00	27.58	82.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.21
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

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Historical Summary

Lifetime energy generation	:	280971.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.83 %
Cumulative Energy Availability Factor (EAF)	:	84.83 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.24 %
Cumulative Unit Capability Factor (UCF)	:	85.14 %	Cumulative Planned Unavailability Factor (PUF)	:	8.61 %
Cumulative Load Factor (LF)	:	82.83 %	Cumulative Externally cause unavailability (XUF)	:	0.32 %
Cumulative Operating Factor (OF)	:	85.46 %			

Electricity Production (net) [GWh]

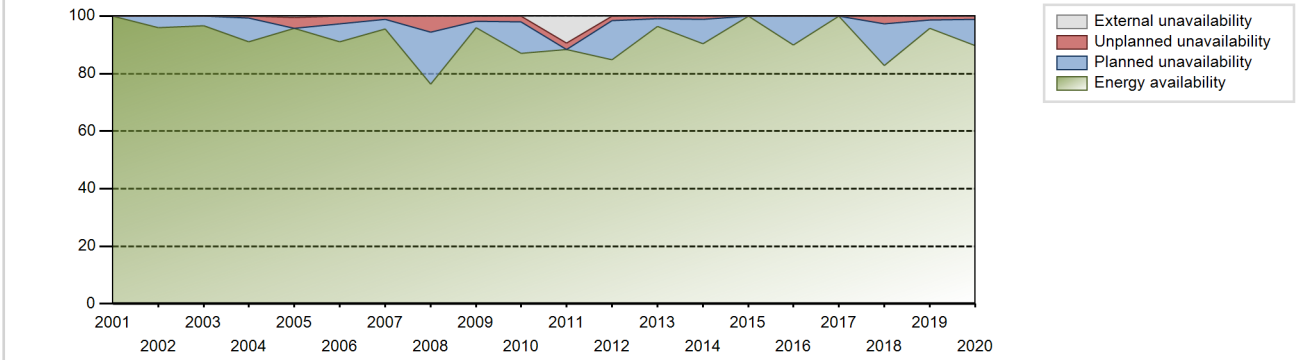


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	7247.50	7857	1065	74.81	74.81	74.81	88.49	25.19	25.19	0.00	0.00
1978	5554.30	6225	1065	59.52	59.52	59.54	71.06	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 - Long-term shutdown										
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

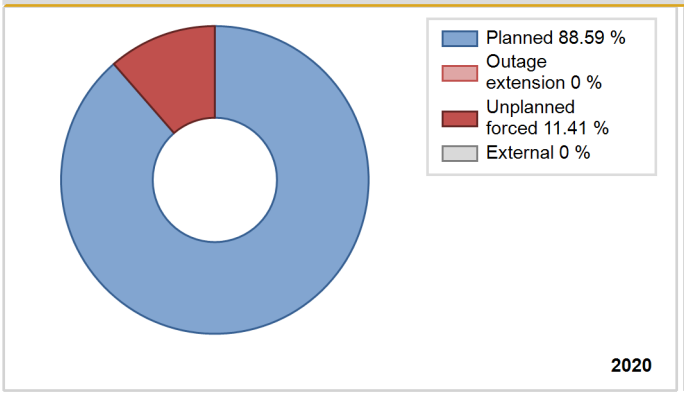
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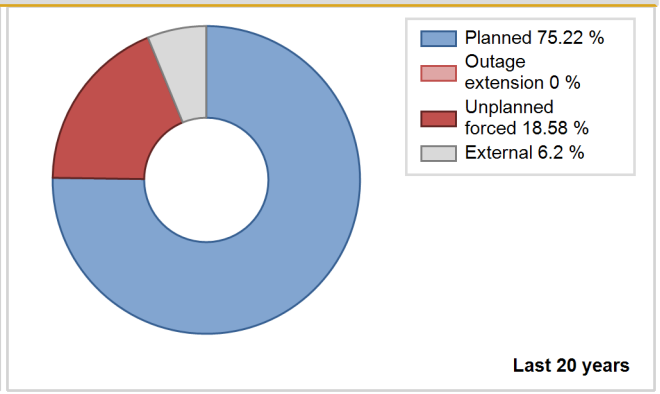
2014	8565.45	7911	1105	90.31	90.31	88.49	90.31	1.22	1.11	8.58	0.00
2015	9623.05	8760	1105	100.00	100.00	99.41	100.00	0.00	0.00	0.00	0.00
2016	8308.77	7906	1105	90.01	90.01	85.60	90.00	0.00	0.00	9.99	0.00
2017	9651.06	8760	1105	100.00	100.00	99.70	100.00	0.00	0.00	0.00	0.00
2018	8099.12	7243	1105	82.69	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					235	
B. Refuelling without maintenance	809			24		
C. Inspection, maintenance or repair combined with refuelling				684	235	
D. Inspection, maintenance or repair without refuelling				525		
E. Testing of plant systems or components				6	1	
H. Nuclear regulatory requirements					2303	
J. Grid limitation, failure or grid unavailability						25
L. Human factor related					12	
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		104			13	
Subtotal	809	104		1242	2799	30
Total		**913**			**4071**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		17
13. Reactor Auxiliary Systems		14
14. Safety Systems		15
15. Reactor Cooling Systems		41
31. Turbine and auxiliaries		71
32. Feedwater and Main Steam System		25
33. Circulating Water System		1
34. Miscellaneous Systems		270
41. Main Generator Systems		17
42. Electrical Power Supply Systems		27
Total		**501**

Highlights (2020)

U3C19 Refueling Outage

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	2923 MWth
Gross electrical power	:	990 MWe
Reference unit power (net)	:	938 MWe

Key Dates

Construction Date	:	1970-02-07
Grid Date	:	1976-12-04
Commercial Date	:	1977-03-18
Age at end of year	:	44 years

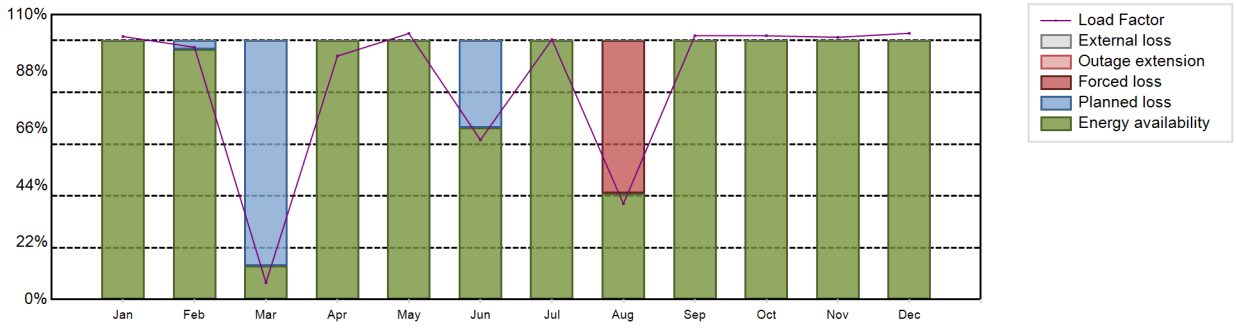
Design Characteristics

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 (2020)

Net Energy Production	:	6917.77 GW(e).h	Forced Loss Rate (FLR)	:	5.57 %
Energy Availability Factor (EAF)	:	84.62 %	Unplanned Capability Loss Factor (UCL)	:	4.99 %
Unit Capability Factor (UCF)	:	84.62 %	Planned Unavailability Factor (PUF)	:	10.39 %
Load Factor (LF)	:	83.96 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	84.61 %	Total off-line time	:	1352 hours

Annual Summary



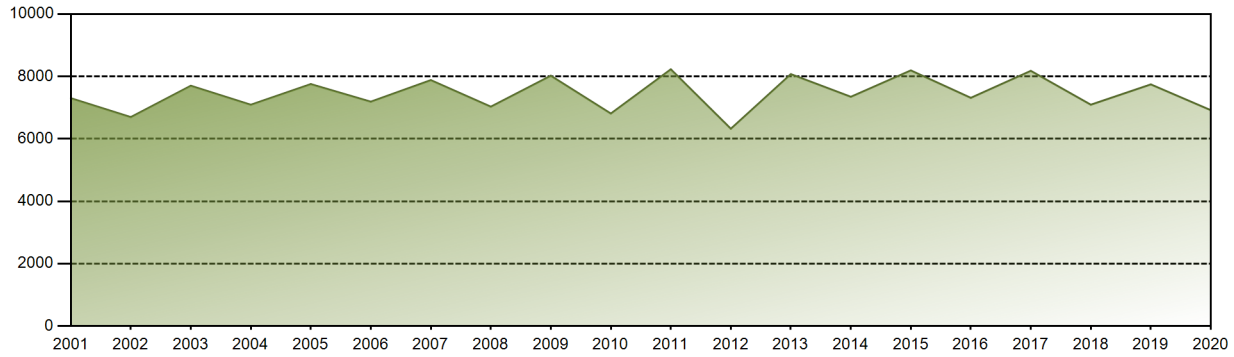
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	708.91	635.96	45.28	635.04	716.94	416.19	700.74	258.05	688.25	710.82	684.03	717.58	6917.77
EAF [%]	100.00	96.66	12.93	100.00	100.00	66.46	100.00	41.10	100.00	100.00	100.00	100.00	84.62
UCF [%]	100.00	96.66	12.93	100.00	100.00	66.46	100.00	41.10	100.00	100.00	100.00	100.00	84.62
LF [%]	101.58	97.41	6.49	94.03	102.73	61.62	100.41	36.98	101.91	101.85	101.28	102.82	83.96
OF [%]	100.00	96.70	12.77	100.00	100.00	66.39	100.00	41.13	100.00	100.00	100.00	100.00	84.61
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.90	0.00	0.00	0.00	0.00	5.57
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.90	0.00	0.00	0.00	0.00	4.99
PUF [%]	0.00	3.34	87.07	0.00	0.00	33.54	0.00	0.00	0.00	0.00	0.00	0.00	10.39
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

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Historical Summary

Lifetime energy generation	:	259494 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.71 %
Cumulative Energy Availability Factor (EAF)	:	78.95 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.8 %
Cumulative Unit Capability Factor (UCF)	:	79.25 %	Cumulative Planned Unavailability Factor (PUF)	:	15.95 %
Cumulative Load Factor (LF)	:	77.32 %	Cumulative Externally cause unavailability (XUF)	:	0.3 %
Cumulative Operating Factor (OF)	:	78.29 %			

Electricity Production (net) [GWh]

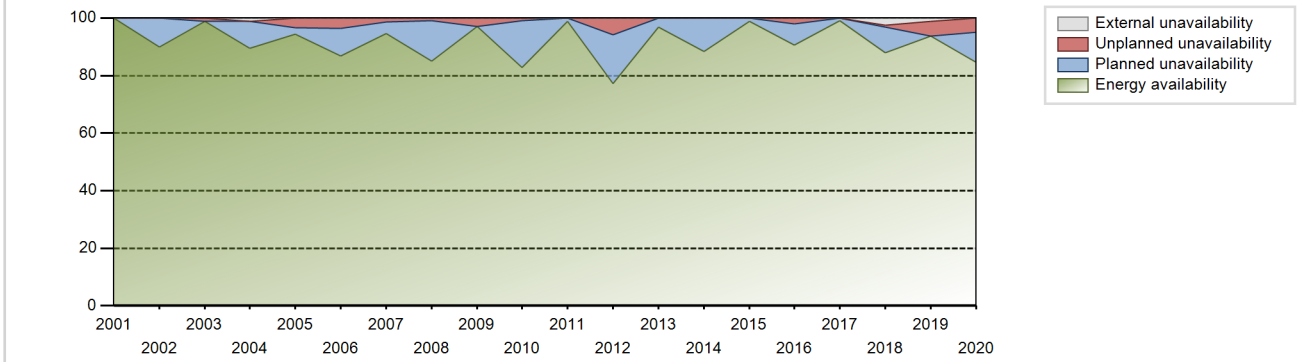


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	2984.50	4949	790	43.63	43.63	43.63	54.61	56.37	56.37	0.00	0.00
1978	5122.90	7624	790	74.11	74.11	74.03	87.03	16.75	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

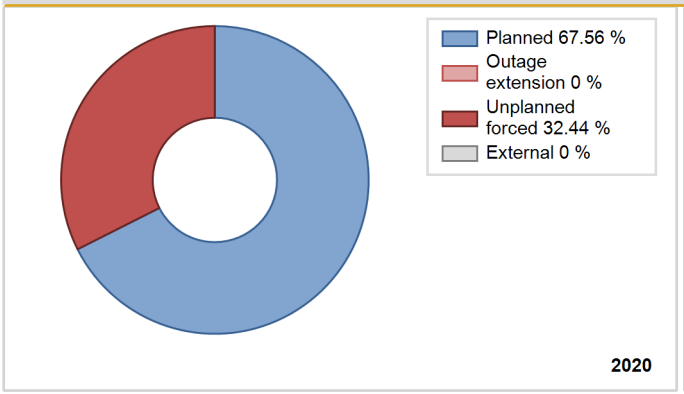
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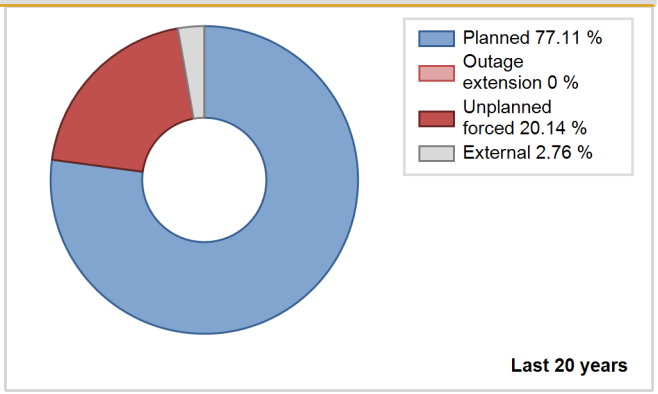
2014	7347.75	7751	938	88.48	88.48	89.42	88.48	0.00	0.00	11.52	0.00
2015	8192.60	8653	938	98.78	98.78	99.70	98.78	0.00	0.00	1.22	0.00
2016	7313.54	7959	938	90.60	90.60	88.76	90.61	2.18	2.01	7.39	0.00
2017	8179.12	8685	938	99.14	99.14	99.54	99.14	0.00	0.00	0.86	0.00
2018	7094.07	7700	938	87.90	90.31	86.34	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					303	
B. Refuelling without maintenance	671			15		
C. Inspection, maintenance or repair combined with refuelling				1067		
D. Inspection, maintenance or repair without refuelling	242			376		
E. Testing of plant systems or components				5	49	
H. Nuclear regulatory requirements					10	
J. Grid limitation, failure or grid unavailability						3
L. Human factor related					29	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						27
Z. Other		438			16	
Subtotal	913	438		1463	407	30
Total	**1351**			**1900**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		12
12. Reactor I&C Systems		17
13. Reactor Auxiliary Systems		8
14. Safety Systems		26
15. Reactor Cooling Systems		48
31. Turbine and auxiliaries		28
32. Feedwater and Main Steam System		11
33. Circulating Water System		5
34. Miscellaneous Systems		64
41. Main Generator Systems		92
42. Electrical Power Supply Systems		44
Total		**355**

Highlights (2020)

Refueling Outage 23 (B1R23)

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2020 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	:	45 years

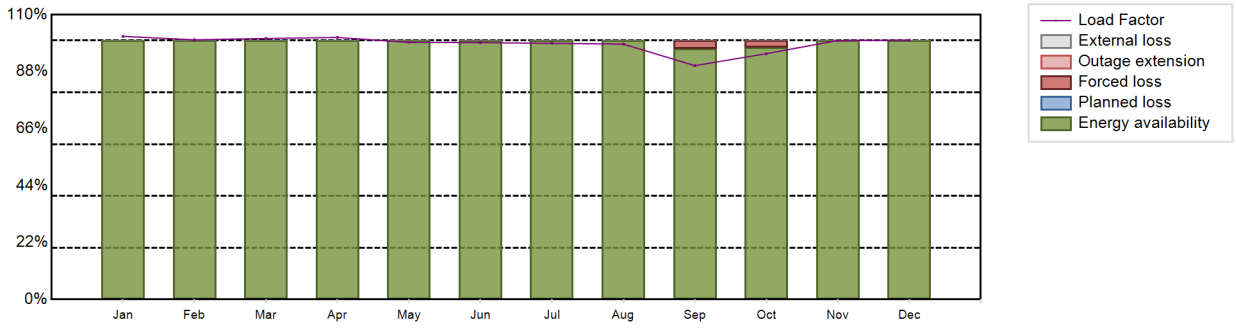
Design Characteristics

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]	:	18.61	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 (2020)

Net Energy Production	:	8088.45 GW(e).h	Forced Loss Rate (FLR)	:	0.49 %
Energy Availability Factor (EAF)	:	99.51 %	Unplanned Capability Loss Factor (UCL)	:	0.49 %
Unit Capability Factor (UCF)	:	99.51 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	98.8 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.5 %	Total off-line time	:	44 hours

Annual Summary



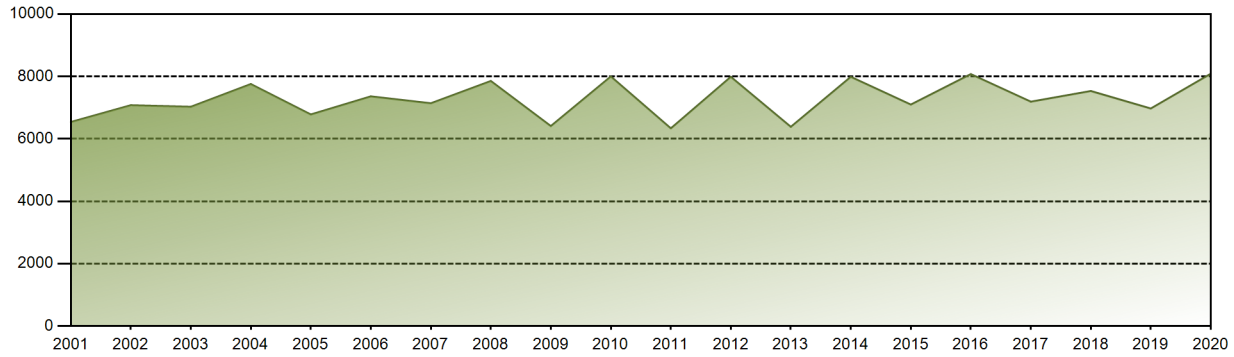
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	704.75	650.61	699.03	679.25	688.62	665.75	686.06	683.96	606.09	658.41	671.33	694.59	8088.45
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	96.77	97.29	100.00	100.00	99.51
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	96.77	97.29	100.00	100.00	99.51
LF [%]	101.64	100.30	100.81	101.22	99.31	99.21	98.94	98.64	90.32	94.95	100.04	100.17	98.80
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	96.81	97.31	100.00	100.00	99.50
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	2.71	0.00	0.00	0.49
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	2.71	0.00	0.00	0.49
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

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Historical Summary

Lifetime energy generation	:	209082.25 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.73 %
Cumulative Energy Availability Factor (EAF)	:	78.12 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.65 %
Cumulative Unit Capability Factor (UCF)	:	78.43 %	Cumulative Planned Unavailability Factor (PUF)	:	15.92 %
Cumulative Load Factor (LF)	:	75.35 %	Cumulative Externally cause unavailability (XUF)	:	0.31 %
Cumulative Operating Factor (OF)	:	78.1 %			

Electricity Production (net) [GWh]

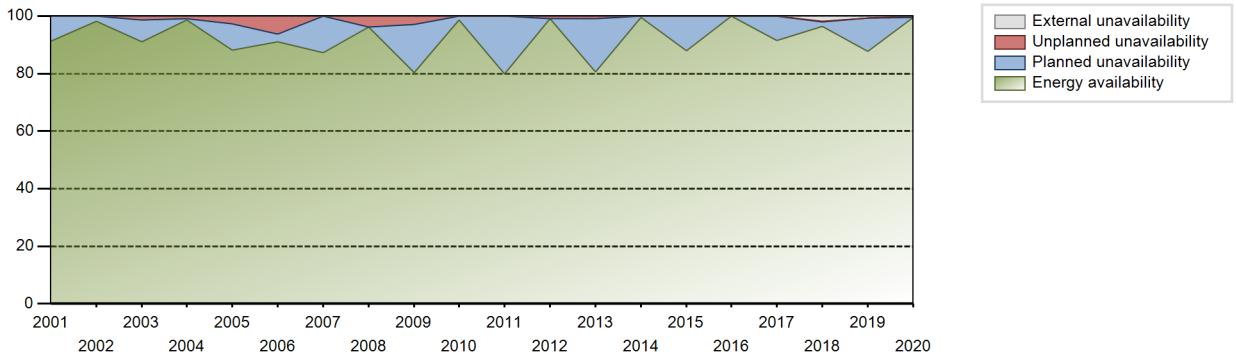


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	1423.80	3254	804	93.19	93.19	58.80	93.17	6.81	6.81	0.00	0.00
1976	2486.60	4911	789	35.81	35.81	35.88	55.91	48.62	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

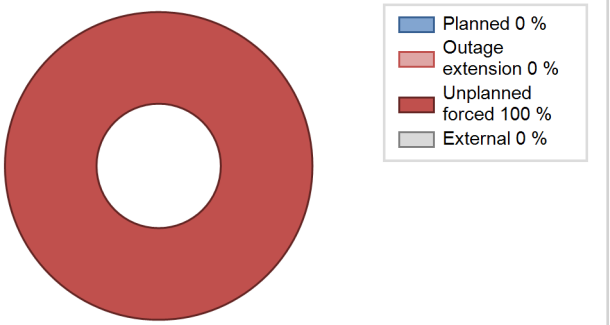
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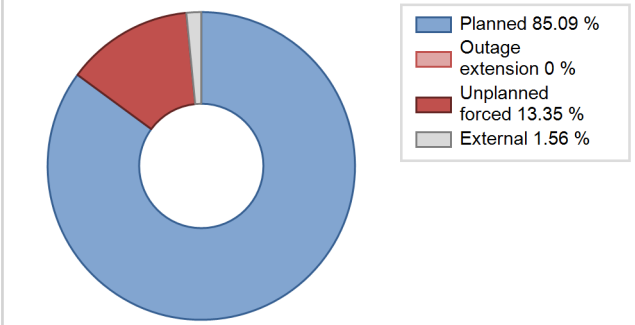
2012	7987.81	8704	920	99.10	99.10	98.84	99.09	0.90	0.90	0.00	0.00
2013	6385.33	7059	920	80.58	80.58	79.22	80.57	1.25	1.02	18.40	0.00
2014	7987.55	8715	920	99.48	99.48	99.11	99.49	0.00	0.00	0.52	0.00
2015	7098.43	7704	920	87.92	87.92	88.08	87.95	0.00	0.00	12.08	0.00
2016	8075.19	8784	920	100.00	100.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					513	
C. Inspection, maintenance or repair combined with refuelling				1039		
D. Inspection, maintenance or repair without refuelling				313		
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					39	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						27
Z. Other		43			5	1
Subtotal		43		1362	565	28
Total		**43**			**1955**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		10
14. Safety Systems		29
15. Reactor Cooling Systems		195
17. Safety I&C Systems (excluding reactor I&C)		5
21. Fuel Handling and Storage Facilities		23
31. Turbine and auxiliaries		68
32. Feedwater and Main Steam System		42
33. Circulating Water System		1
34. Miscellaneous Systems		14
41. Main Generator Systems		32
42. Electrical Power Supply Systems		61
Total		**511**

Highlights (2020)

Turbine offline to repair main generator phase 'C' no-load disconnect switch. Phase 'B' also repaired to prevent further downpowers from this issue

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2020 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	:	35 years

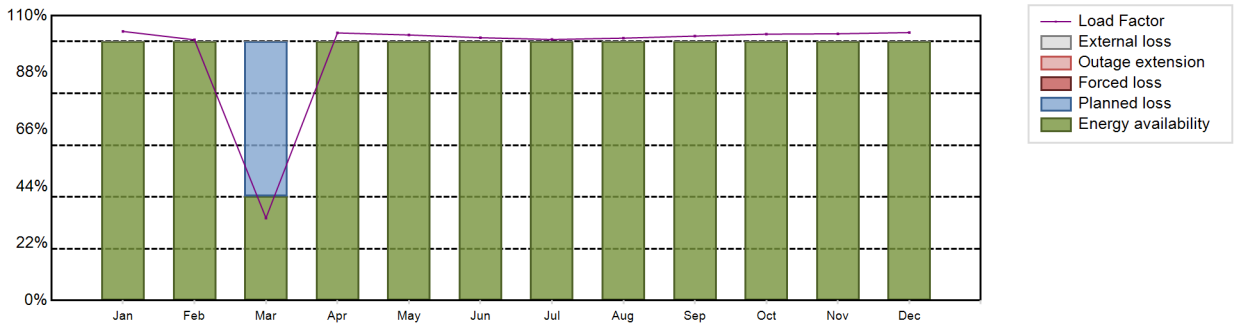
Design Characteristics

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 Towers
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 (2020)

Net Energy Production	:	9853.74 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	94.95 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	94.95 %	Planned Unavailability Factor (PUF)	:	5.05 %
Load Factor (LF)	:	96.37 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	94.93 %	Total off-line time	:	445 hours

Annual Summary



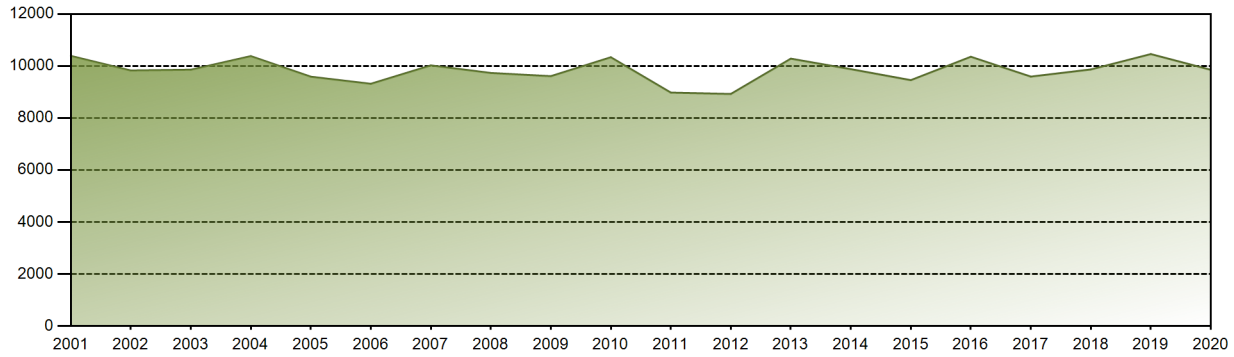
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	900.05	815.75	275.84	866.14	888.16	850.58	873.14	877.58	855.88	891.00	863.41	896.22	9853.74
EAF [%]	100.00	100.00	40.38	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.95
UCF [%]	100.00	100.00	40.38	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.95
LF [%]	103.93	100.69	31.85	103.35	102.56	101.49	100.82	101.33	102.12	102.88	103.02	103.49	96.37
OF [%]	100.00	100.00	40.19	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.93
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	59.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.05
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

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Historical Summary

Lifetime energy generation	:	376681.15 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.81 %
Cumulative Energy Availability Factor (EAF)	:	90.07 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.74 %
Cumulative Unit Capability Factor (UCF)	:	90.14 %	Cumulative Planned Unavailability Factor (PUF)	:	9.12 %
Cumulative Load Factor (LF)	:	87.9 %	Cumulative Externally cause unavailability (XUF)	:	0.08 %
Cumulative Operating Factor (OF)	:	89.97 %			

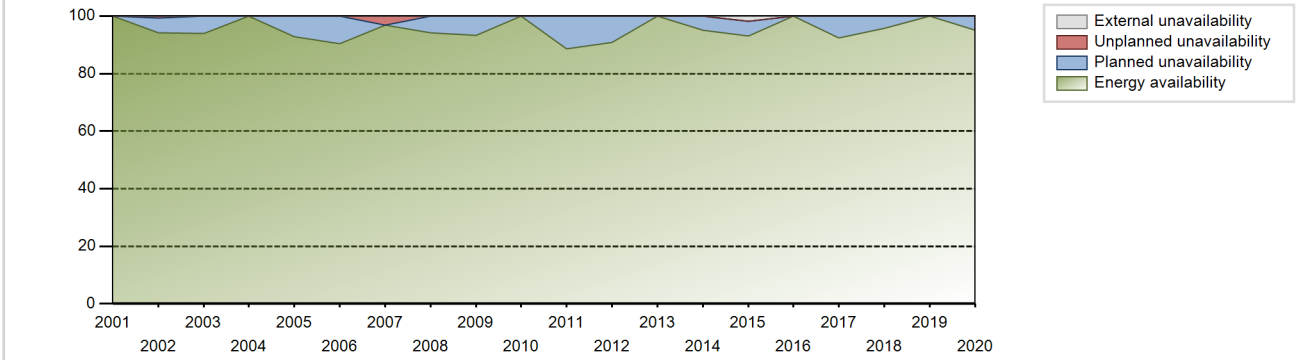
Electricity Production (net) [GWh]



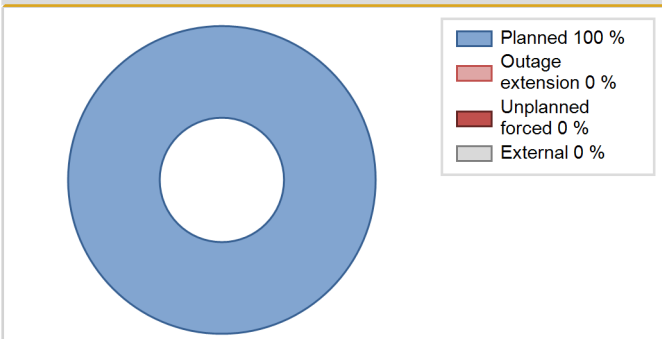
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	1696.12	2025	1124	41.27	41.27	31.22	40.74	3.54	1.51	57.21	0.00
1986	7396.00	7760	1129	89.09	89.09	74.78	88.58	7.52	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

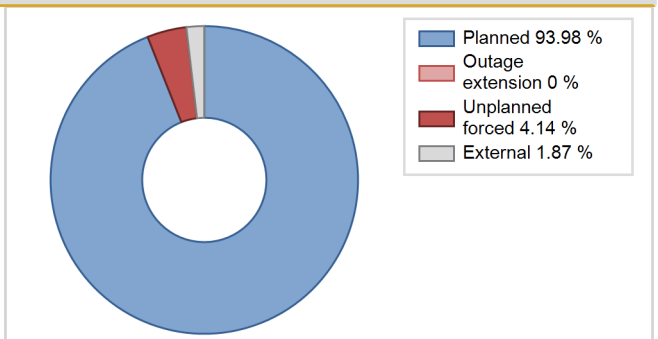
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					47	
B. Refuelling without maintenance	444			23		
C. Inspection, maintenance or repair combined with refuelling				655		
D. Inspection, maintenance or repair without refuelling				124		
E. Testing of plant systems or components					0	
H. Nuclear regulatory requirements					10	
L. Human factor related					7	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						8
Z. Other				3	2	
Subtotal	444			805	66	8
Total	**444**			**879**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		14
12. Reactor I&C Systems		2
13. Reactor Auxiliary Systems		2
15. Reactor Cooling Systems		5
31. Turbine and auxiliaries		11
32. Feedwater and Main Steam System		8
34. Miscellaneous Systems		4
41. Main Generator Systems		0
42. Electrical Power Supply Systems		4
Total		**50**

Highlights (2020)

Refueling Outage 23 (B1R23)

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2020 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	:	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 [%]	:	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

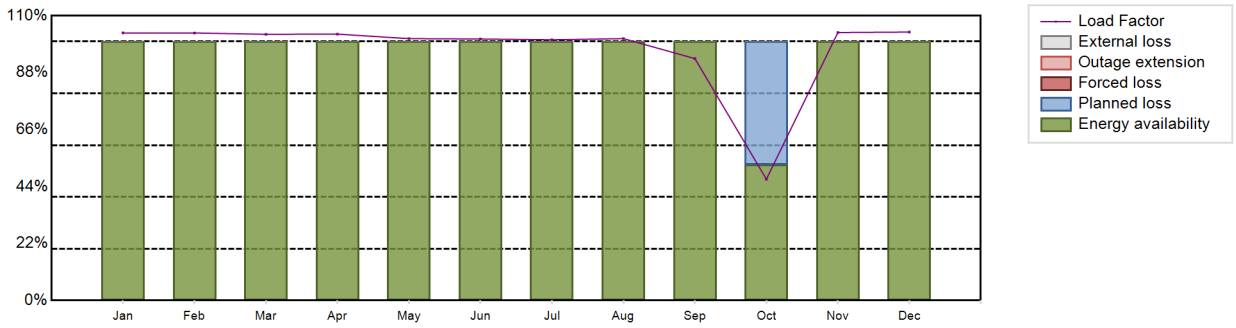
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	326
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.42
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	9671.16 GW(e).h
Energy Availability Factor (EAF)	:	95.98 %
Unit Capability Factor (UCF)	:	95.98 %
Load Factor (LF)	:	96.92 %
Operating Factor (OF)	:	95.97 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	4.02 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	354 hours

Annual Summary



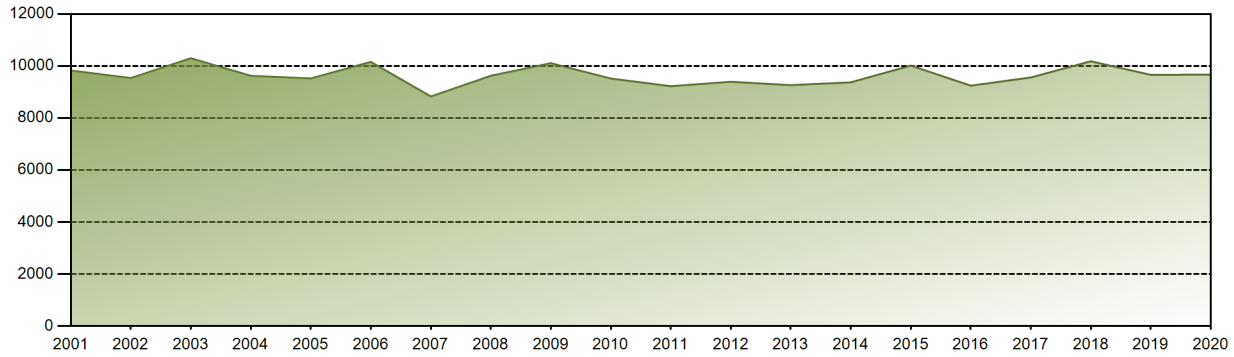
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	873.47	816.99	868.97	841.54	854.78	826.16	851.13	854.90	764.27	396.03	846.59	876.36	9671.16
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	52.56	100.00	100.00	95.98
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	52.56	100.00	100.00	95.98
LF [%]	103.35	103.33	102.81	102.89	101.13	101.01	100.70	101.15	93.44	46.86	103.50	103.69	96.92
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	52.55	100.00	100.00	95.97
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	47.44	0.00	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

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Historical Summary

Lifetime energy generation	:	297572.98 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	0.85 %
Cumulative Energy Availability Factor (EAF)	:	93.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	0.8 %
Cumulative Unit Capability Factor (UCF)	:	93.09 %	Cumulative Planned Unavailability Factor (PUF)	:	6.11 %
Cumulative Load Factor (LF)	:	90.77 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	92.65 %			

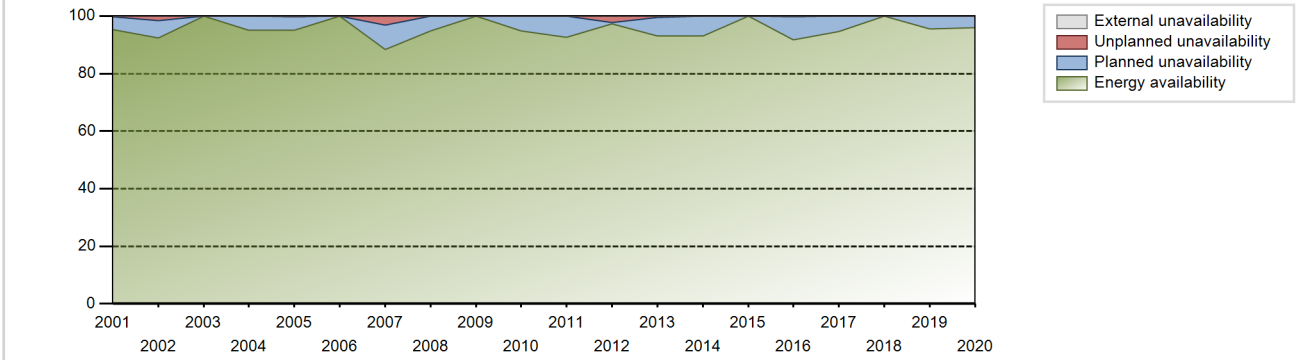
Electricity Production (net) [GWh]



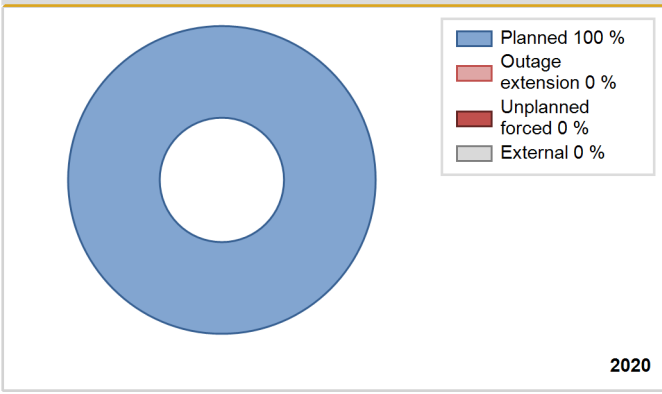
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	3876.06	5071	1128	100.00	100.00	47.54	62.91	0.00	0.00	0.00	0.00
1988	6357.92	8419	1112	95.86	95.86	65.06	95.84	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

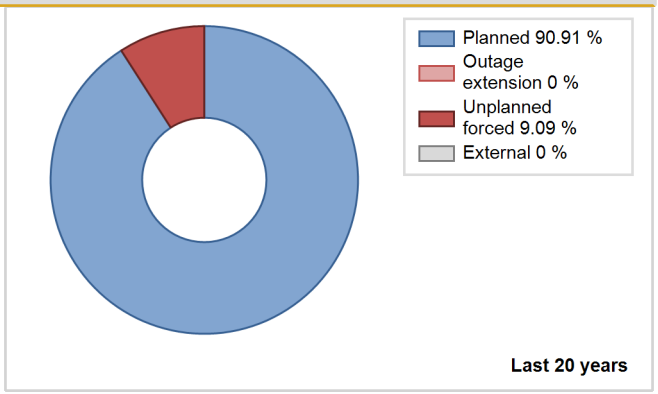
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1987 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					58	
B. Refuelling without maintenance	353			11		
C. Inspection, maintenance or repair combined with refuelling				497		
D. Inspection, maintenance or repair without refuelling				32		
H. Nuclear regulatory requirements					8	
Z. Other					5	
Subtotal	353			540	71	
Total	**353**			**611**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		3
15. Reactor Cooling Systems		7
16. Steam generation systems		13
17. Safety I&C Systems (excluding reactor I&C)		2
32. Feedwater and Main Steam System		6
34. Miscellaneous Systems		10
35. All other I&C Systems		2
41. Main Generator Systems		7
42. Electrical Power Supply Systems		6
Total		**58**

Highlights (2020)

Refueling Outage B2R22

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2020 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	:	36 years

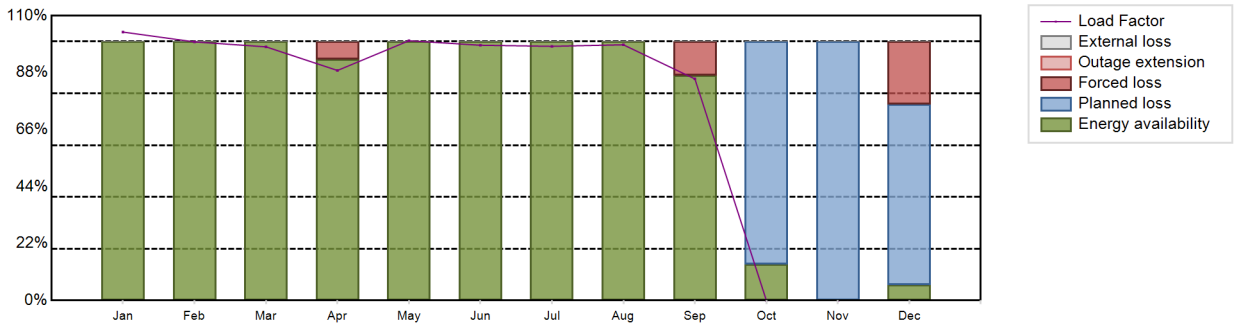
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	329
Fuel material	:	UO2	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	-
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.34
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]	:	42000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.37	HP cylinder inlet steam pressure [MPa]	:	6.78
Active core height/length [m]	:	3.65	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	Cooling Towers
Fuel linear heat generation rate [kW/m]	:	19.13	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 (2020)

Net Energy Production	:	7742.12 GW(e).h	Forced Loss Rate (FLR)	:	4.68 %
Energy Availability Factor (EAF)	:	74.93 %	Unplanned Capability Loss Factor (UCL)	:	3.68 %
Unit Capability Factor (UCF)	:	74.93 %	Planned Unavailability Factor (PUF)	:	21.39 %
Load Factor (LF)	:	72.54 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	73.74 %	Total off-line time	:	2307 hours

Annual Summary



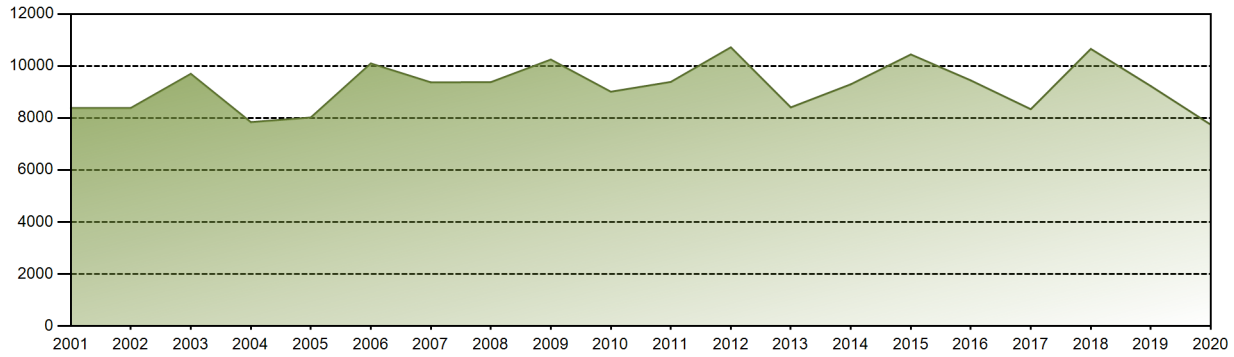
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	937.23	844.72	885.73	777.26	907.01	862.35	887.51	892.76	748.77	0.00	0.00	-1.22	7742.12
EAF [%]	100.00	100.00	100.00	93.06	100.00	100.00	100.00	100.00	86.95	13.98	0.00	6.16	74.93
UCF [%]	100.00	100.00	100.00	93.06	100.00	100.00	100.00	100.00	86.95	13.98	0.00	6.16	74.93
LF [%]	103.68	99.89	97.98	88.85	100.34	98.58	98.18	98.76	85.59	0.00	0.00	-0.13	72.54
OF [%]	100.00	100.00	99.87	93.06	100.00	100.00	100.00	100.00	86.94	0.00	0.00	6.18	73.74
FLR [%]	0.00	0.00	0.00	6.94	0.00	0.00	0.00	0.00	13.05	0.00	0.00	79.65	4.68
UCL [%]	0.00	0.00	0.00	6.94	0.00	0.00	0.00	0.00	13.05	0.00	0.00	24.12	3.68
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86.02	100.00	69.72	21.39
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

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Historical Summary

Lifetime energy generation	:	344513.03 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.11 %
Cumulative Energy Availability Factor (EAF)	:	88.39 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.91 %
Cumulative Unit Capability Factor (UCF)	:	88.39 %	Cumulative Planned Unavailability Factor (PUF)	:	9.7 %
Cumulative Load Factor (LF)	:	87.56 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	88.12 %			

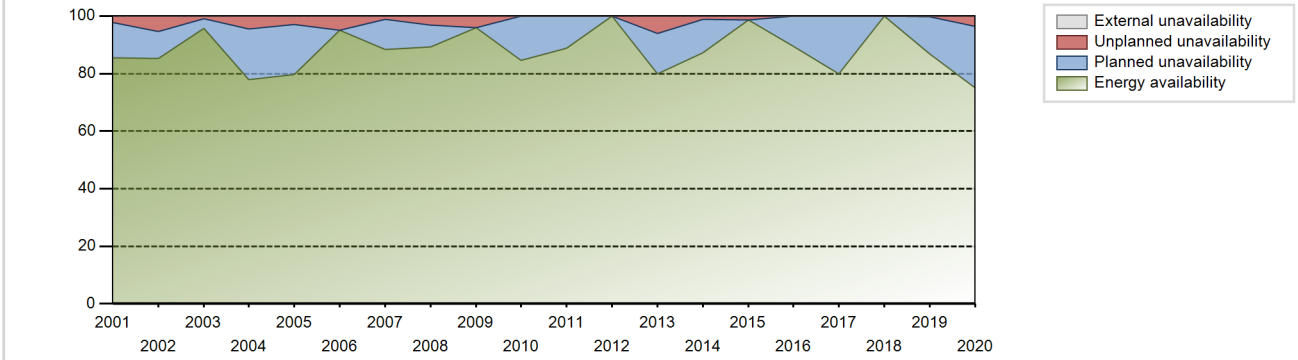
Electricity Production (net) [GWh]



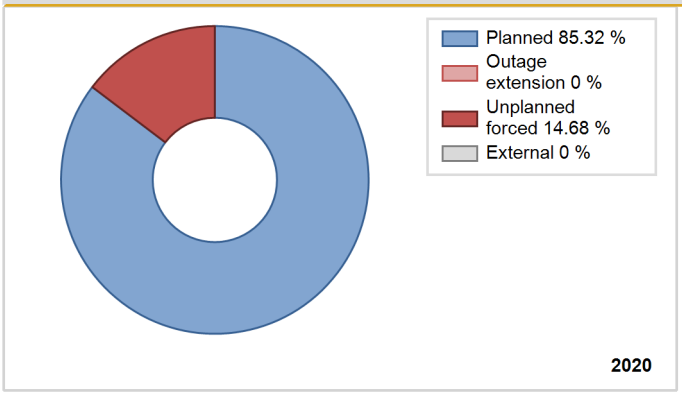
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	577.21	863	1140	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1985	8045.76	7882	1120	89.99	89.99	82.01	89.98	6.38	6.14	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

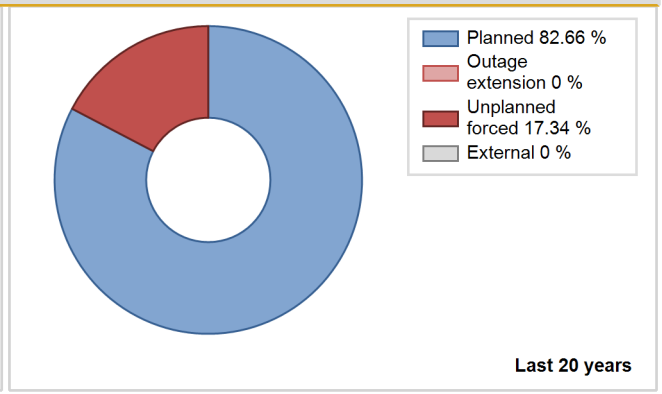
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1984 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					146	
B. Refuelling without maintenance	1879			52		
C. Inspection, maintenance or repair combined with refuelling				735		
D. Inspection, maintenance or repair without refuelling				61		
E. Testing of plant systems or components				0	1	
H. Nuclear regulatory requirements					0	
L. Human factor related					6	
Z. Other		427			17	1
Subtotal	1879	427		848	170	1
Total	**2306**			**1019**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		4
12. Reactor I&C Systems		7
13. Reactor Auxiliary Systems		1
14. Safety Systems		1
15. Reactor Cooling Systems		13
16. Steam generation systems		3
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		24
32. Feedwater and Main Steam System		29
33. Circulating Water System		10
34. Miscellaneous Systems		5
35. All other I&C Systems		2
41. Main Generator Systems		10
42. Electrical Power Supply Systems		38
Total		**148**

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Highlights (2020)

Refueling Outage 24. Transitioned from forced outage to scheduled refueling outage 24 at 0800 10/4/2020.

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2020 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	:	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]	:	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

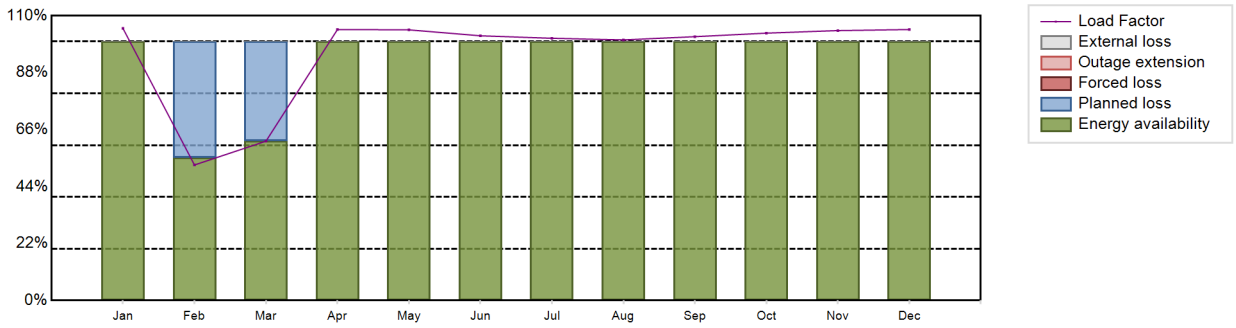
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	314
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.352
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7371.35 GW(e).h
Energy Availability Factor (EAF)	:	93.2 %
Unit Capability Factor (UCF)	:	93.2 %
Load Factor (LF)	:	95.69 %
Operating Factor (OF)	:	93.18 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	6.8 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	599 hours

Annual Summary



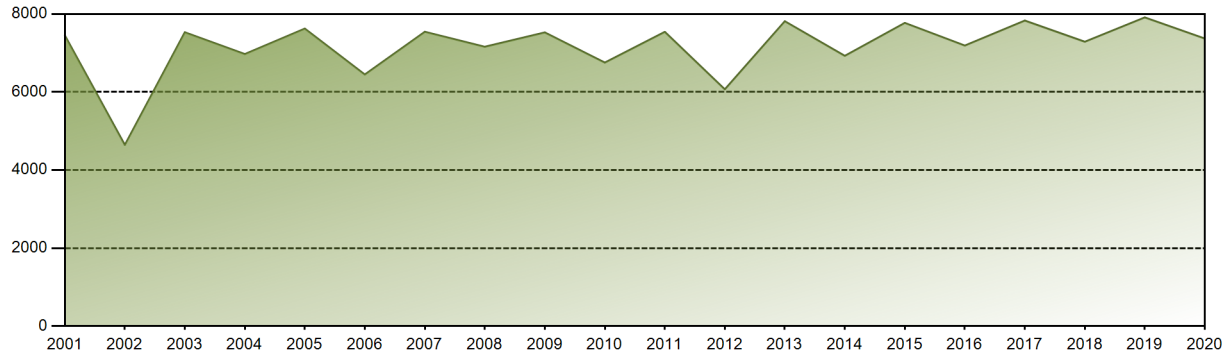
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	685.64	319.57	401.58	660.80	682.11	645.64	660.81	656.79	643.46	673.80	658.38	682.79	7371.35
EAF [%]	100.00	55.18	61.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.20
UCF [%]	100.00	55.18	61.61	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.20
LF [%]	105.08	52.35	61.55	104.65	104.54	102.25	101.28	100.66	101.90	103.27	104.27	104.64	95.69
OF [%]	100.00	55.17	61.42	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.18
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	44.82	38.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.80
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

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Historical Summary

Lifetime energy generation	:	275586.32 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.14 %
Cumulative Energy Availability Factor (EAF)	:	81.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.55 %
Cumulative Unit Capability Factor (UCF)	:	82.1 %	Cumulative Planned Unavailability Factor (PUF)	:	14.36 %
Cumulative Load Factor (LF)	:	82.88 %	Cumulative Externally cause unavailability (XUF)	:	0.25 %
Cumulative Operating Factor (OF)	:	82.25 %			

Electricity Production (net) [GWh]

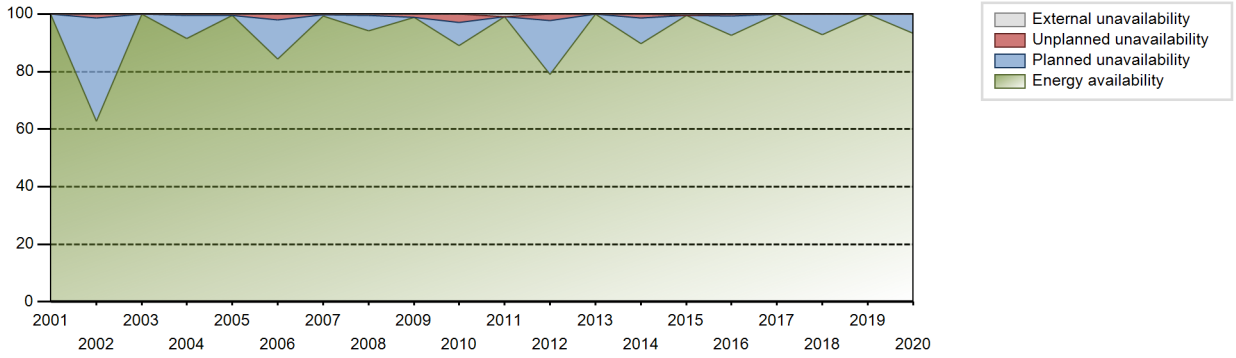


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	4381.60	6667	800	77.16	77.16	77.40	81.75	15.38	14.02	8.82	0.00
1976	6303.90	8356	800	89.70	89.70	89.71	95.13	2.27	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

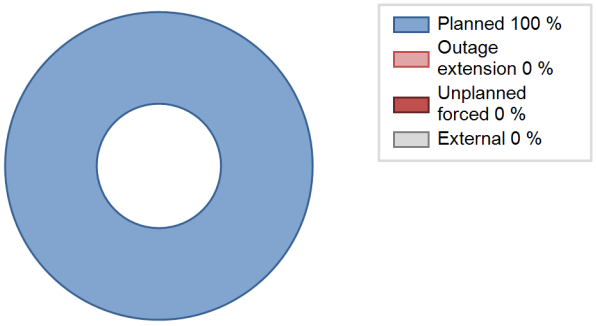
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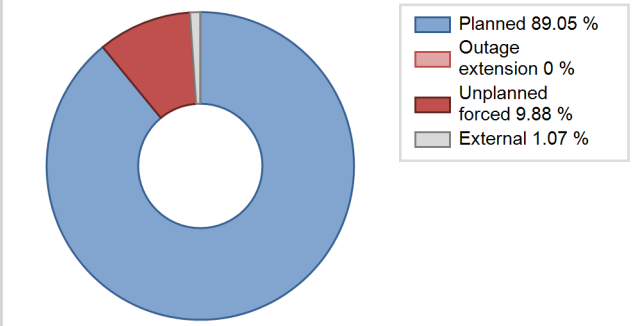
2012	6070.18	6930	866	79.08	79.08	80.13	78.89	2.84	2.31	18.61	0.00
2013	7815.24	8760	866	100.00	100.00	103.01	99.99	0.00	0.00	0.00	0.00
2014	6928.82	7868	866	89.82	89.82	91.34	89.82	1.60	1.46	8.72	0.00
2015	7772.62	8718	866	99.52	100.00	102.46	99.52	0.00	0.00	0.00	0.48
2016	7191.74	8132	866	92.58	92.58	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					265	
B. Refuelling without maintenance	598			13		
C. Inspection, maintenance or repair combined with refuelling				823		
D. Inspection, maintenance or repair without refuelling				369		
E. Testing of plant systems or components				35		
H. Nuclear regulatory requirements					20	
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.)						10
Z. Other					18	
Subtotal	598			1240	309	13
Total	**598**			**1562**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		9
12. Reactor I&C Systems		11
13. Reactor Auxiliary Systems		49
14. Safety Systems		29
15. Reactor Cooling Systems		51
16. Steam generation systems		1
17. Safety I&C Systems (excluding reactor I&C)		3
21. Fuel Handling and Storage Facilities		5
31. Turbine and auxiliaries		49
32. Feedwater and Main Steam System		41
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		25
Total		**288**

Highlights (2020)

Refueling Outage 24.

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2020 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	:	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]	:	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

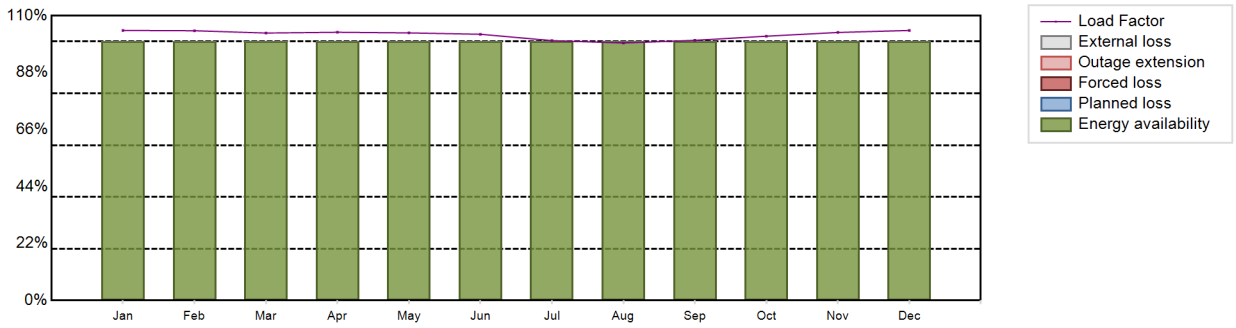
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	314
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.352
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7709.21 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	102.65 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



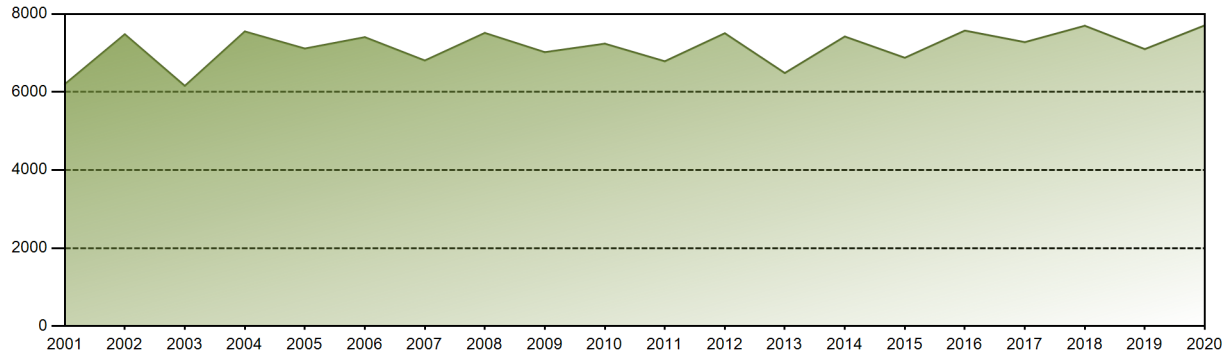
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	663.58	620.10	657.14	637.84	657.45	633.00	638.53	632.73	618.63	649.41	637.30	663.50	7709.21
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	104.32	104.20	103.31	103.61	103.35	102.83	100.38	99.47	100.49	102.09	103.52	104.30	102.65
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	273903.27 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.75 %
Cumulative Energy Availability Factor (EAF)	:	85.02 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.41 %
Cumulative Unit Capability Factor (UCF)	:	85.09 %	Cumulative Planned Unavailability Factor (PUF)	:	12.5 %
Cumulative Load Factor (LF)	:	85.16 %	Cumulative Externally cause unavailability (XUF)	:	0.07 %
Cumulative Operating Factor (OF)	:	84.88 %			

Electricity Production (net) [GWh]

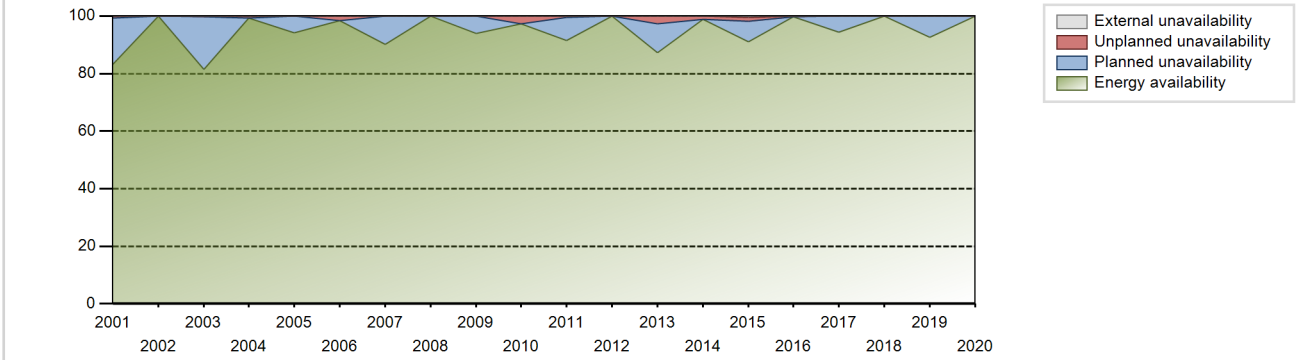


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	6009.80	7608	810	100.00	100.00	84.95	86.00	0.00	0.00	0.00	0.00
1978	5226.60	7129	810	72.85	72.85	73.66	81.38	15.43	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

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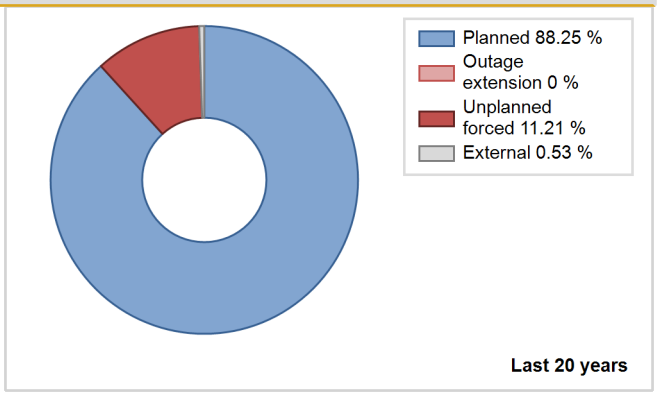
2014	7422.54	8662	850	98.88	98.88	99.68	98.88	1.12	1.12	0.00	0.00
2015	6877.67	7969	850	90.98	91.55	92.37	90.97	1.46	1.36	7.10	0.57
2016	7574.55	8753	850	99.64	99.64	101.45	99.65	0.36	0.36	0.00	0.00
2017	7278.30	8257	855	94.28	94.28	97.36	94.26	0.00	0.00	5.72	0.00
2018	7698.56	8760	855	100.00	100.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1977 to 2020 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				1013		
D. Inspection, maintenance or repair without refuelling				63		
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					13	
Z. Other					0	
Subtotal				1083	213	1
Total	**0**			**1297**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		14
13. Reactor Auxiliary Systems		20
14. Safety Systems		1
15. Reactor Cooling Systems		61
16. Steam generation systems		8
31. Turbine and auxiliaries		21
32. Feedwater and Main Steam System		32
34. Miscellaneous Systems		0
35. All other I&C Systems		2
41. Main Generator Systems		12
42. Electrical Power Supply Systems		27
Total		**200**

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2020 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	:	35 years

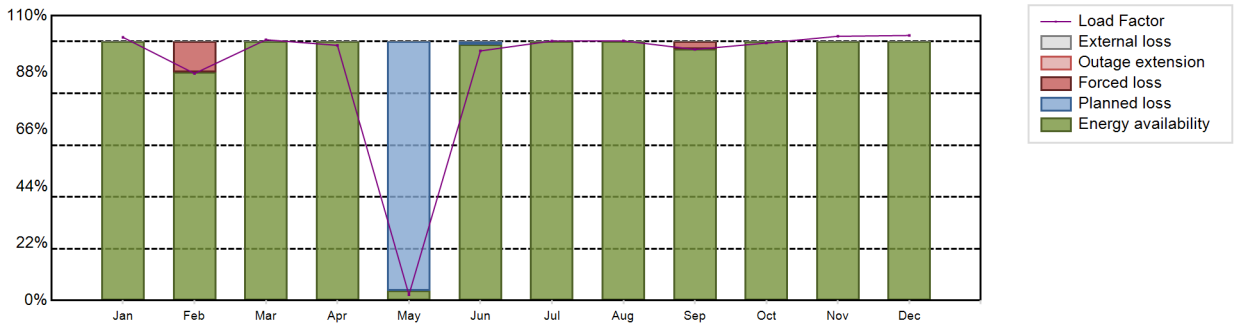
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
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]	:	0.204
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	39	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	40200	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.37	HP cylinder inlet steam pressure [MPa]	:	6.83
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]	:	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 (2020)

Net Energy Production	:	9235.52 GW(e).h	Forced Loss Rate (FLR)	:	1.28 %
Energy Availability Factor (EAF)	:	90.58 %	Unplanned Capability Loss Factor (UCL)	:	1.17 %
Unit Capability Factor (UCF)	:	90.58 %	Planned Unavailability Factor (PUF)	:	8.25 %
Load Factor (LF)	:	90.64 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	90.56 %	Total off-line time	:	829 hours

Annual Summary



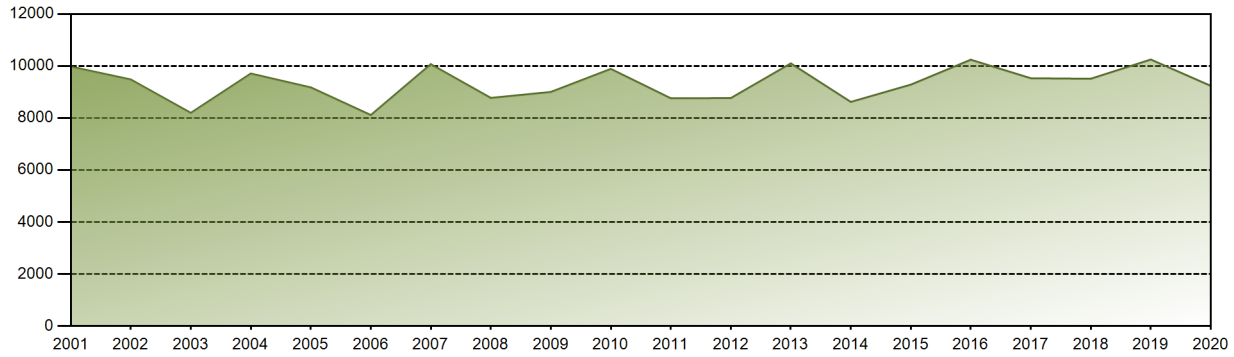
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	877.23	707.87	869.11	822.95	19.18	805.10	864.93	865.41	809.83	858.14	852.31	883.46	9235.52
EAF [%]	100.00	88.20	100.00	100.00	3.76	98.81	100.00	100.00	97.14	100.00	100.00	100.00	90.58
UCF [%]	100.00	88.20	100.00	100.00	3.76	98.81	100.00	100.00	97.14	100.00	100.00	100.00	90.58
LF [%]	101.64	87.68	100.70	98.53	2.22	96.40	100.22	100.27	96.96	99.43	102.05	102.37	90.64
OF [%]	100.00	88.22	99.87	100.00	3.76	98.75	100.00	100.00	97.08	100.00	100.00	100.00	90.56
FLR [%]	0.00	11.80	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00	1.28
UCL [%]	0.00	11.80	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.00	0.00	0.00	1.17
PUF [%]	0.00	0.00	0.00	0.00	96.24	1.19	0.00	0.00	0.00	0.00	0.00	0.00	8.25
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

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Historical Summary

Lifetime energy generation	:	402409.12 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.19 %
Cumulative Energy Availability Factor (EAF)	:	87.05 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.87 %
Cumulative Unit Capability Factor (UCF)	:	87.05 %	Cumulative Planned Unavailability Factor (PUF)	:	10.08 %
Cumulative Load Factor (LF)	:	86.63 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	86.96 %			

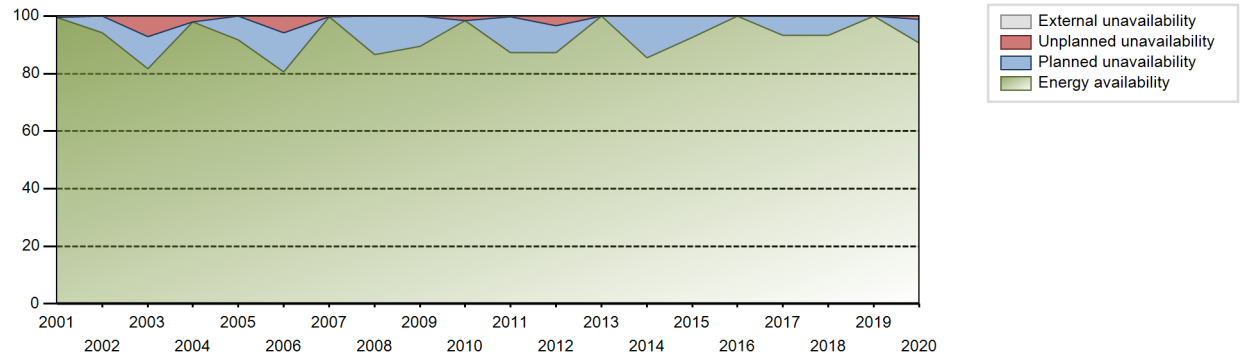
Electricity Production (net) [GWh]



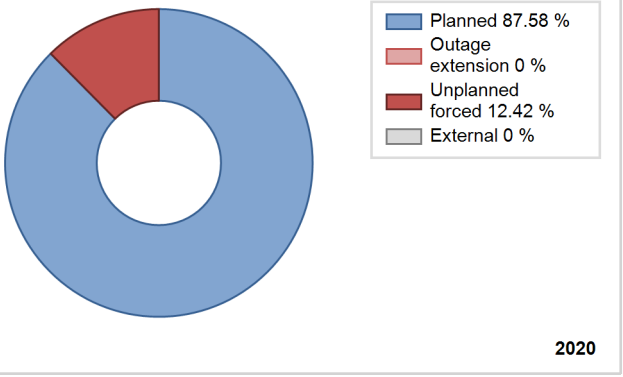
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	3440.51	3513	1138	78.55	78.55	66.98	78.45	21.45	21.45	0.00	0.00
1986	5199.12	5151	1145	58.88	58.88	51.83	58.80	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

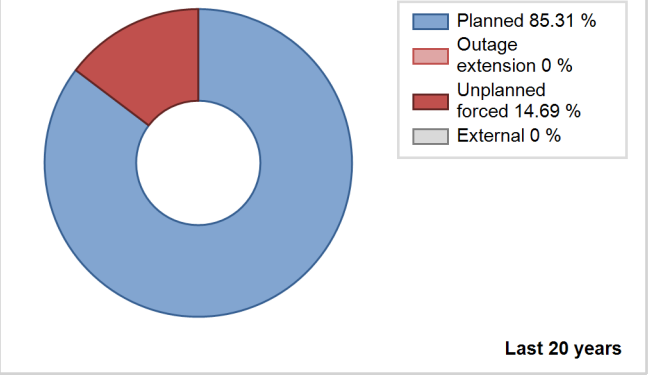
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					231	
B. Refuelling without maintenance	725			20		
C. Inspection, maintenance or repair combined with refuelling				819		
D. Inspection, maintenance or repair without refuelling				40		
E. Testing of plant systems or components				2	3	
H. Nuclear regulatory requirements					4	
L. Human factor related					5	
Z. Other		103		2	7	
Subtotal	725	103		883	250	
Total		**828**			**1133**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		4
12. Reactor I&C Systems		25
13. Reactor Auxiliary Systems		11
14. Safety Systems		16
15. Reactor Cooling Systems		86
16. Steam generation systems		2
31. Turbine and auxiliaries		10
32. Feedwater and Main Steam System		41
33. Circulating Water System		9
34. Miscellaneous Systems		7
41. Main Generator Systems		11
42. Electrical Power Supply Systems		22
Total		**244**

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Highlights (2020)

Auto scram following main generator trip due to loss of generator excitation voltage.

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2020 Operating Experience

US-414 CATAWBA-2 UNITED STATES OF AMERICA



Status at end of year	:	**Operational**
Operator	:	DUKEENER (Duke Energy Corp.)
Owner	:	NCMPA1 (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	:	34 years

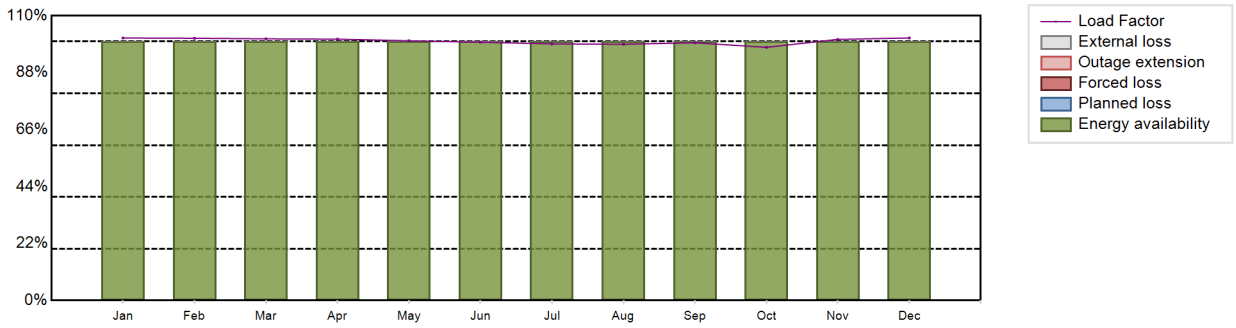
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	326
Fuel material	:	UO2	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	Single
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.204
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	46	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	40200	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.4	HP cylinder inlet steam pressure [MPa]	:	6.83
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]	:	18.3	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 (2020)

Net Energy Production	:	10121.15 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)	:	100.19 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



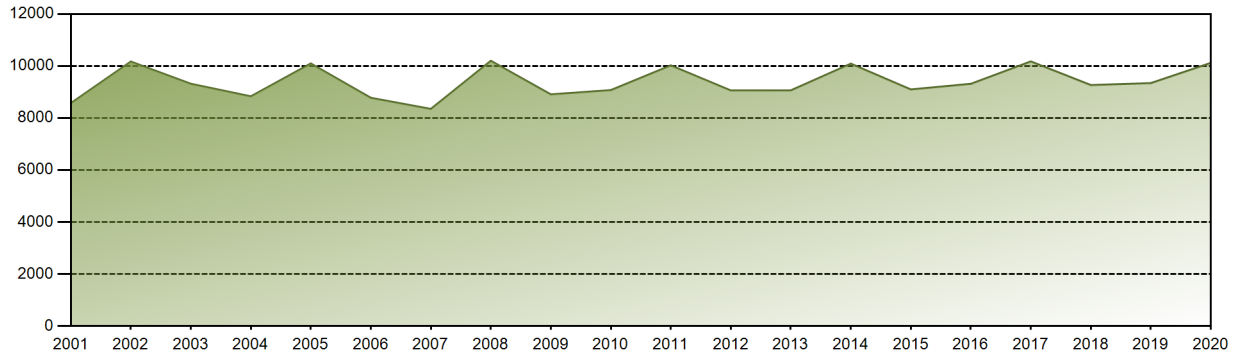
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	867.50	810.65	864.76	835.93	858.14	826.04	847.99	846.84	824.27	836.54	834.99	867.50	10121.15
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	101.39	101.28	101.07	100.96	100.30	99.76	99.11	98.98	99.55	97.77	100.84	101.39	100.19
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	302633.83 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.68 %
Cumulative Energy Availability Factor (EAF)	:	88.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.36 %
Cumulative Unit Capability Factor (UCF)	:	88.11 %	Cumulative Planned Unavailability Factor (PUF)	:	8.53 %
Cumulative Load Factor (LF)	:	87.63 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	87.8 %			

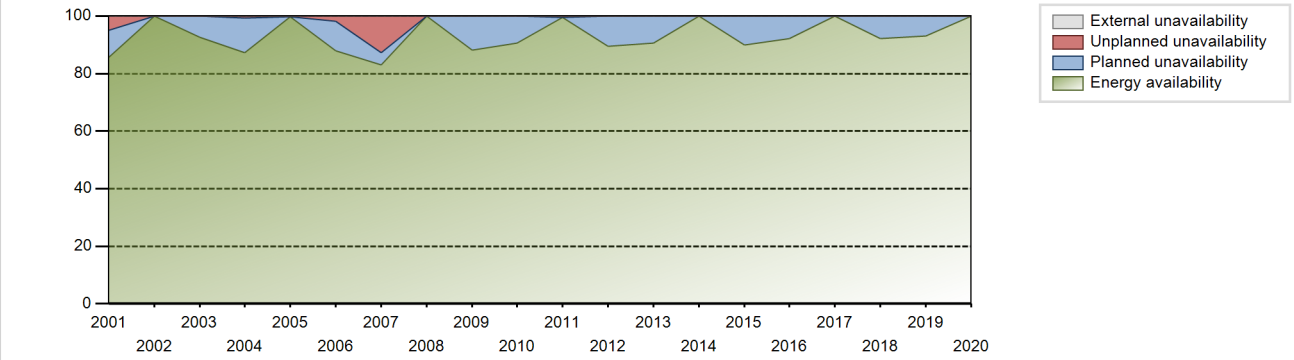
Electricity Production (net) [GWh]



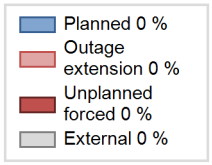
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	1324.22	1325	1135	35.55	35.55	29.10	34.59	64.45	64.45	0.00	0.00
1987	7169.49	7014	1145	80.16	80.16	71.48	80.07	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

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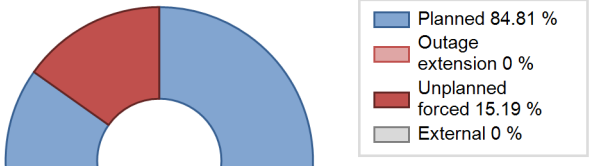
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					279	
C. Inspection, maintenance or repair combined with refuelling				695		
D. Inspection, maintenance or repair without refuelling				52		
E. Testing of plant systems or components				3	3	
H. Nuclear regulatory requirements					4	
L. Human factor related					1	
Z. Other				0	6	
Subtotal				750	293	
Total		**0**			**1043**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems		24
14. Safety Systems		6
15. Reactor Cooling Systems		24
16. Steam generation systems		3
17. Safety I&C Systems (excluding reactor I&C)		10
31. Turbine and auxiliaries		43
32. Feedwater and Main Steam System		65
33. Circulating Water System		0
34. Miscellaneous Systems		1
41. Main Generator Systems		84
42. Electrical Power Supply Systems		26
Total		**290**

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2020 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	:	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]	:	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

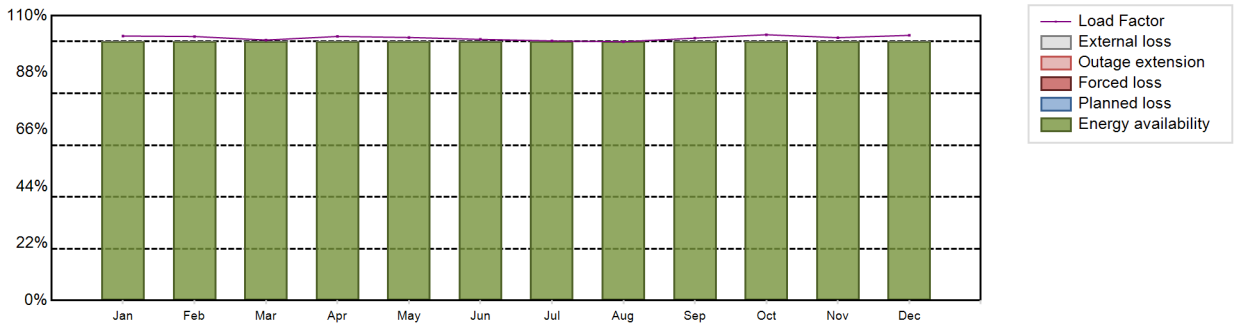
Operating coolant pressure [MPa]	:	7.3
Reactor outlet temperature [°C]	:	288.3
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.10
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
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 (2020)

Net Energy Production	:	9462.48 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	101.44 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



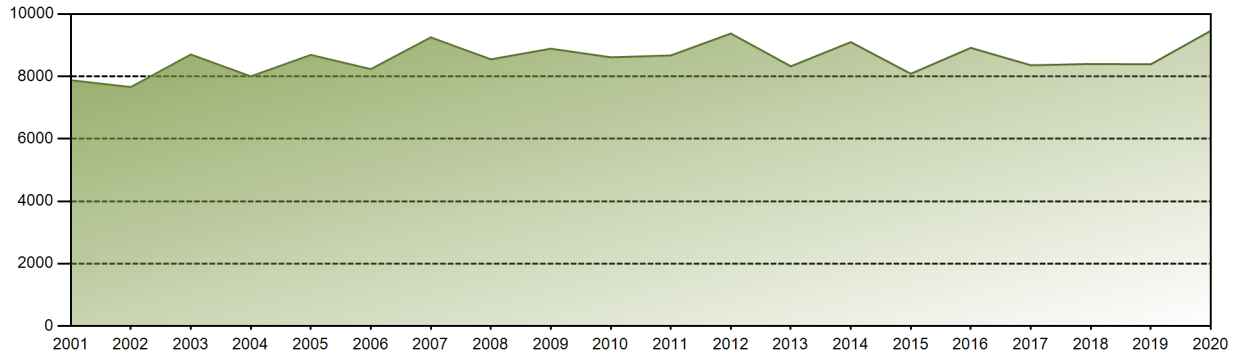
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	807.11	753.65	794.89	779.73	802.66	771.26	792.20	789.70	774.85	811.03	776.26	809.14	9462.48
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	102.15	101.96	100.60	101.97	101.59	100.87	100.26	99.95	101.34	102.65	101.52	102.41	101.44
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	229792.08 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.95 %
Cumulative Energy Availability Factor (EAF)	:	82.17 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.38 %
Cumulative Unit Capability Factor (UCF)	:	82.21 %	Cumulative Planned Unavailability Factor (PUF)	:	14.4 %
Cumulative Load Factor (LF)	:	80 %	Cumulative Externally cause unavailability (XUF)	:	0.05 %
Cumulative Operating Factor (OF)	:	81.21 %			

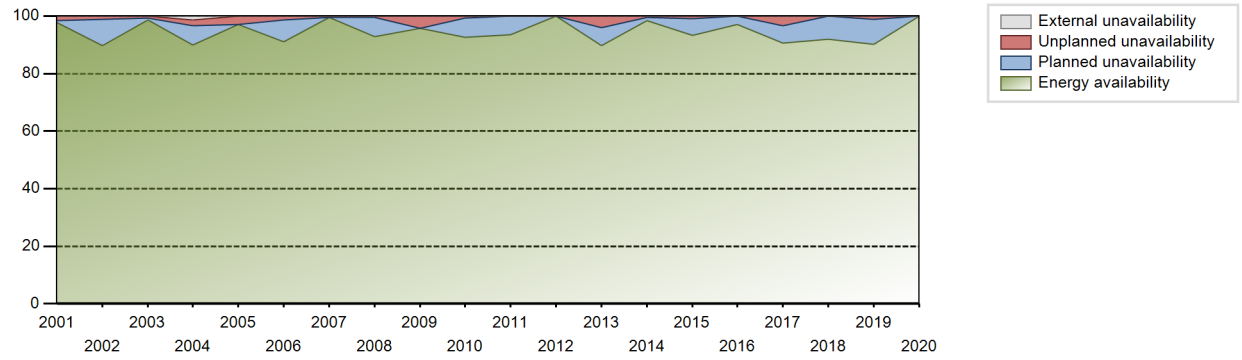
Electricity Production (net) [GWh]



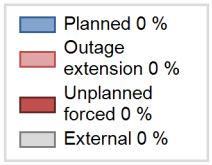
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	1628.83	3264	932	100.00	100.00	80.98	100.00	0.00	0.00	0.00	0.00
1988	5860.74	7244	930	82.50	82.50	71.73	82.46	6.52	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

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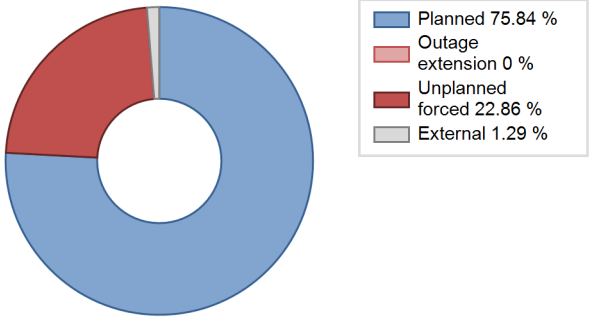
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					255	
C. Inspection, maintenance or repair combined with refuelling				1202		
D. Inspection, maintenance or repair without refuelling				130		
E. Testing of plant systems or components				2		
H. Nuclear regulatory requirements					6	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L. Human factor related					12	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						4
Z. Other					36	
Subtotal				1334	309	4
Total		**0**			**1647**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		18
14. Safety Systems		8
15. Reactor Cooling Systems		61
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		33
32. Feedwater and Main Steam System		94
34. Miscellaneous Systems		3
41. Main Generator Systems		13
42. Electrical Power Supply Systems		30
Total		**261**

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2020 Operating Experience

US-397 COLUMBIA — UNITED STATES OF AMERICA



Status at end of year	:	**Operational**
Operator	:	ENERGYNW (Energy Northwest)
Owner	:	ENERGYNW (Energy Northwest)
Reactor Supplier	:	GE (GENERAL ELECTRIC CO.)
Turbine Supplier	:	WH (WESTINGHOUSE ELECTRIC CORPORATION)

Reactor Unit Details

Reactor type and model	:	BWR / BWR-5 (Mark 2)
Thermal power	:	3486 MWth
Gross electrical power	:	1190 MWe
Reference unit power (net)	:	1131 MWe

Key Dates

Construction Date	:	1972-08-01
Grid Date	:	1984-05-27
Commercial Date	:	1984-12-13
Age at end of year	:	36 years

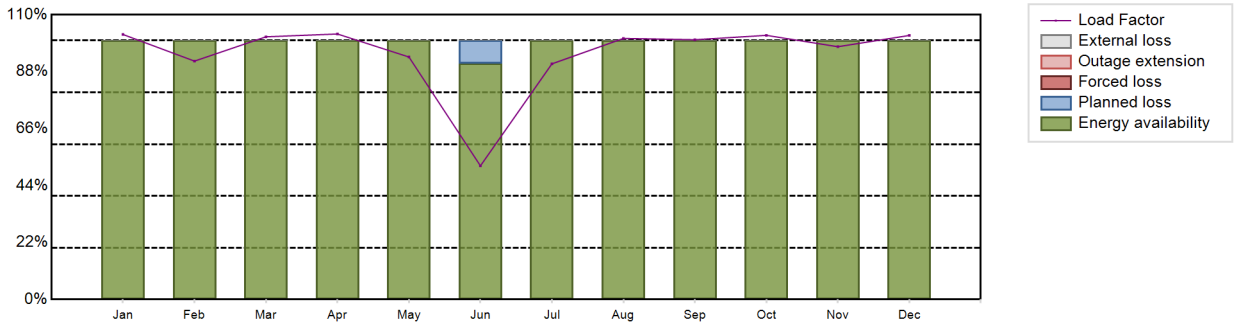
Design Characteristics

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 [%]	:	20
Average discharge burnup [MWd/t]	:	42000
Active core diameter [m]	:	4.75
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	43
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.17
Reactor outlet temperature [°C]	:	287
Number of SG	:	NA
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]	:	6.82
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 (2020)

Net Energy Production	:	9427.05 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	99.28 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	99.28 %	Planned Unavailability Factor (PUF)	:	0.72 %
Load Factor (LF)	:	94.89 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.27 %	Total off-line time	:	64 hours

Annual Summary



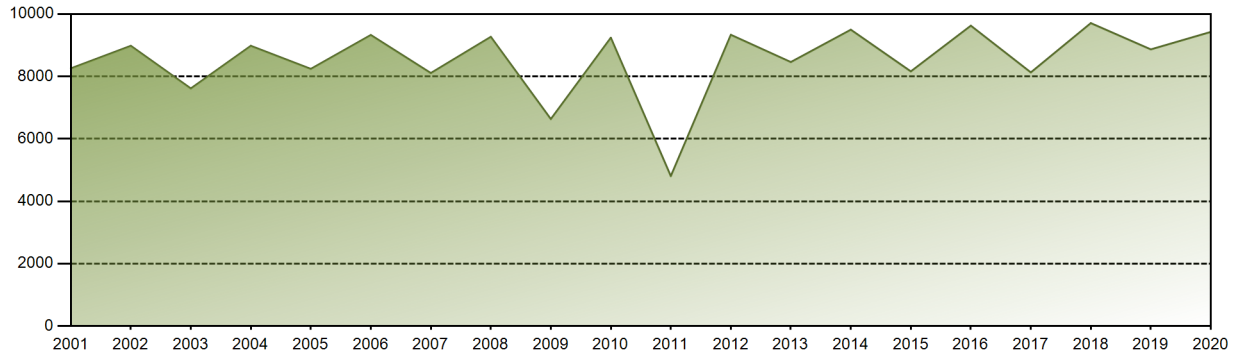
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	861.32	724.80	853.82	835.10	788.14	420.42	765.92	848.52	817.09	858.56	795.09	858.27	9427.05
EAF [%]	100.00	100.00	100.00	100.00	100.00	91.24	100.00	100.00	100.00	100.00	100.00	100.00	99.28
UCF [%]	100.00	100.00	100.00	100.00	100.00	91.24	100.00	100.00	100.00	100.00	100.00	100.00	99.28
LF [%]	102.36	92.08	101.47	102.55	93.66	51.63	91.02	100.84	100.34	102.03	97.64	102.00	94.89
OF [%]	100.00	100.00	99.87	100.00	100.00	91.25	100.00	100.00	100.00	100.00	100.00	100.00	99.27
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	0.00	8.76	0.00	0.00	0.00	0.00	0.00	0.00	0.72
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

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Historical Summary

Lifetime energy generation	:	285920.22 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.09 %
Cumulative Energy Availability Factor (EAF)	:	81.51 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.4 %
Cumulative Unit Capability Factor (UCF)	:	82.07 %	Cumulative Planned Unavailability Factor (PUF)	:	13.53 %
Cumulative Load Factor (LF)	:	76.71 %	Cumulative Externally cause unavailability (XUF)	:	0.56 %
Cumulative Operating Factor (OF)	:	81.36 %			

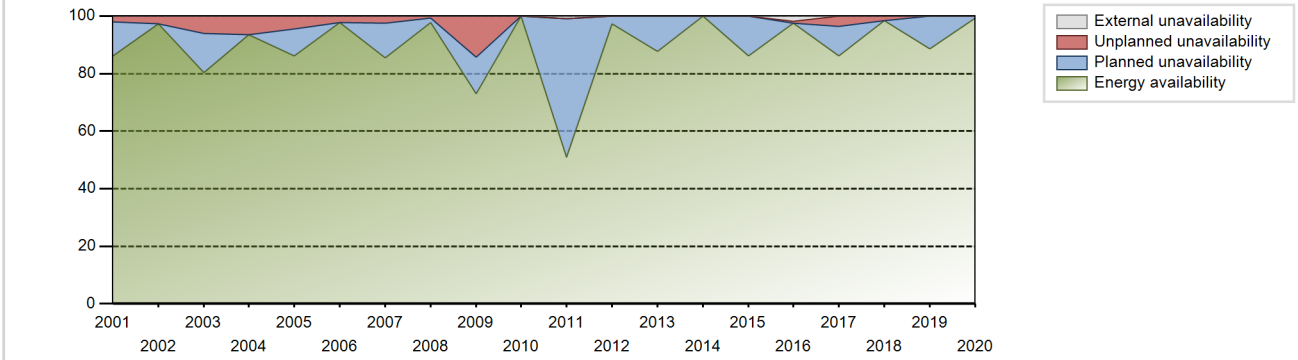
Electricity Production (net) [GWh]



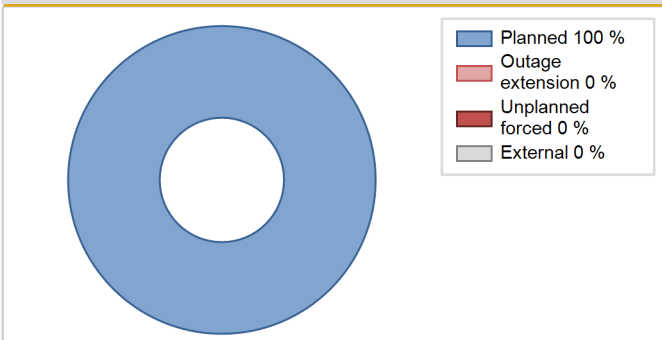
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	1458.42	2393	1104	90.49	90.49	84.56	90.68	9.51	9.51	0.00	0.00
1985	5176.39	6624	1100	77.10	77.10	53.70	75.62	8.28	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

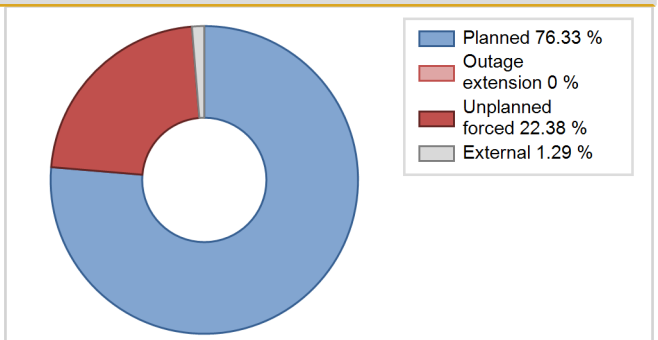
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					248	
C. Inspection, maintenance or repair combined with refuelling				1017		
D. Inspection, maintenance or repair without refuelling	22			94		
E. Testing of plant systems or components				17	1	
H. Nuclear regulatory requirements					99	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						42
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
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				52		2
Z. Other	63			2	21	
Subtotal	85			1182	385	48
Total	**85**			**1615**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		11
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		2
14. Safety Systems		27
15. Reactor Cooling Systems		29
17. Safety I&C Systems (excluding reactor I&C)		20
31. Turbine and auxiliaries		78
32. Feedwater and Main Steam System		29
33. Circulating Water System		0
35. All other I&C Systems		4
41. Main Generator Systems		2
42. Electrical Power Supply Systems		63
Total		**273**

Highlights (2020)

Dispatched by grid operator to go offline

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2020 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	:	30 years

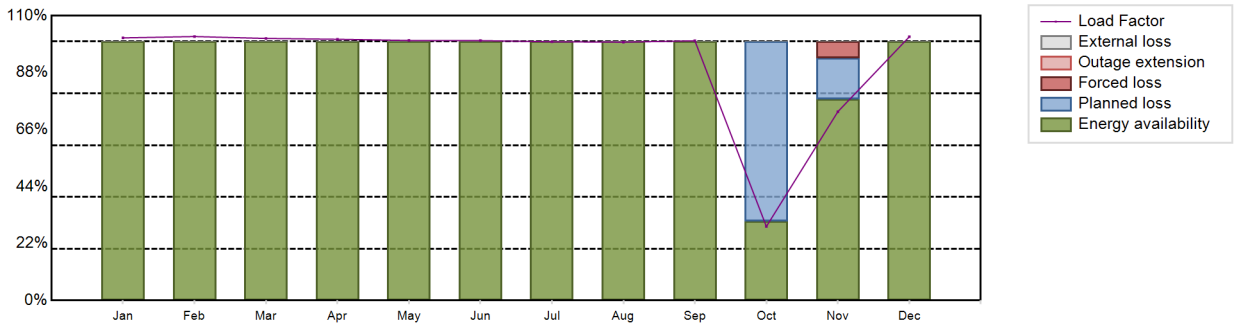
Design Characteristics

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	:	-
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.103
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]	:	40000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.37	HP cylinder inlet steam pressure [MPa]	:	6.75
Active core height/length [m]	:	3.66	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	Lake (once-through)
Fuel linear heat generation rate [kW/m]	:	17.81	Number of main condensate pumps	:	-
Number of control rod assemblies	:	-	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 (2020)

Net Energy Production	:	9781.85 GW(e).h	Forced Loss Rate (FLR)	:	0.55 %
Energy Availability Factor (EAF)	:	92.31 %	Unplanned Capability Loss Factor (UCL)	:	0.51 %
Unit Capability Factor (UCF)	:	92.31 %	Planned Unavailability Factor (PUF)	:	7.18 %
Load Factor (LF)	:	92.41 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	92.57 %	Total off-line time	:	653 hours

Annual Summary



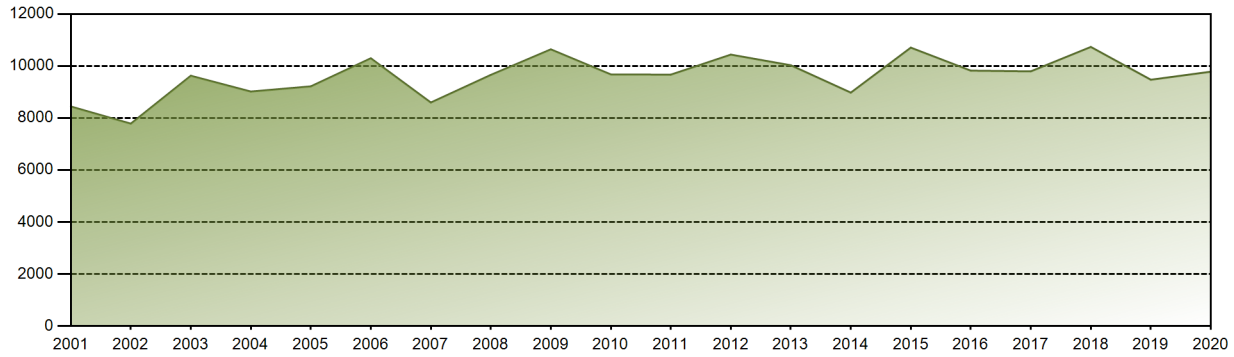
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	909.46	854.96	907.38	875.52	900.30	870.87	895.91	894.62	870.40	256.33	632.80	913.30	9781.85
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	30.65	77.81	100.00	92.31
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	30.65	77.81	100.00	92.31
LF [%]	101.44	101.94	101.21	100.91	100.42	100.38	99.93	99.79	100.32	28.59	72.94	101.87	92.41
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	30.65	81.11	100.00	92.57
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.45	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	6.26	0.00	0.51
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.35	15.93	0.00	7.18
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

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Historical Summary

Lifetime energy generation	:	281135.26 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.52 %
Cumulative Energy Availability Factor (EAF)	:	90.62 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.4 %
Cumulative Unit Capability Factor (UCF)	:	90.63 %	Cumulative Planned Unavailability Factor (PUF)	:	7.98 %
Cumulative Load Factor (LF)	:	88.14 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	90.5 %			

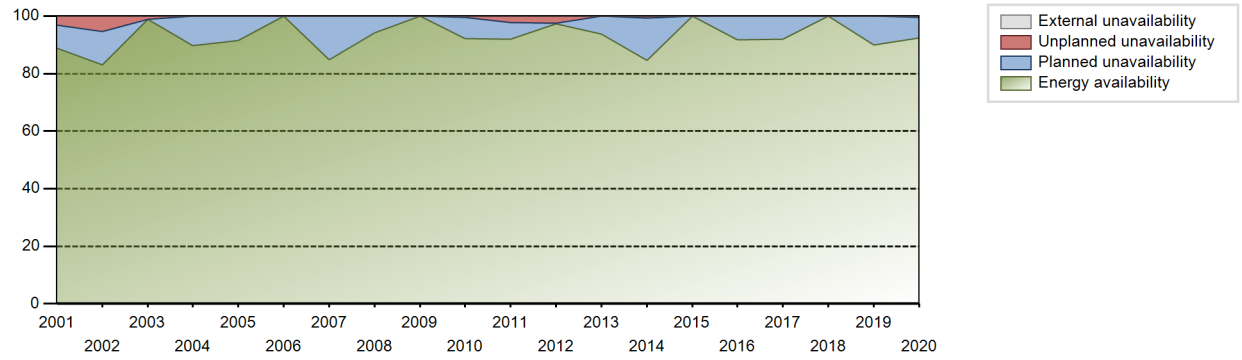
Electricity Production (net) [GWh]



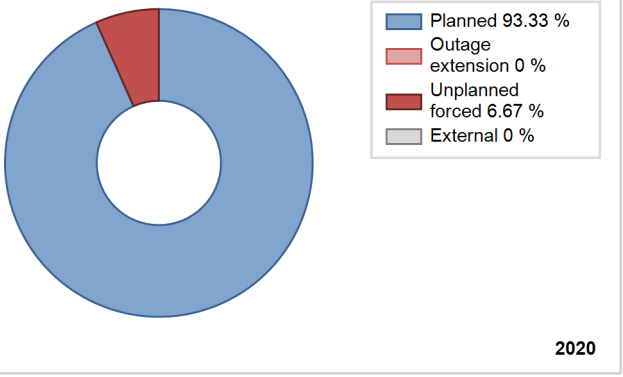
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	3335.18	4399	1140	80.61	80.61	60.19	78.00	8.53	7.52	11.87	0.00
1991	5360.52	5341	1150	60.51	60.51	53.21	60.97	12.05	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

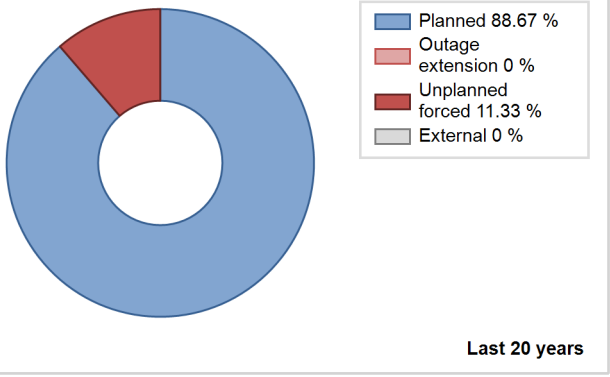
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1990 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					113	
B. Refuelling without maintenance	631			21		
C. Inspection, maintenance or repair combined with refuelling				629		
D. Inspection, maintenance or repair without refuelling				78		
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
Z. Other		45			1	
Subtotal	631	45		728	125	5
Total		**676**			**858**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1990 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		0
15. Reactor Cooling Systems		12
16. Steam generation systems		7
31. Turbine and auxiliaries		26
32. Feedwater and Main Steam System		23
35. All other I&C Systems		6
41. Main Generator Systems		12
42. Electrical Power Supply Systems		17
Total		**116**

Highlights (2020)

Refueling Outage 21 (1RF21).

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2020 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	:	27 years

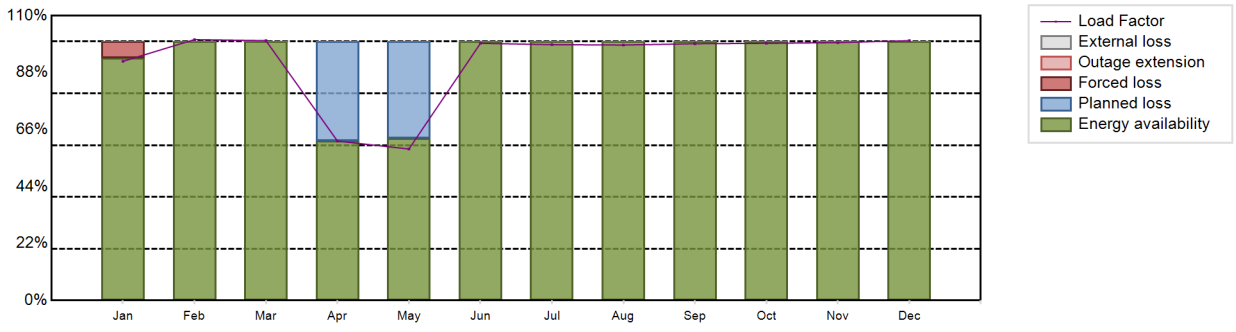
Design Characteristics

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	:	-
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.103
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]	:	36000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.37	HP cylinder inlet steam pressure [MPa]	:	6.75
Active core height/length [m]	:	3.66	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	Lake (once-through)
Fuel linear heat generation rate [kW/m]	:	17.81	Number of main condensate pumps	:	-
Number of control rod assemblies	:	-	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 (2020)

Net Energy Production	:	9698.1 GW(e).h	Forced Loss Rate (FLR)	:	0.58 %
Energy Availability Factor (EAF)	:	93.15 %	Unplanned Capability Loss Factor (UCL)	:	0.54 %
Unit Capability Factor (UCF)	:	93.15 %	Planned Unavailability Factor (PUF)	:	6.31 %
Load Factor (LF)	:	92.39 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	93.15 %	Total off-line time	:	602 hours

Annual Summary



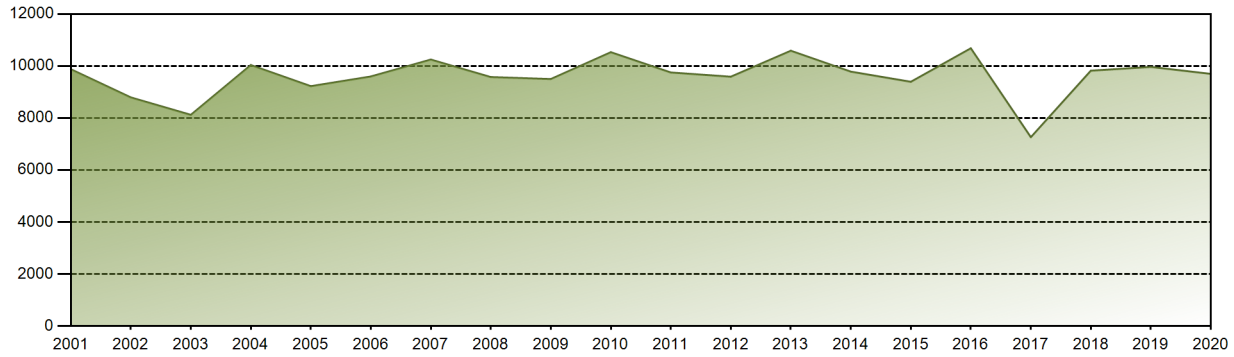
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	821.28	838.15	892.29	529.83	520.29	854.63	878.51	877.35	853.29	883.16	856.99	892.33	9698.10
EAF [%]	93.63	100.00	100.00	61.67	62.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.15
UCF [%]	93.63	100.00	100.00	61.67	62.65	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.15
LF [%]	92.37	100.77	100.36	61.58	58.52	99.33	98.81	98.68	99.17	99.33	99.60	100.37	92.39
OF [%]	93.68	100.00	99.87	61.67	62.63	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.15
FLR [%]	6.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58
UCL [%]	6.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54
PUF [%]	0.00	0.00	0.00	38.33	37.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.31
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

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Historical Summary

Lifetime energy generation	:	237824.8 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.37 %
Cumulative Energy Availability Factor (EAF)	:	91.37 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.22 %
Cumulative Unit Capability Factor (UCF)	:	91.4 %	Cumulative Planned Unavailability Factor (PUF)	:	6.38 %
Cumulative Load Factor (LF)	:	89.9 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	91.34 %			

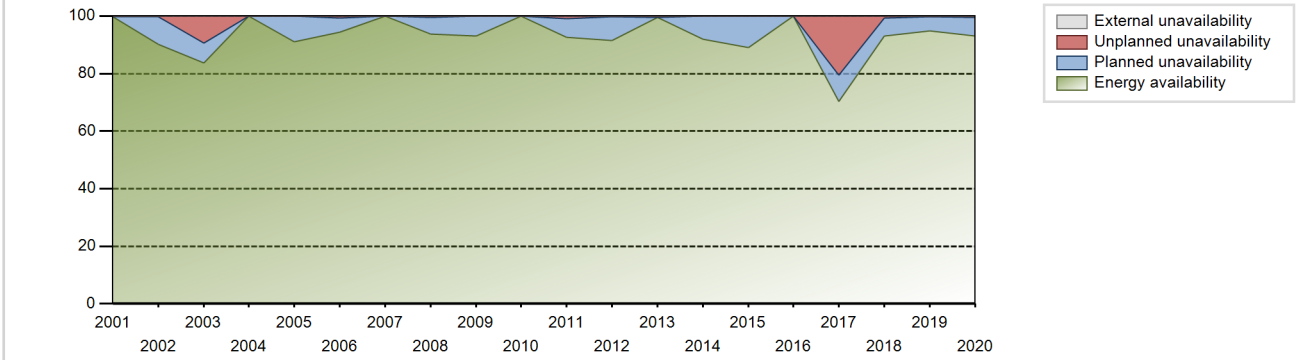
Electricity Production (net) [GWh]



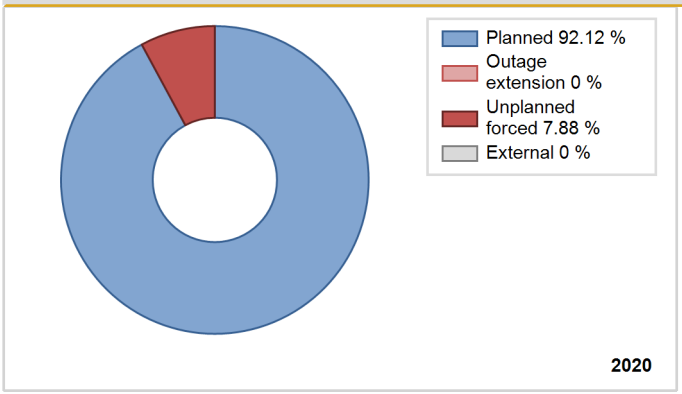
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1993	4131.71	4600	1150	89.74	89.74	82.77	89.74	10.26	10.26	0.00	0.00
1994	5263.15	5697	1150	65.07	65.07	52.24	65.03	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

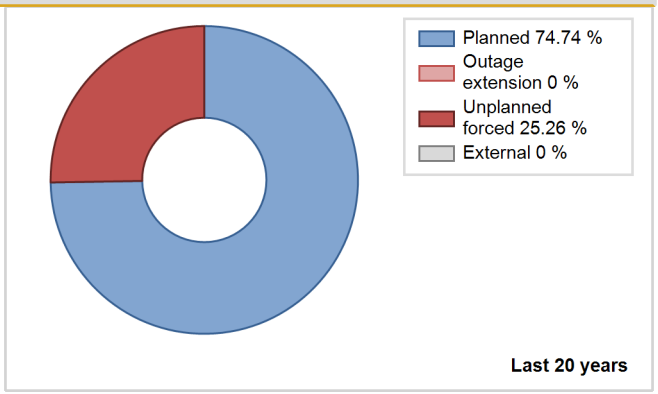
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1993 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					182	
B. Refuelling without maintenance	554			20		
C. Inspection, maintenance or repair combined with refuelling				498		
D. Inspection, maintenance or repair without refuelling				50		
E. Testing of plant systems or components				38		
L. Human factor related					1	
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)				8		
Z. Other		47			3	
Subtotal	554	47		614	186	16
Total		**601**			**816**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1993 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		5
13. Reactor Auxiliary Systems		1
14. Safety Systems		25
15. Reactor Cooling Systems		33
16. Steam generation systems		6
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		11
32. Feedwater and Main Steam System		32
34. Miscellaneous Systems		2
41. Main Generator Systems		63
42. Electrical Power Supply Systems		15
Total		**194**

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Highlights (2020)

Operators manually tripped the unit due to loss of both main feed water pumps.

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2020 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	:	45 years

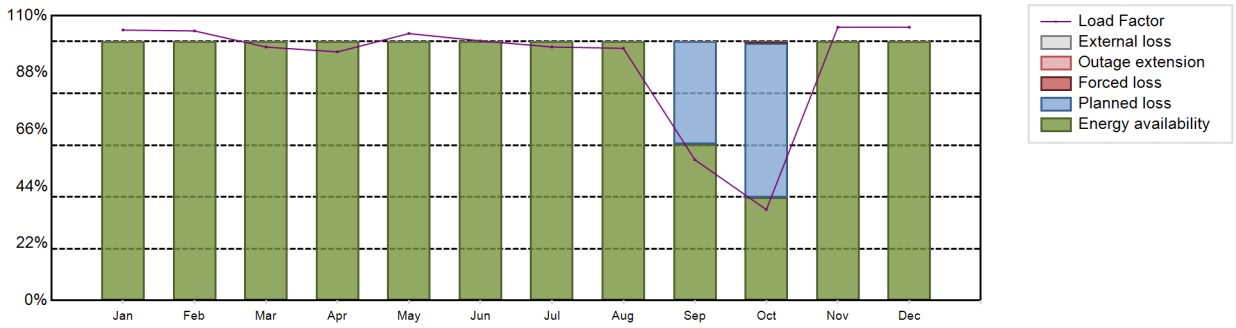
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	14.76
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	306
Fuel material	:	UO2	Number of SG	:	4
Refuelling type	:	OFF-line	Containment type	:	-
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.19
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]	:	38000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.37	HP cylinder inlet steam pressure [MPa]	:	5.12
Active core height/length [m]	:	3.66	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	193	Primary means of condenser cooling	:	Lake (once-through)
Fuel linear heat generation rate [kW/m]	:	21.98	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	:	4	Number of on-site safety related diesel generators	:	-
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	8303.66 GW(e).h	Forced Loss Rate (FLR)	:	0.06 %
Energy Availability Factor (EAF)	:	91.65 %	Unplanned Capability Loss Factor (UCL)	:	0.06 %
Unit Capability Factor (UCF)	:	91.65 %	Planned Unavailability Factor (PUF)	:	8.29 %
Load Factor (LF)	:	91.78 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	91.64 %	Total off-line time	:	734 hours

Annual Summary



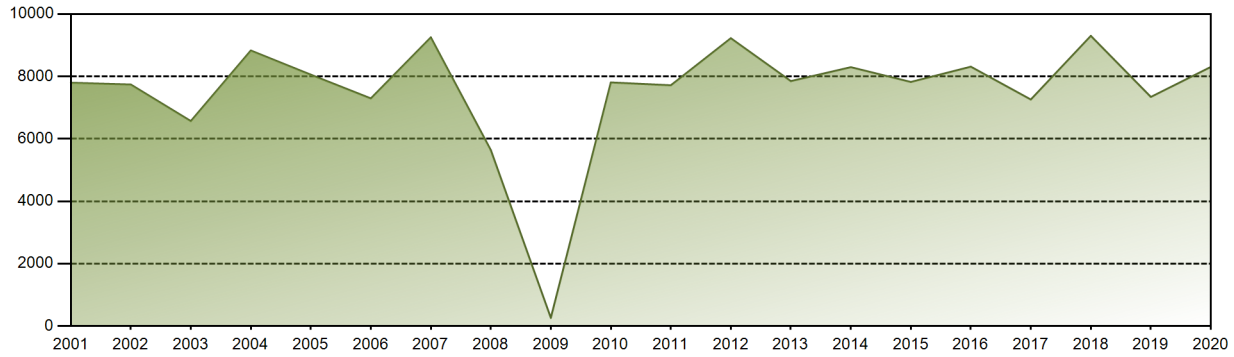
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	800.53	746.40	750.15	712.05	790.04	743.74	750.37	746.38	403.18	268.95	782.90	808.98	8303.66
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	60.41	39.77	100.00	100.00	91.65
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	60.41	39.77	100.00	100.00	91.65
LF [%]	104.46	104.12	97.89	96.02	103.10	100.29	97.92	97.40	54.37	35.10	105.57	105.57	91.78
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	60.42	39.78	100.00	100.00	91.64
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.74	0.00	0.00	0.06
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.06
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.59	59.53	0.00	0.00	8.29
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

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Historical Summary

Lifetime energy generation	:	316292.4 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	15.17 %
Cumulative Energy Availability Factor (EAF)	:	72.88 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.06 %
Cumulative Unit Capability Factor (UCF)	:	73.01 %	Cumulative Planned Unavailability Factor (PUF)	:	13.93 %
Cumulative Load Factor (LF)	:	70.66 %	Cumulative Externally cause unavailability (XUF)	:	0.13 %
Cumulative Operating Factor (OF)	:	73.41 %			

Electricity Production (net) [GWh]

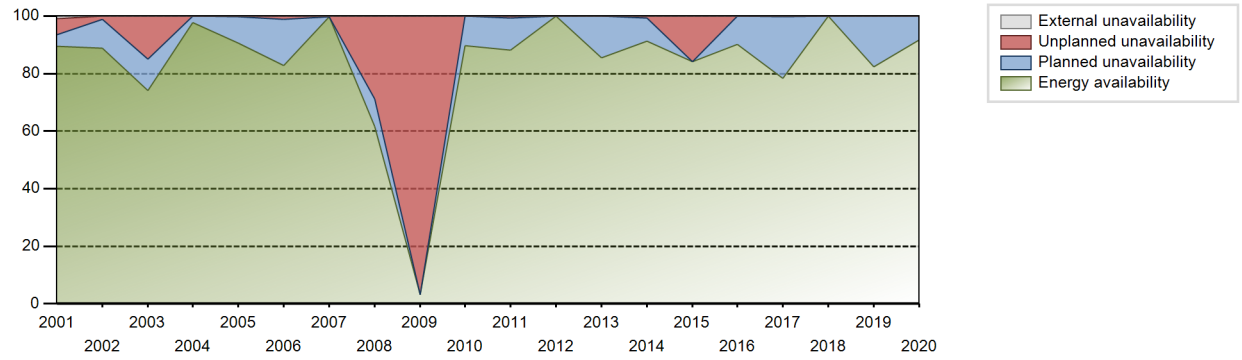


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	4450.80	5955	848	80.79	80.79	80.81	82.48	5.03	4.28	14.94	0.00
1976	6804.90	7298	983	79.21	79.21	78.81	83.08	3.86	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

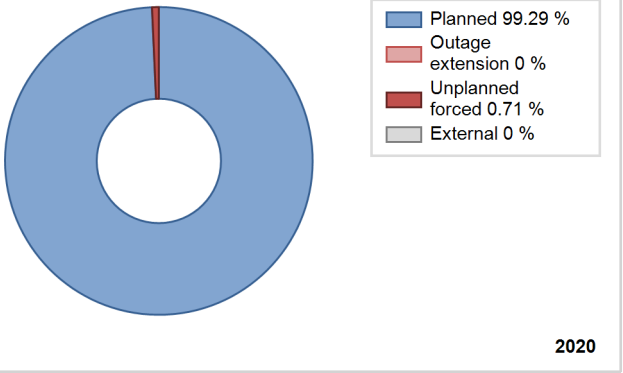
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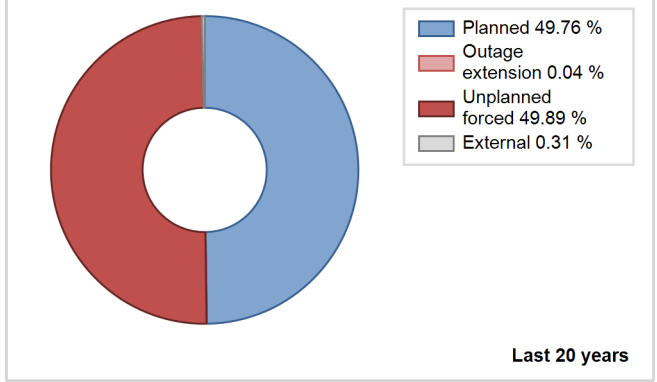
2012	9224.63	8784	1045	100.00	100.00	100.49	100.00	0.00	0.00	0.00	0.00
2013	7850.11	7470	1045	85.49	85.49	85.74	85.26	0.00	0.00	14.51	0.00
2014	8296.79	7974	1045	91.16	91.16	90.63	91.03	0.71	0.65	8.19	0.00
2015	7822.53	7352	1045	84.15	84.15	85.45	83.93	15.85	15.85	0.00	0.00
2016	8311.75	7914	1045	90.09	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					419	
B. Refuelling without maintenance	1013			22		
C. Inspection, maintenance or repair combined with refuelling				1059		
D. Inspection, maintenance or repair without refuelling				102		
E. Testing of plant systems or components				7	5	
F. Major backfitting, refurbishment or upgrading activities with refuelling				2		
H. Nuclear regulatory requirements					686	
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					11	
Z. Other		5			1	2
Subtotal	1013	5		1192	1131	6
Total	**1018**			**2329**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		15
14. Safety Systems		7
15. Reactor Cooling Systems		28
16. Steam generation systems		6
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		289
32. Feedwater and Main Steam System		15
33. Circulating Water System		30
34. Miscellaneous Systems		629
35. All other I&C Systems		0
41. Main Generator Systems		22
42. Electrical Power Supply Systems		54
Total		**1098**

Highlights (2020)

Turb/Gen trip only following generator parallel (AR 2020-8808)

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2020 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	:	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]	:	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

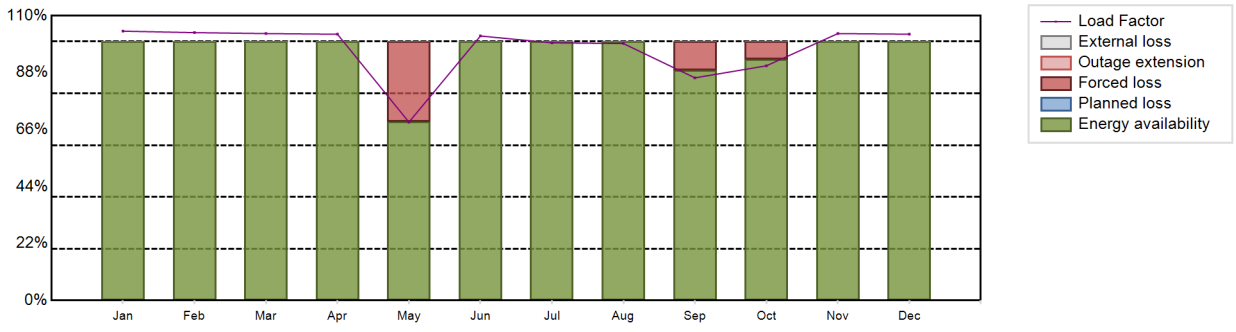
Operating coolant pressure [MPa]	:	15.82
Reactor outlet temperature [°C]	:	319
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.19
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	9962.98 GW(e).h
Energy Availability Factor (EAF)	:	95.89 %
Unit Capability Factor (UCF)	:	95.89 %
Load Factor (LF)	:	97.11 %
Operating Factor (OF)	:	95.89 %

Forced Loss Rate (FLR)	:	4.11 %
Unplanned Capability Loss Factor (UCL)	:	4.11 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	361 hours

Annual Summary



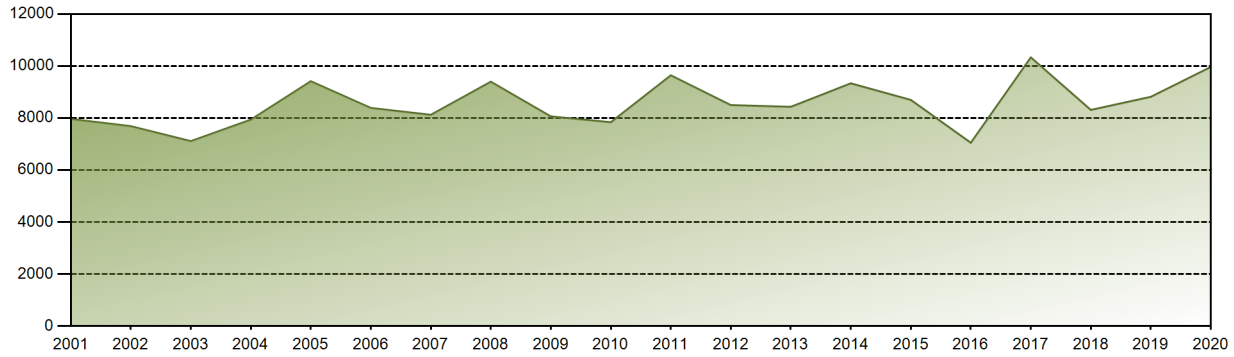
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	904.02	841.06	895.95	864.87	598.72	859.15	864.86	862.44	723.28	787.73	867.02	893.88	9962.98
EAF [%]	100.00	100.00	100.00	100.00	69.07	100.00	100.00	100.00	88.99	93.13	100.00	100.00	95.89
UCF [%]	100.00	100.00	100.00	100.00	69.07	100.00	100.00	100.00	88.99	93.13	100.00	100.00	95.89
LF [%]	104.03	103.46	103.10	102.84	68.90	102.16	99.52	99.25	86.01	90.65	103.10	102.86	97.11
OF [%]	100.00	100.00	99.87	100.00	69.09	100.00	100.00	100.00	89.03	93.15	100.00	100.00	95.89
FLR [%]	0.00	0.00	0.00	0.00	30.93	0.00	0.00	0.00	11.01	6.88	0.00	0.00	4.11
UCL [%]	0.00	0.00	0.00	0.00	30.93	0.00	0.00	0.00	11.01	6.88	0.00	0.00	4.11
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

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Historical Summary

Lifetime energy generation	:	295777.06 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.09 %
Cumulative Energy Availability Factor (EAF)	:	74.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	12.2 %
Cumulative Unit Capability Factor (UCF)	:	74.43 %	Cumulative Planned Unavailability Factor (PUF)	:	13.37 %
Cumulative Load Factor (LF)	:	72.04 %	Cumulative Externally cause unavailability (XUF)	:	0.14 %
Cumulative Operating Factor (OF)	:	74.23 %			

Electricity Production (net) [GWh]

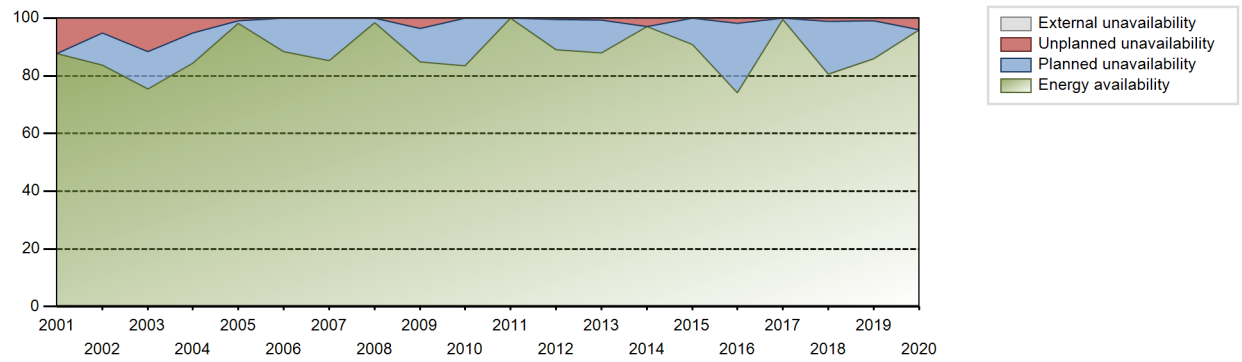


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1978	3814.00	4729	1078	65.36	65.36	65.34	77.22	21.39	17.78	16.86	0.00
1979	5953.50	5773	1082	62.81	62.81	62.81	65.90	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

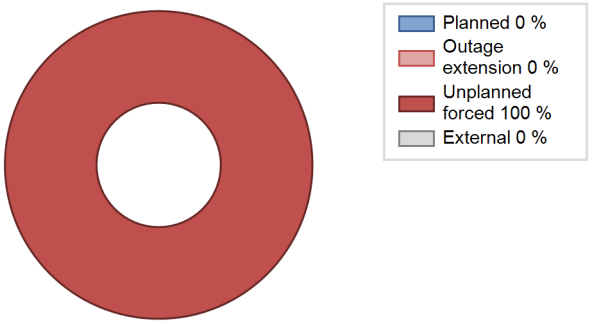
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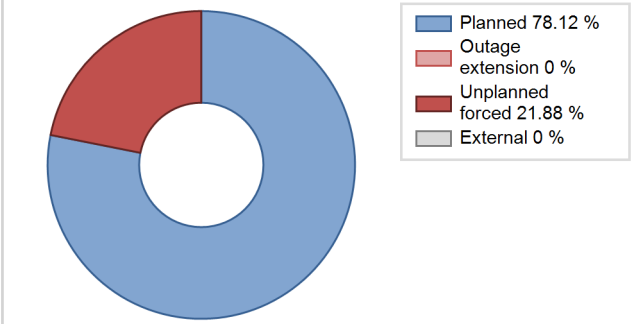
2015	8696.59	7942	1107	90.91	90.91	89.68	90.66	0.00	0.00	9.09	0.00
2016	7048.50	6510	1107	74.12	74.12	72.49	74.11	2.42	1.84	24.04	0.00
2017	10332.09	8717	1168	99.53	99.53	100.98	99.51	0.00	0.00	0.47	0.00
2018	8311.42	7056	1168	80.55	80.55	81.23	80.55	1.34	1.10	18.35	0.00
2019	8816.66	7525	1168	85.92	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1978 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					503	
C. Inspection, maintenance or repair combined with refuelling				1049		
D. Inspection, maintenance or repair without refuelling				91		
E. Testing of plant systems or components				0		
H. Nuclear regulatory requirements					546	
L. Human factor related					14	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
Z. Other		361			15	
Subtotal		361		1140	1078	1
Total		**361**			**2219**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1978 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		0
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		36
15. Reactor Cooling Systems		74
16. Steam generation systems		131
17. Safety I&C Systems (excluding reactor I&C)		7
31. Turbine and auxiliaries		115
32. Feedwater and Main Steam System		17
33. Circulating Water System		38
34. Miscellaneous Systems		525
35. All other I&C Systems		10
41. Main Generator Systems		33
42. Electrical Power Supply Systems		33
Total		**1032**

Highlights (2020)

Operational Procedure Error AR 2020-8488

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2020 Operating Experience

US-298 COOPER — UNITED STATES OF AMERICA

Status at end of year	:	**Operational**
Operator	:	ENTERGY (Entergy Nuclear Operations, Inc.)
Owner	:	NPPD (NEBRASKA PUBLIC POWER DISTRICT)
Reactor Supplier	:	GE (GENERAL ELECTRIC CO.)
Turbine Supplier	:	WH (WESTINGHOUSE ELECTRIC CORPORATION)



Reactor Unit Details

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	2419 MWth
Gross electrical power	:	801 MWe
Reference unit power (net)	:	769 MWe

Key Dates

Construction Date	:	1968-06-01
Grid Date	:	1974-05-10
Commercial Date	:	1974-07-01
Age at end of year	:	46 years

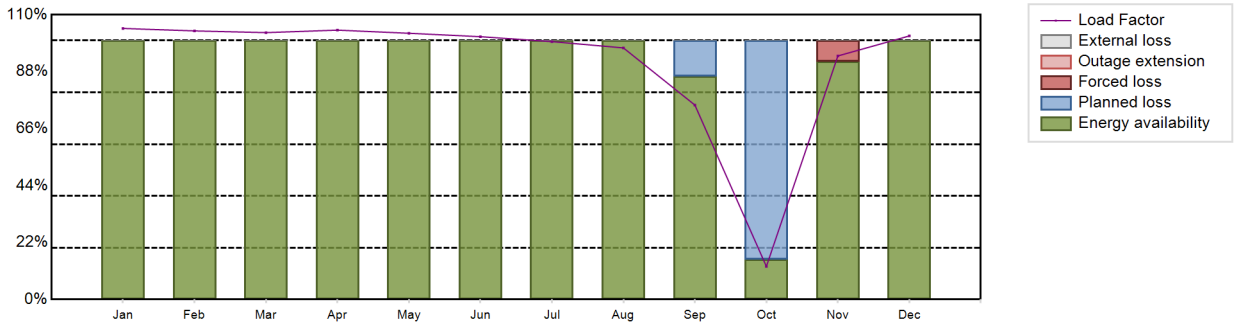
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.28
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]	:	0.31
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	25	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	17349	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	4.03	HP cylinder inlet steam pressure [MPa]	:	6.83
Active core height/length [m]	:	3.81	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	548	Primary means of condenser cooling	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	43.6	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 (2020)

Net Energy Production	:	6188.55 GW(e).h	Forced Loss Rate (FLR)	:	0.73 %
Energy Availability Factor (EAF)	:	91.04 %	Unplanned Capability Loss Factor (UCL)	:	0.67 %
Unit Capability Factor (UCF)	:	91.04 %	Planned Unavailability Factor (PUF)	:	8.29 %
Load Factor (LF)	:	91.62 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	91.04 %	Total off-line time	:	787 hours

Annual Summary



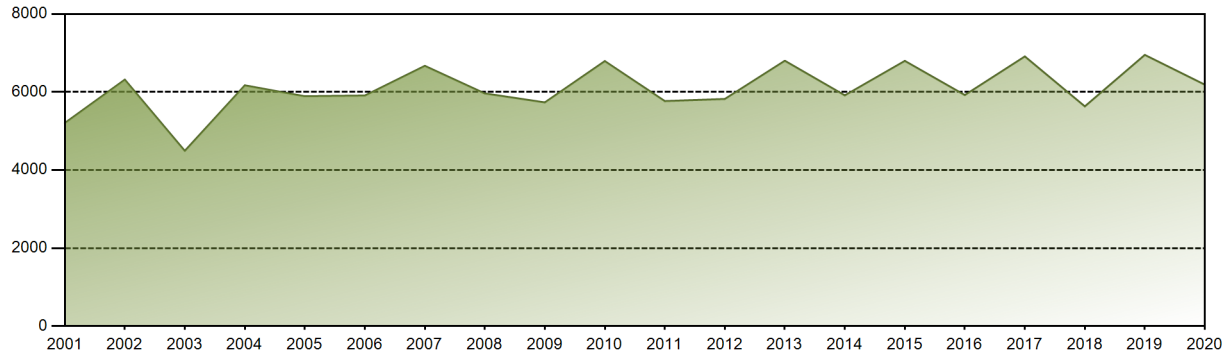
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	599.02	555.27	589.73	576.02	588.37	562.03	569.90	556.02	415.83	73.06	520.87	582.42	6188.55
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.11	15.54	91.80	100.00	91.04
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.11	15.54	91.80	100.00	91.04
LF [%]	104.70	103.74	103.08	104.04	102.84	101.51	99.61	97.18	75.10	12.77	94.07	101.80	91.62
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	86.11	15.59	91.94	100.00	91.04
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.20	0.00	0.73
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.20	0.00	0.67
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.89	84.46	0.00	0.00	8.29
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

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Historical Summary

Lifetime energy generation	:	223317.54 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.64 %
Cumulative Energy Availability Factor (EAF)	:	79.69 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.76 %
Cumulative Unit Capability Factor (UCF)	:	79.73 %	Cumulative Planned Unavailability Factor (PUF)	:	15.51 %
Cumulative Load Factor (LF)	:	76.46 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	81.76 %			

Electricity Production (net) [GWh]

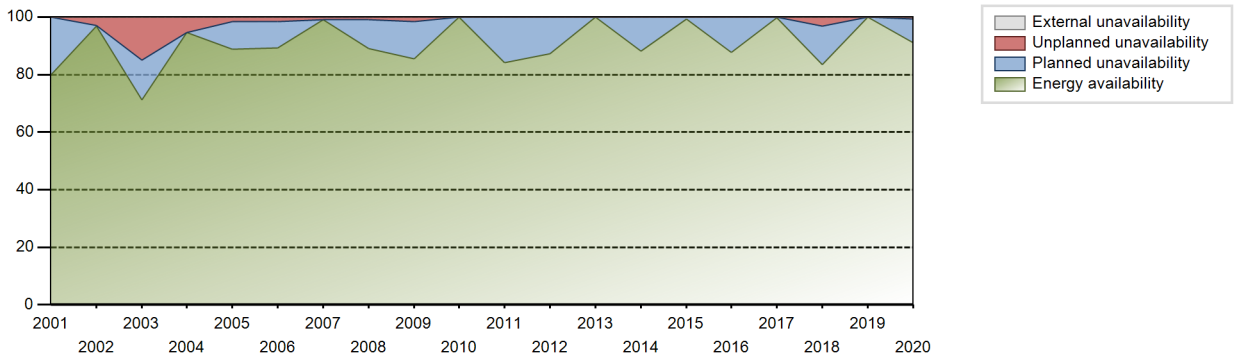


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	1885.60	3897	778	100.00	100.00	50.66	73.37	0.00	0.00	0.00	0.00
1975	3363.20	7320	764	50.30	50.30	50.25	83.56	30.39	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

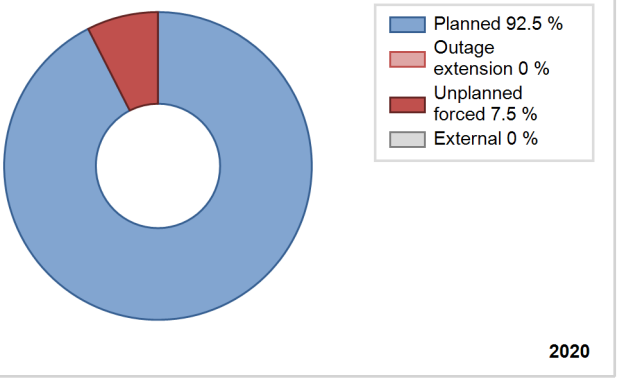
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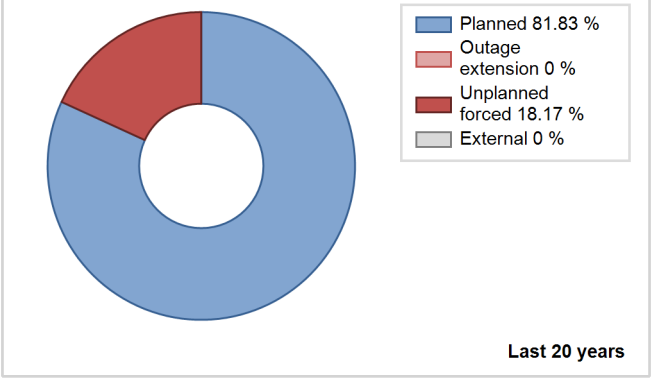
2011	5768.10	7376	774	84.21	84.21	85.07	84.20	0.00	0.00	15.79	0.00
2012	5822.50	7657	768	87.19	87.19	86.31	87.17	0.00	0.00	12.81	0.00
2013	6801.93	8760	766	100.00	100.00	101.36	99.99	0.00	0.00	0.00	0.00
2014	5915.35	7726	768	88.20	88.20	87.93	88.20	0.00	0.00	11.80	0.00
2015	6798.49	8692	768	99.23	99.23	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					161	
B. Refuelling without maintenance	728			16		
C. Inspection, maintenance or repair combined with refuelling				1088		
D. Inspection, maintenance or repair without refuelling				118		
E. Testing of plant systems or components				1	141	
H. Nuclear regulatory requirements					8	
J. Grid limitation, failure or grid unavailability						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.)						1
P. Fire					3	
Z. Other		59			33	
Subtotal	728	59		1223	353	3
Total		**787**			**1579**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		20
14. Safety Systems		8
15. Reactor Cooling Systems		14
31. Turbine and auxiliaries		68
32. Feedwater and Main Steam System		10
34. Miscellaneous Systems		156
35. All other I&C Systems		5
41. Main Generator Systems		6
42. Electrical Power Supply Systems		13
Total		**309**

Highlights (2020)

Equipment Condition Resolved

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2020 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

Reactor type and model	:	PWR / B&W RLP (DRYAMB)
Thermal power	:	2817 MWth
Gross electrical power	:	925 MWe
Reference unit power (net)	:	894 MWe

Key Dates

Construction Date	:	1970-09-01
Grid Date	:	1977-08-28
Commercial Date	:	1978-07-31
Age at end of year	:	43 years

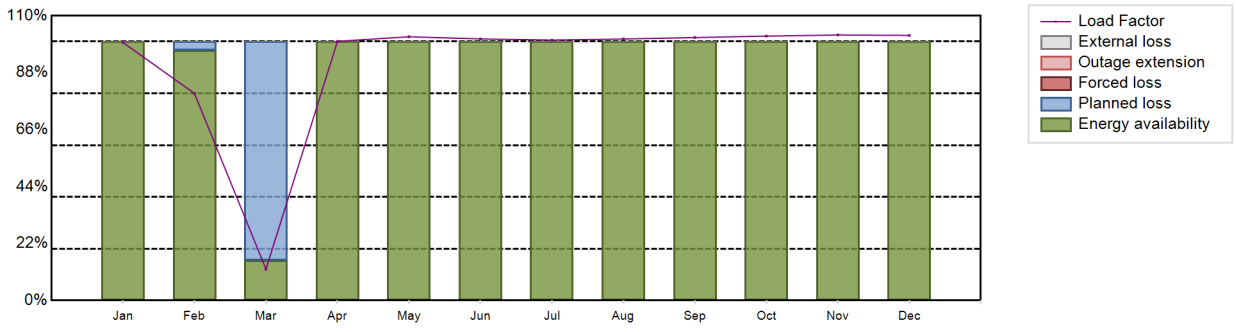
Design Characteristics

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 (2020)

Net Energy Production	:	7228.06 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	92.57 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	92.57 %	Planned Unavailability Factor (PUF)	:	7.43 %
Load Factor (LF)	:	92.04 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	92.55 %	Total off-line time	:	654 hours

Annual Summary



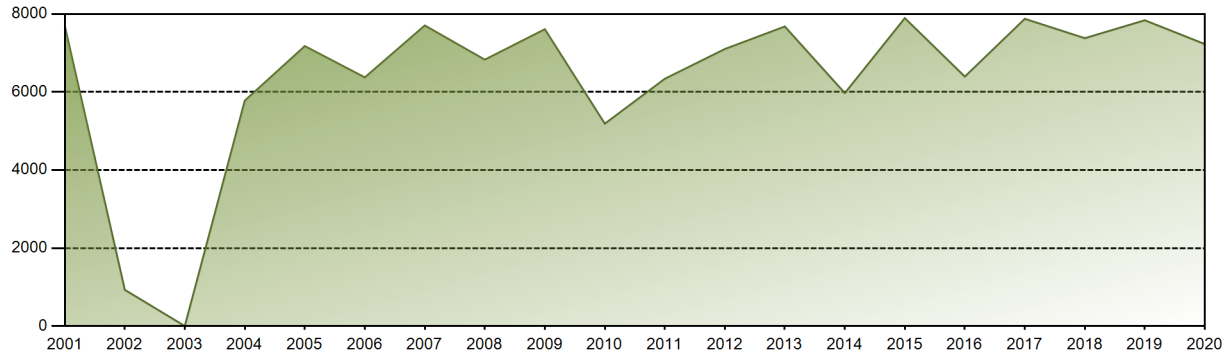
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	662.77	497.61	80.58	644.30	677.54	650.29	669.01	671.79	653.72	679.26	660.11	681.08	7228.06
EAF [%]	100.00	96.56	15.51	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.57
UCF [%]	100.00	96.56	15.51	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.57
LF [%]	99.64	79.97	12.12	100.10	101.86	101.03	100.58	101.00	101.56	102.12	102.55	102.40	92.04
OF [%]	100.00	96.55	15.32	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.55
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	3.44	84.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.43
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

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Historical Summary

Lifetime energy generation	:	243488.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.19 %
Cumulative Energy Availability Factor (EAF)	:	74.12 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.51 %
Cumulative Unit Capability Factor (UCF)	:	74.2 %	Cumulative Planned Unavailability Factor (PUF)	:	18.29 %
Cumulative Load Factor (LF)	:	72.49 %	Cumulative Externally cause unavailability (XUF)	:	0.08 %
Cumulative Operating Factor (OF)	:	74.5 %			

Electricity Production (net) [GWh]

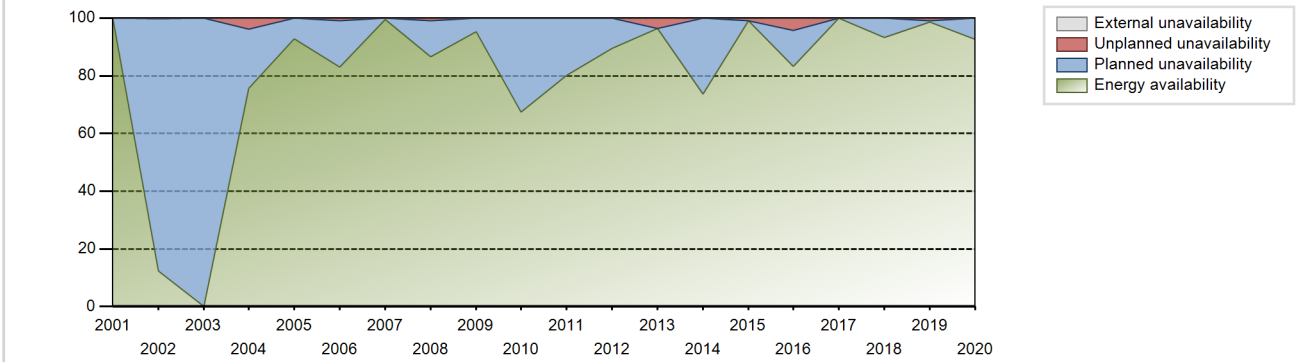


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1978	2614.50	4263	906	39.26	39.26	39.27	54.72	49.49	38.46	22.28	0.00
1979	3129.10	4139	906	39.43	39.43	39.43	47.25	36.36	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

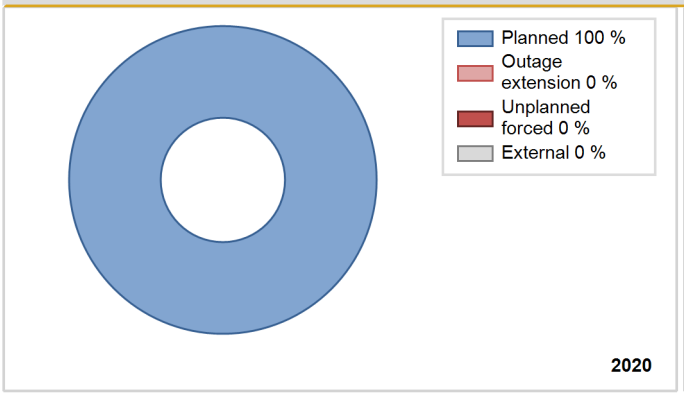
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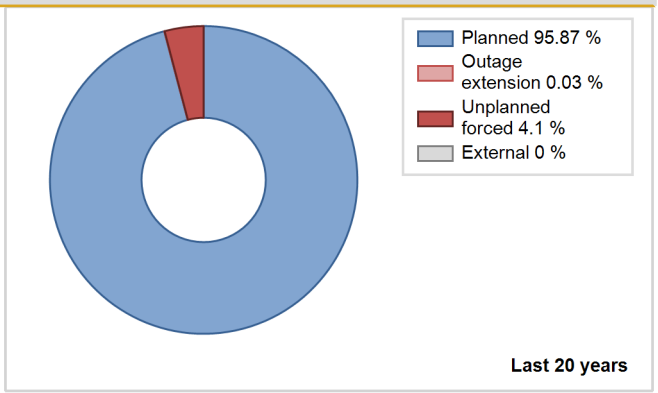
2015	7893.92	8684	894	99.13	99.13	100.80	99.13	0.87	0.87	0.00	0.00
2016	6394.93	7321	894	83.35	83.35	81.43	83.34	4.97	4.36	12.28	0.00
2017	7876.43	8760	894	100.00	100.00	100.57	100.00	0.00	0.00	0.00	0.00
2018	7380.27	8169	894	93.25	93.25	94.24	93.25	0.00	0.00	6.75	0.00
2019	7839.46	8632	894	98.55	98.55	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1978 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					632	
B. Refuelling without maintenance	653			29		
C. Inspection, maintenance or repair combined with refuelling				902		
D. Inspection, maintenance or repair without refuelling				222		
E. Testing of plant systems or components				9	3	
F. Major backfitting, refurbishment or upgrading activities with refuelling				430		
H. Nuclear regulatory requirements					41	
L. Human factor related					11	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						7
Z. Other					13	
Subtotal	653			1592	700	7
Total	**653**			**2299**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1978 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		78
12. Reactor I&C Systems		51
13. Reactor Auxiliary Systems		5
14. Safety Systems		0
15. Reactor Cooling Systems		47
16. Steam generation systems		0
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		353
34. Miscellaneous Systems		1
35. All other I&C Systems		2
41. Main Generator Systems		8
42. Electrical Power Supply Systems		61
Total		**625**

Highlights (2020)

Refueling Outage 21

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2020 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

Reactor type and model	:	PWR / WH 4LP (DRYAMB)
Thermal power	:	3411 MWth
Gross electrical power	:	1197 MWe
Reference unit power (net)	:	1138 MWe

Key Dates

Construction Date	:	1968-04-23
Grid Date	:	1984-11-11
Commercial Date	:	1985-05-07
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
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]	:	17.5
Number of control rod assemblies	:	53
Number of external reactor coolant loops	:	4
Coolant type	:	H2O

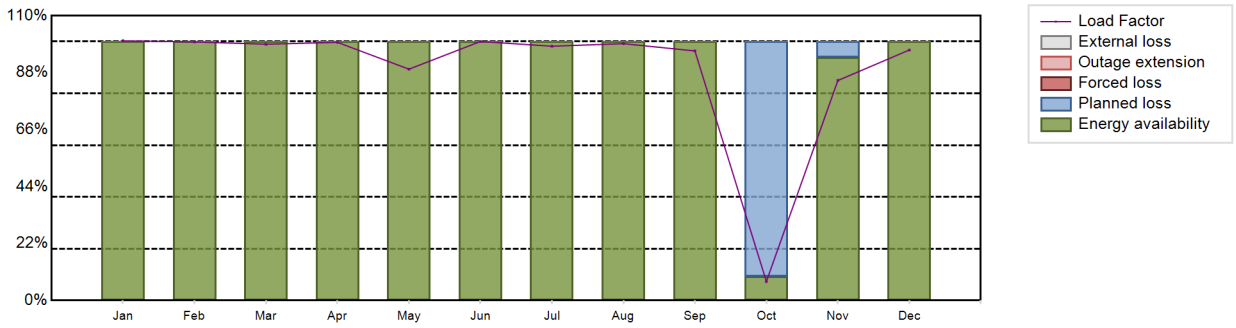
Operating coolant pressure [MPa]	:	15.83
Reactor outlet temperature [°C]	:	320
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.331
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	8910.58 GW(e).h
Energy Availability Factor (EAF)	:	91.81 %
Unit Capability Factor (UCF)	:	91.81 %
Load Factor (LF)	:	89.14 %
Operating Factor (OF)	:	91.8 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.19 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	720 hours

Annual Summary



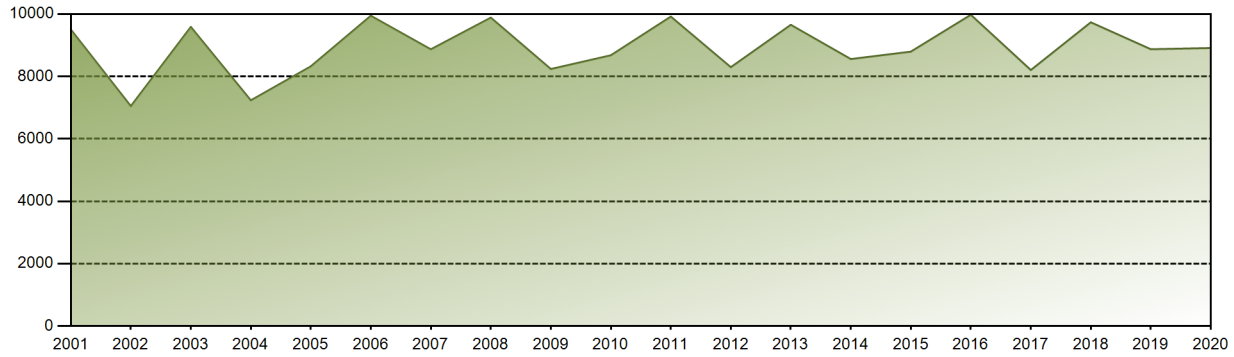
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	849.20	791.01	838.10	817.02	756.50	819.72	831.53	839.97	789.83	62.20	696.27	819.22	8910.57
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	9.27	93.80	100.00	91.81
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	9.27	93.80	100.00	91.81
LF [%]	100.30	99.87	98.99	99.71	89.35	100.04	98.21	99.21	96.40	7.35	84.98	96.76	89.14
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	9.27	93.89	100.00	91.80
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	0.00	0.00	0.00	0.00	0.00	0.00	90.73	6.20	0.00	8.19
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

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Historical Summary

Lifetime energy generation	:	305532.68 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.22 %
Cumulative Energy Availability Factor (EAF)	:	88.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2 %
Cumulative Unit Capability Factor (UCF)	:	88.16 %	Cumulative Planned Unavailability Factor (PUF)	:	9.84 %
Cumulative Load Factor (LF)	:	87.09 %	Cumulative Externally cause unavailability (XUF)	:	0.04 %
Cumulative Operating Factor (OF)	:	88.83 %			

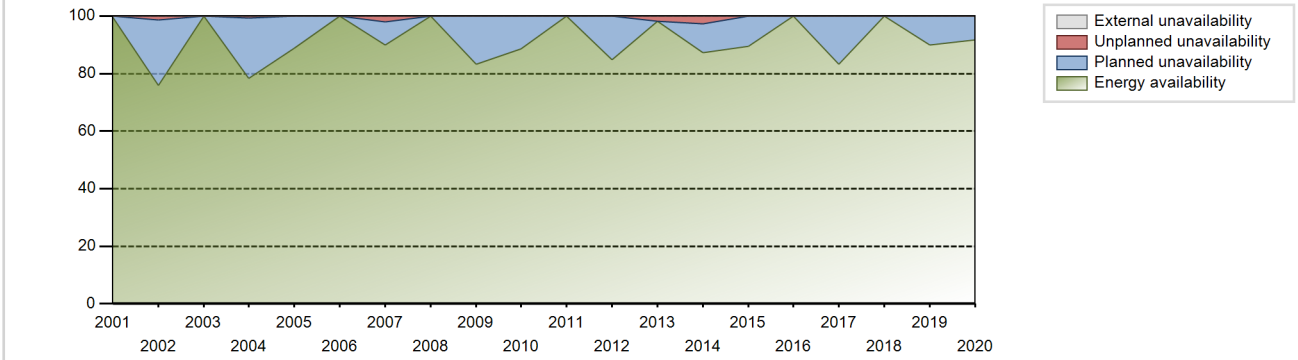
Electricity Production (net) [GWh]



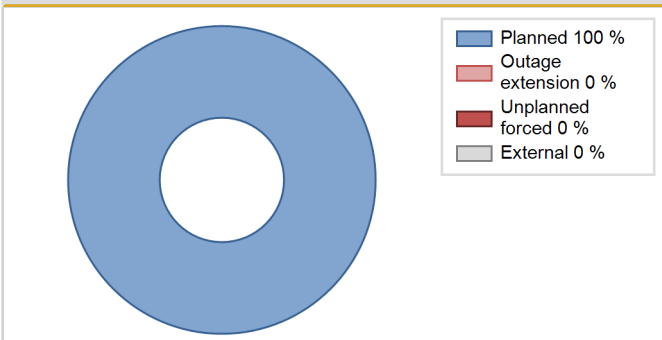
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	5234.23	5206	1073	90.81	90.81	85.07	90.79	4.54	4.31	4.87	0.00
1986	5316.22	5757	1073	65.74	65.74	56.56	65.72	1.98	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

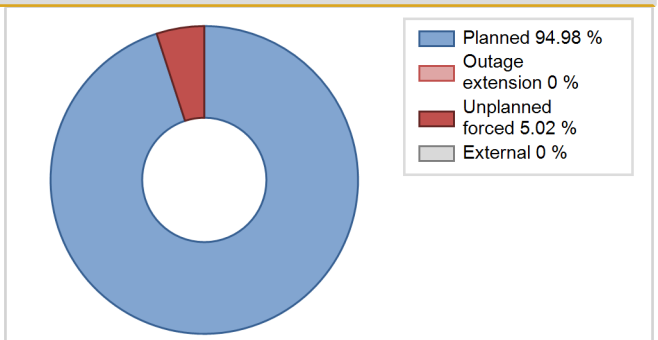
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					165	
B. Refuelling without maintenance	720			20		
C. Inspection, maintenance or repair combined with refuelling				793		
D. Inspection, maintenance or repair without refuelling				62		
E. Testing of plant systems or components				0	2	
H. Nuclear regulatory requirements					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
P. Fire					2	
Z. Other					4	
Subtotal	720			875	182	4
Total	**720**			**1061**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems		6
14. Safety Systems		7
15. Reactor Cooling Systems		12
16. Steam generation systems		1
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		11
32. Feedwater and Main Steam System		80
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		39
Total		**173**

Highlights (2020)

Refueling Outage 22

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2020 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	:	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 [%]	:	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

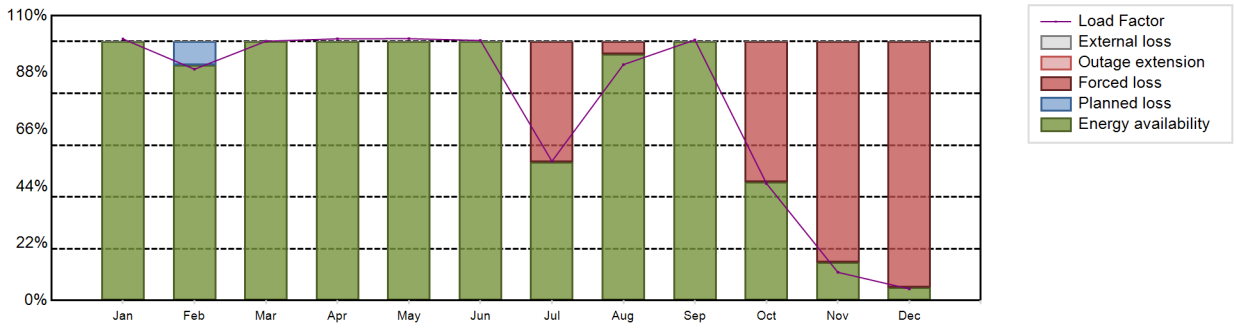
Operating coolant pressure [MPa]	:	15.83
Reactor outlet temperature [°C]	:	321
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.331
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	7348.12 GW(e).h
Energy Availability Factor (EAF)	:	75.28 %
Unit Capability Factor (UCF)	:	75.28 %
Load Factor (LF)	:	74.82 %
Operating Factor (OF)	:	75.28 %

Forced Loss Rate (FLR)	:	24.17 %
Unplanned Capability Loss Factor (UCL)	:	24 %
Planned Unavailability Factor (PUF)	:	0.72 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	2171 hours

Annual Summary



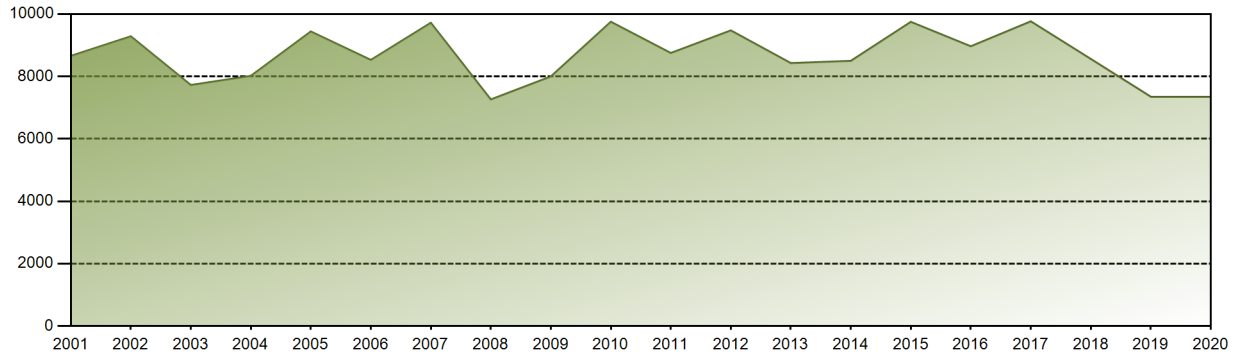
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	840.35	695.04	832.93	813.63	841.15	808.35	447.17	757.83	810.16	376.40	87.74	37.38	7348.12
EAF [%]	100.00	90.94	100.00	100.00	100.00	100.00	53.46	95.10	100.00	45.66	14.65	5.01	75.28
UCF [%]	100.00	90.94	100.00	100.00	100.00	100.00	53.46	95.10	100.00	45.66	14.65	5.01	75.28
LF [%]	101.03	89.32	100.14	101.08	101.12	100.42	53.76	91.11	100.65	45.25	10.90	4.49	74.82
OF [%]	100.00	90.95	99.87	100.00	100.00	100.00	53.49	95.16	100.00	45.70	14.72	4.97	75.28
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	46.54	4.90	0.00	54.34	85.35	94.99	24.17
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	46.54	4.90	0.00	54.34	85.35	94.99	24.00
PUF [%]	0.00	9.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72
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

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Historical Summary

Lifetime energy generation	:	328196.58 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.79 %
Cumulative Energy Availability Factor (EAF)	:	88.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.55 %
Cumulative Unit Capability Factor (UCF)	:	88.94 %	Cumulative Planned Unavailability Factor (PUF)	:	8.51 %
Cumulative Load Factor (LF)	:	87.11 %	Cumulative Externally cause unavailability (XUF)	:	0.09 %
Cumulative Operating Factor (OF)	:	88.81 %			

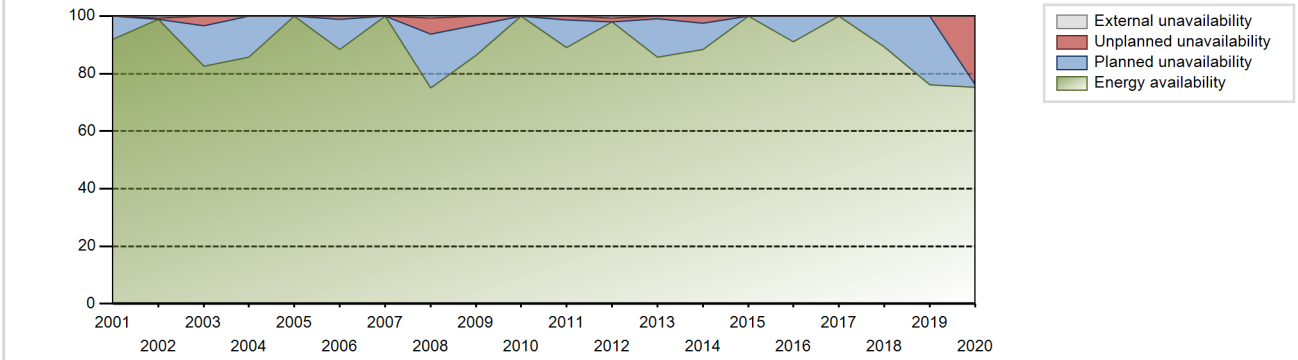
Electricity Production (net) [GWh]



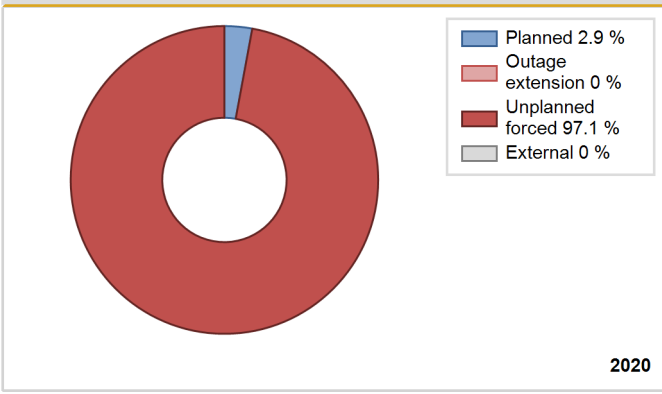
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	6757.71	7078	1080	95.39	95.39	86.22	95.41	4.21	4.19	0.42	0.00
1987	5728.78	5752	1079	65.44	65.44	60.61	65.66	9.03	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

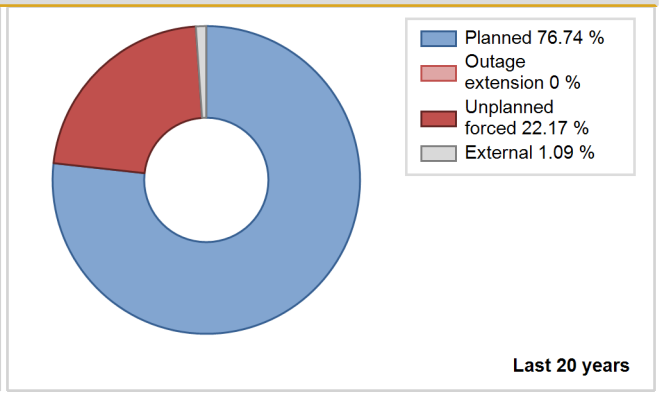
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					145	
C. Inspection, maintenance or repair combined with refuelling				734		
D. Inspection, maintenance or repair without refuelling	63			14		
E. Testing of plant systems or components				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.)						17
Z. Other		3127			100	
Subtotal	63	3127		749	254	19
Total		**3190**			**1022**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		5
15. Reactor Cooling Systems		4
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		29
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		68
Total		**156**

Highlights (2020)

Shutdown due to hydrogen leak in the main generator

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2020 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	:	50 years

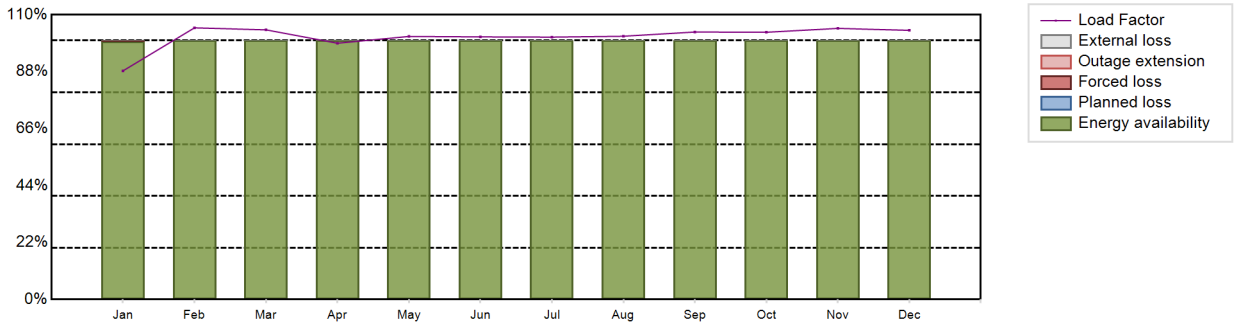
Design Characteristics

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	:	-	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 (2020)

Net Energy Production	:	7966.53 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)	:	101.45 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	98.75 %	Total off-line time	:	110 hours

Annual Summary



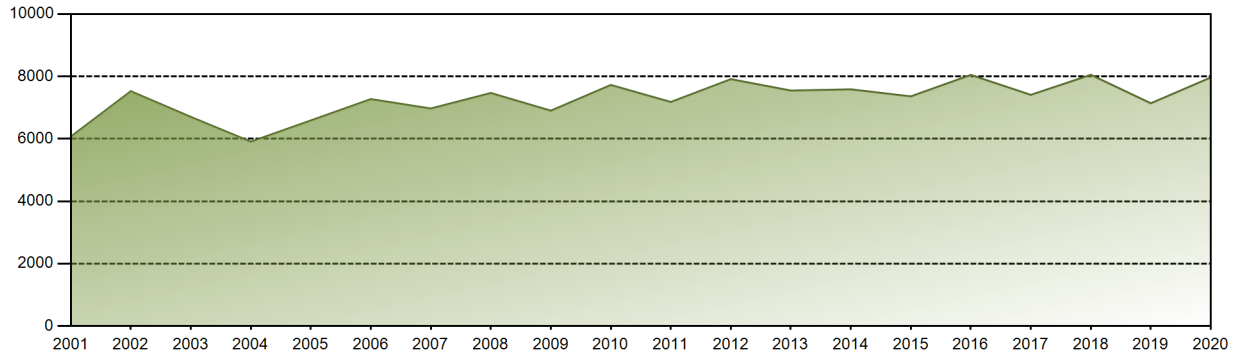
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	587.40	652.89	692.79	637.16	675.81	652.92	674.09	676.37	665.05	686.51	673.99	691.55	7966.53
EAF [%]	99.66	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97
UCF [%]	99.66	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.97
LF [%]	88.31	104.93	104.16	98.99	101.60	101.44	101.35	101.69	103.32	103.21	104.71	103.97	101.45
OF [%]	85.35	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.75
FLR [%]	0.34	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 [%]	0.34	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	0.00	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

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Historical Summary

Lifetime energy generation	:	270011.91 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.18 %
Cumulative Energy Availability Factor (EAF)	:	82.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.35 %
Cumulative Unit Capability Factor (UCF)	:	82.14 %	Cumulative Planned Unavailability Factor (PUF)	:	11.51 %
Cumulative Load Factor (LF)	:	74.83 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	80.28 %			

Electricity Production (net) [GWh]

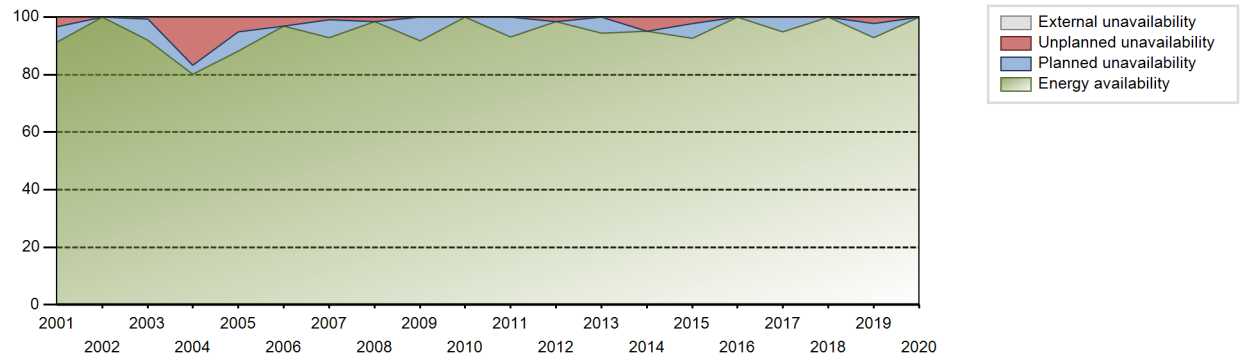


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1970	1253.00	2558	804	100.00	100.00	23.94	37.87	0.00	0.00	0.00	0.00
1971	2806.30	5694	815	100.00	100.00	39.31	65.00	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

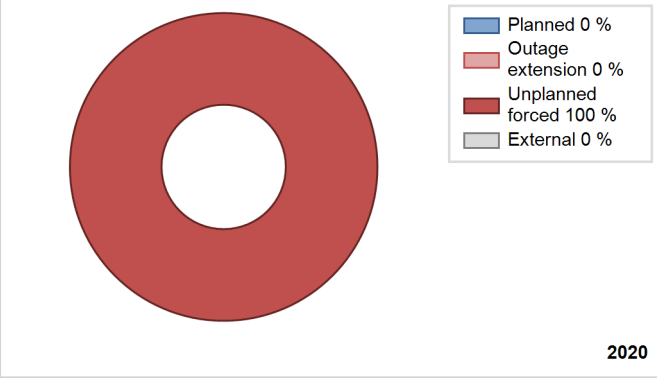
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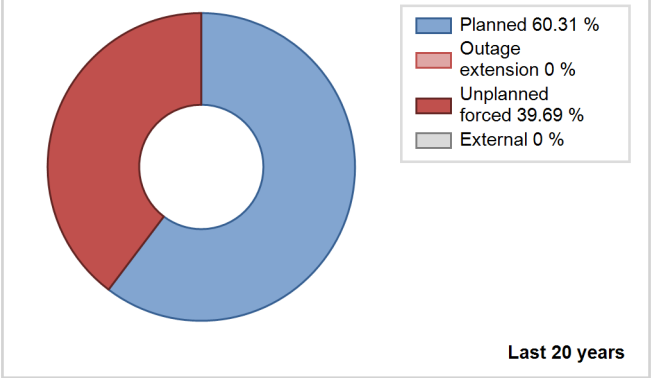
2007	6972.69	8132	867	92.84	92.84	91.81	92.83	1.09	1.02	6.13	0.00
2008	7469.52	8639	867	98.37	98.37	98.08	98.35	1.63	1.63	0.00	0.00
2009	6902.62	8033	867	91.71	91.71	90.88	91.70	0.00	0.00	8.29	0.00
2010	7726.88	8760	867	100.00	100.00	101.74	100.00	0.00	0.00	0.00	0.00
2011	7181.34	8150	883	93.07	93.07	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1970 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					489	
C. Inspection, maintenance or repair combined with refuelling				1028		
D. Inspection, maintenance or repair without refuelling				52		
E. Testing of plant systems or components				9	34	
H. Nuclear regulatory requirements					3	
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.)						3
Z. Other		3			8	1
Subtotal		3		1089	548	5
Total		**3**			**1642**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1970 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		56
12. Reactor I&C Systems		60
13. Reactor Auxiliary Systems		11
14. Safety Systems		20
15. Reactor Cooling Systems	3	80
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		118
32. Feedwater and Main Steam System		31
34. Miscellaneous Systems		38
35. All other I&C Systems		16
41. Main Generator Systems		45
42. Electrical Power Supply Systems		53
Total	**3**	**529**

Highlights (2020)

Restore cooling to TR2

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2020 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

Reactor type and model	:	BWR / BWR-3 (Mark 1)
Thermal power	:	2957 MWth
Gross electrical power	:	935 MWe
Reference unit power (net)	:	879 MWe

Key Dates

Construction Date	:	1966-10-14
Grid Date	:	1971-07-22
Commercial Date	:	1971-11-16
Age at end of year	:	49 years

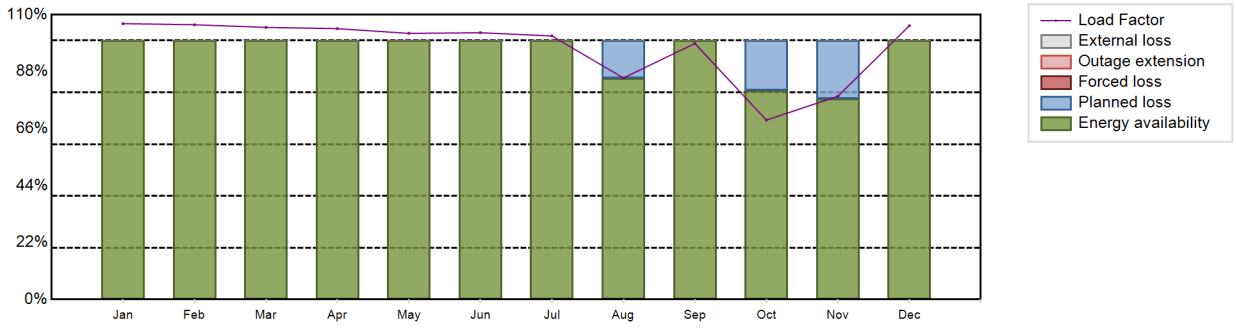
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.1
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	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 (2020)

Net Energy Production	:	7512.35 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	95.3 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	95.3 %	Planned Unavailability Factor (PUF)	:	4.7 %
Load Factor (LF)	:	97.3 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	95.31 %	Total off-line time	:	412 hours

Annual Summary



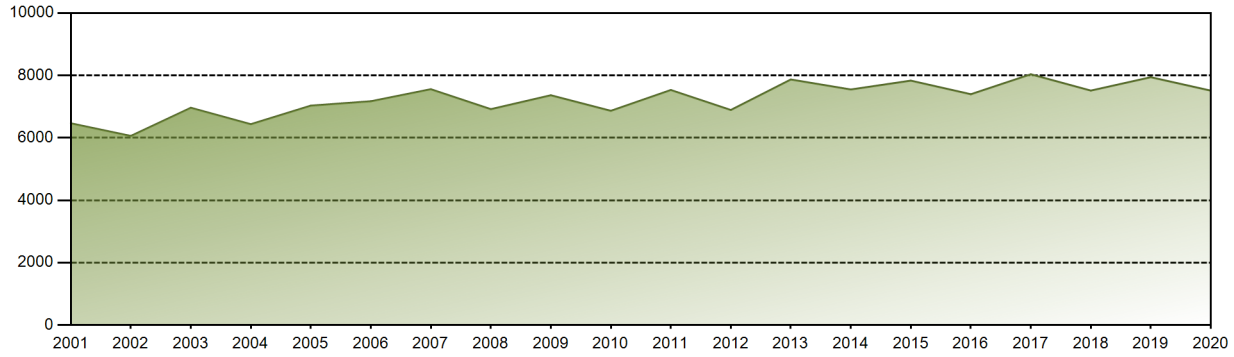
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	696.80	649.23	687.29	662.12	672.23	652.04	665.74	559.65	625.78	453.22	496.84	691.41	7512.35
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	85.58	100.00	80.65	77.59	100.00	95.30
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	85.58	100.00	80.65	77.59	100.00	95.30
LF [%]	106.55	106.12	105.09	104.62	102.79	103.03	101.80	85.58	98.88	69.30	78.51	105.72	97.30
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	85.62	100.00	80.65	77.78	100.00	95.31
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	14.42	0.00	19.35	22.41	0.00	4.70
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

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Historical Summary

Lifetime energy generation	:	267573.67 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.44 %
Cumulative Energy Availability Factor (EAF)	:	79.63 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.4 %
Cumulative Unit Capability Factor (UCF)	:	79.65 %	Cumulative Planned Unavailability Factor (PUF)	:	13.95 %
Cumulative Load Factor (LF)	:	75.1 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	80.24 %			

Electricity Production (net) [GWh]

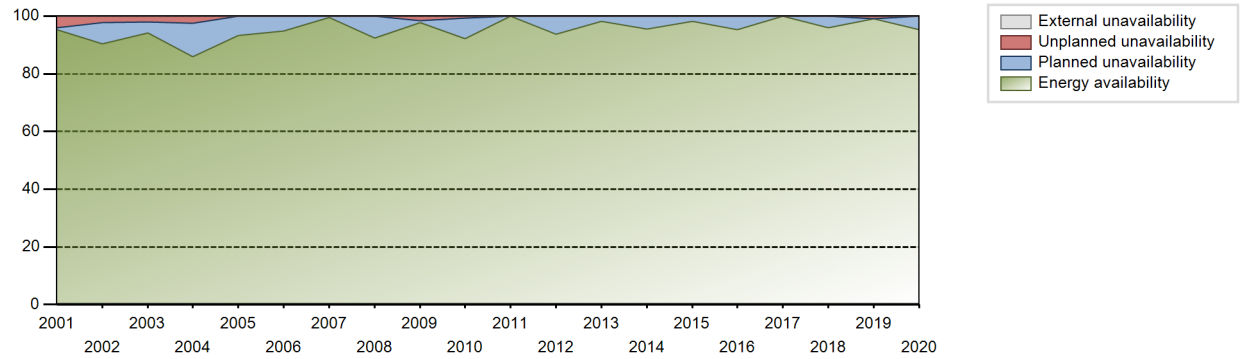


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1971	1188.60	2137	794	100.00	100.00	27.90	32.39	0.00	0.00	0.00	0.00
1972	5175.60	7549	815	100.00	100.00	72.30	85.94	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

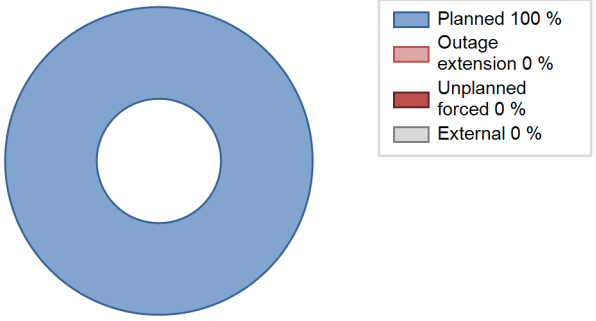
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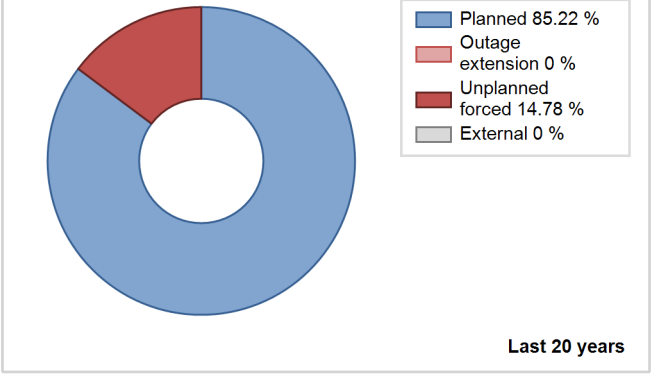
2008	6919.05	8118	867	92.43	92.43	90.85	92.42	0.00	0.00	7.57	0.00
2009	7364.79	8557	867	97.70	97.70	96.97	97.68	1.65	1.64	0.66	0.00
2010	6866.24	8076	867	92.21	92.21	90.41	92.19	0.79	0.73	7.05	0.00
2011	7533.02	8760	867	100.00	100.00	99.18	100.00	0.00	0.00	0.00	0.00
2012	6892.73	8218	867	93.69	93.69	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1971 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					513	
B. Refuelling without maintenance	305			14		
C. Inspection, maintenance or repair combined with refuelling				1074		
D. Inspection, maintenance or repair without refuelling	107			93		
E. Testing of plant systems or components				2	7	
H. Nuclear regulatory requirements					1	
L. Human factor related					18	
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					13	
Subtotal	412			1184	552	1
Total	**412**			**1737**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1971 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		6
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		2
14. Safety Systems		45
15. Reactor Cooling Systems		45
17. Safety I&C Systems (excluding reactor I&C)		50
31. Turbine and auxiliaries		163
32. Feedwater and Main Steam System		48
33. Circulating Water System		5
34. Miscellaneous Systems		63
35. All other I&C Systems		1
41. Main Generator Systems		13
42. Electrical Power Supply Systems		72
Total		**528**

Highlights (2020)

Refueling Outage D3R26

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2020 Operating Experience

US-331 DUANE ARNOLD-1 UNITED STATES OF AMERICA

Status at end of year	:	**Permanent Shutdown**
Operator	:	NEXTERA (NextEra Energy Resources, LLC
Owner	:	NEXTERA (NextEra Energy Resources, LLC
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	:	1912 MWth
Gross electrical power	:	624 MWe
Reference unit power (net)	:	601 MWe

Key Dates

Construction Date	:	1970-06-22
Grid Date	:	1974-05-19
Commercial Date	:	1975-02-01
Age at end of year	:	46 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]	:	0.436
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	24	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	25	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	27800	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.33	HP cylinder inlet steam pressure [MPa]	:	6.68
Active core height/length [m]	:	3.66	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	368	Primary means of condenser cooling	:	Cooling Towers
Fuel linear heat generation rate [kW/m]	:	14.4	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 (2020)

Net Energy Production	:	2904.86 GW(e).h	Forced Loss Rate (FLR)	:	18.78 %
Energy Availability Factor (EAF)	:	81.22 %	Unplanned Capability Loss Factor (UCL)	:	18.78 %
Unit Capability Factor (UCF)	:	81.22 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	73.5 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	81.2 %	Total off-line time	:	1524 hours

Annual Summary



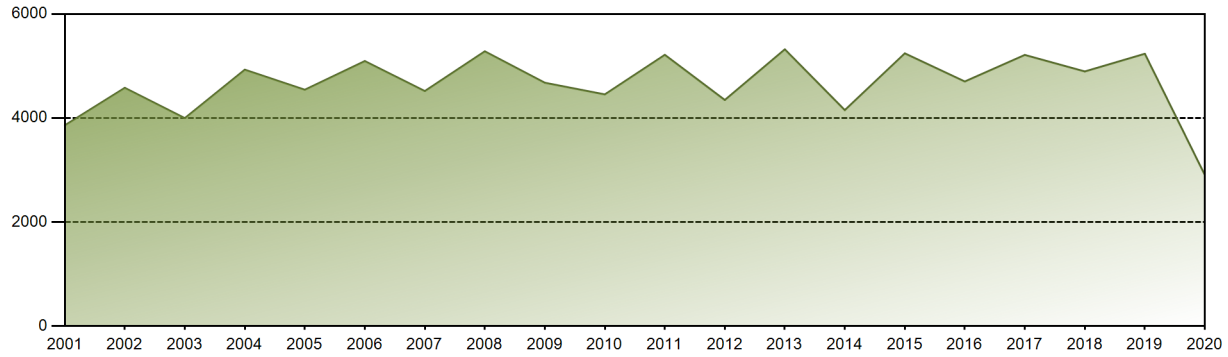
	Dec	Oct	Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
GW(e)-h				456.36	425.23	452.68	419.86	392.82	289.11	358.85	109.96	0.00	2904.86
EAF [%]				100.00	100.00	100.00	100.00	100.00	100.00	100.00	30.76	0.00	81.22
UCF [%]				100.00	100.00	100.00	100.00	100.00	100.00	100.00	30.76	0.00	81.22
LF [%]				102.06	101.66	101.24	97.03	87.85	66.81	80.25	24.59	0.00	73.50
OF [%]				100.00	100.00	99.87	100.00	100.00	100.00	100.00	30.78	0.00	81.20
FLR [%]				0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.24	100.00	18.78
UCL [%]				0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.24	100.00	18.78
PUF [%]				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

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Historical Summary

Lifetime energy generation	:	62443.59 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.08 %
Cumulative Energy Availability Factor (EAF)	:	82.49 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.34 %
Cumulative Unit Capability Factor (UCF)	:	82.56 %	Cumulative Planned Unavailability Factor (PUF)	:	12.1 %
Cumulative Load Factor (LF)	:	79.04 %	Cumulative Externally cause unavailability (XUF)	:	0.07 %
Cumulative Operating Factor (OF)	:	83.75 %			

Electricity Production (net) [GWh]

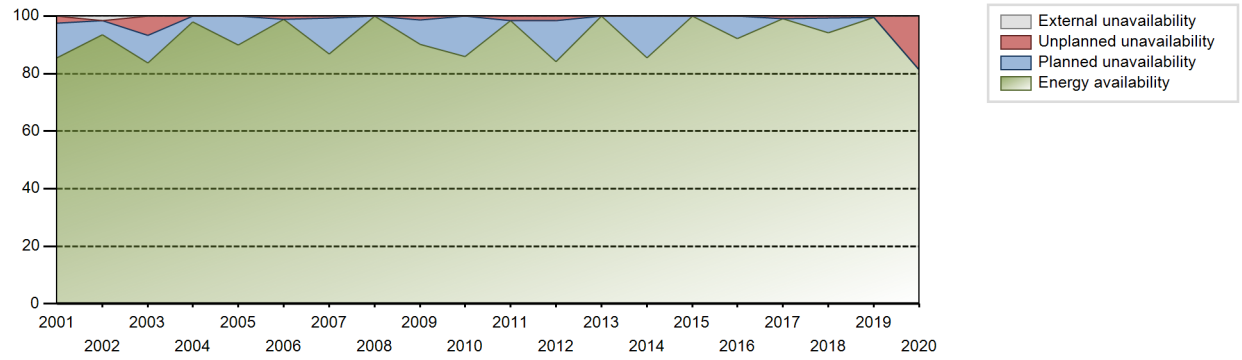


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	2298.20	6965	515	79.39	79.39	50.86	78.57	9.35	8.19	12.41	0.00
1976	2489.40	6847	515	55.09	55.09	55.03	77.95	18.05	12.13	32.78	0.00
1977	2897.80	6908	515	64.30	64.30	64.23	78.86	6.97	4.82	30.89	0.00
1978	1227.50	2902	515	27.21	27.21	27.21	33.13	68.40	58.88	13.91	0.00
1979	2898.90	6830	515	64.25	64.25	64.26	77.97	32.55	31.01	4.74	0.00
1980	2796.30	6456	515	73.15	74.76	61.81	73.50	6.56	5.25	19.99	1.60
1981	2219.50	6108	515	69.29	69.29	49.20	69.73	4.03	2.91	27.80	0.00
1982	2280.40	6543	515	74.15	74.15	50.55	74.69	22.51	21.53	4.31	0.00
1983	2324.30	5503	515	61.83	61.83	51.52	62.82	12.71	9.01	29.16	0.00
1984	2717.56	6402	515	72.24	72.24	60.07	72.88	14.51	12.26	15.50	0.00
1985	1940.49	4711	515	52.63	52.63	43.01	53.78	0.00	0.00	47.37	0.00
1986	3192.83	7495	515	81.51	81.51	70.77	85.56	4.14	3.52	14.97	0.00
1987	2546.58	5513	515	62.04	62.04	56.45	62.93	18.67	14.24	23.72	0.00
1988	3520.21	7128	520	72.29	72.29	77.05	81.15	1.08	0.79	26.92	0.00
1989	3143.64	6561	536	62.45	62.45	66.95	74.90	24.40	20.15	17.40	0.00
1990	3021.05	6498	538	74.68	74.68	64.10	74.18	5.06	3.98	21.34	0.00
1991	4146.80	8217	532	93.87	93.87	88.95	93.80	2.44	2.34	3.78	0.00
1992	3434.64	7112	515	80.50	80.50	75.92	80.97	2.64	2.18	17.32	0.00
1993	3241.40	6755	515	76.55	76.64	71.85	77.11	1.47	1.15	22.21	0.09
1994	4108.36	8078	515	92.00	92.00	91.07	92.21	2.49	2.35	5.65	0.00
1995	3736.97	7253	515	82.40	82.40	82.83	82.80	1.08	0.90	16.70	0.00
1996	3938.54	7906	520	89.87	89.87	86.23	90.00	0.00	0.00	10.13	0.00
1997	4155.53	8125	520	92.70	92.70	91.23	92.75	1.30	1.22	6.09	0.00
1998	3839.16	7477	520	85.16	85.16	84.28	85.35	1.56	1.35	13.49	0.00
1999	3649.04	7267	520	82.97	82.97	80.11	82.96	0.00	0.00	17.03	0.00
2000	4455.71	8553	520	97.39	97.39	97.55	97.37	2.61	2.61	0.00	0.00
2001	3860.64	7473	565	85.43	85.43	84.13	85.31	2.84	2.50	12.07	0.00
2002	4581.08	8147	565	93.57	95.13	92.74	93.00	0.00	0.00	4.87	1.57
2003	3998.57	7209	565	83.76	83.76	80.79	82.29	7.34	6.64	9.61	0.00
2004	4929.91	8596	565	97.88	97.88	99.33	97.86	0.00	0.00	2.12	0.00
2005	4544.47	7882	562	89.99	89.99	92.30	89.97	0.00	0.00	10.01	0.00
2006	5095.41	8664	581	98.91	98.91	100.11	98.90	1.09	1.09	0.00	0.00
2007	4518.88	7598	580	86.74	86.74	88.94	86.74	0.90	0.79	12.48	0.00
2008	5282.81	8784	580	100.00	100.00	103.69	100.00	0.00	0.00	0.00	0.00
2009	4678.93	7891	579	90.08	90.08	92.25	90.08	1.53	1.40	8.52	0.00
2010	4454.36	7471	601	85.85	85.85	84.61	85.29	0.00	0.00	14.15	0.00
2011	5215.23	8611	601	98.30	98.30	99.06	98.30	1.70	1.70	0.00	0.00

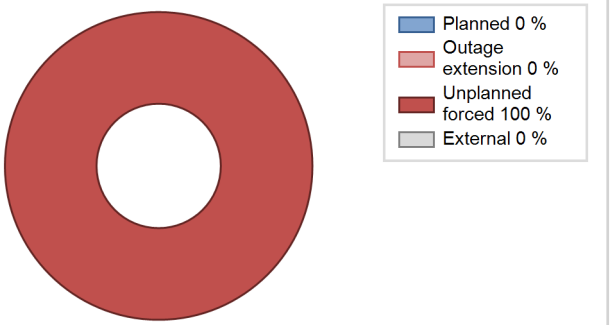
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2012	4347.00	7391	601	84.16	84.16	82.34	84.14	1.93	1.66	14.18	0.00
2013	5320.78	8760	601	100.00	100.00	101.05	99.99	0.00	0.00	0.00	0.00
2014	4152.47	7482	601	85.42	85.42	78.87	85.41	0.00	0.00	14.58	0.00
2015	5243.45	8760	601	100.00	100.00	99.60	100.00	0.00	0.00	0.00	0.00
2016	4702.67	8096	601	92.17	92.17	89.08	92.17	0.00	0.00	7.83	0.00
2017	5213.51	8683	601	99.12	99.12	99.03	99.12	0.88	0.88	0.00	0.00
2018	4895.41	8258	601	94.26	94.26	92.98	94.27	0.67	0.63	5.11	0.00
2019	5235.72	8711	601	99.45	99.45	99.45	99.44	0.55	0.55	0.00	0.00
2020	2904.86	5340	601	81.22	81.22	73.50	81.20	18.78	18.78	0.00	0.00

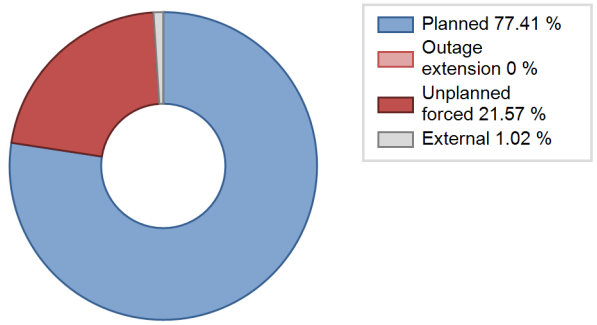
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					332	
B. Refuelling without maintenance				10		
C. Inspection, maintenance or repair combined with refuelling				772		
D. Inspection, maintenance or repair without refuelling				223		
E. Testing of plant systems or components				19	18	
H. Nuclear regulatory requirements					28	
L. Human factor related					36	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						3
Z. Other		1235			43	0
Subtotal		1235		1024	457	3
Total		**1235**			**1484**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		13
14. Safety Systems		13
15. Reactor Cooling Systems		178
16. Steam generation systems		0
17. Safety I&C Systems (excluding reactor I&C)		5
31. Turbine and auxiliaries		52
32. Feedwater and Main Steam System		29
33. Circulating Water System		3
34. Miscellaneous Systems		23
35. All other I&C Systems		2
41. Main Generator Systems		8
42. Electrical Power Supply Systems		16
Total		**349**

Highlights (2020)

Automatic Scram - Loss of Offsite Power due to Derecho Storm

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2020 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

Reactor type and model	:	PWR / WH 3LP (DRYAMB)
Thermal power	:	2775 MWth
Gross electrical power	:	918 MWe
Reference unit power (net)	:	874 MWe

Key Dates

Construction Date	:	1970-10-01
Grid Date	:	1977-08-18
Commercial Date	:	1977-12-01
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 [%]	:	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

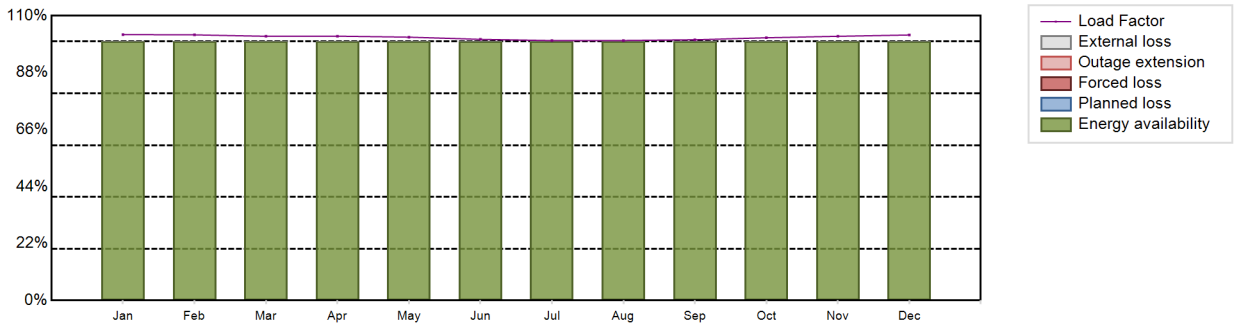
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	322
Number of SG	:	3
Containment type	:	Single
Containment design pressure [MPa]	:	0.38
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7802.42 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	101.63 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



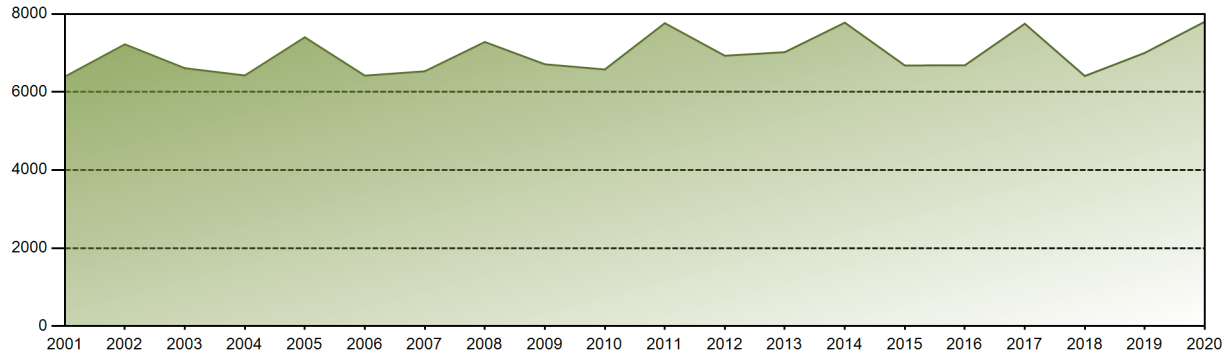
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	667.90	624.09	663.65	642.37	661.44	634.76	652.73	652.89	633.72	659.88	642.14	666.85	7802.41
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	102.71	102.60	102.06	102.08	101.72	100.87	100.38	100.40	100.70	101.48	102.04	102.55	101.63
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	303814.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.96 %
Cumulative Energy Availability Factor (EAF)	:	85.88 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.62 %
Cumulative Unit Capability Factor (UCF)	:	85.99 %	Cumulative Planned Unavailability Factor (PUF)	:	11.39 %
Cumulative Load Factor (LF)	:	84.67 %	Cumulative Externally cause unavailability (XUF)	:	0.11 %
Cumulative Operating Factor (OF)	:	85.86 %			

Electricity Production (net) [GWh]

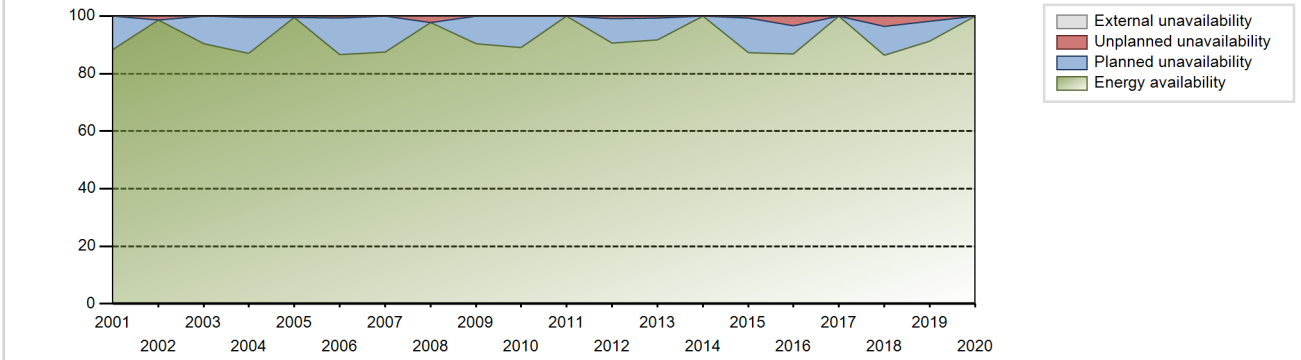


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	1047.90	1747	820	100.00	100.00	64.19	68.82	0.00	0.00	0.00	0.00
1978	5919.80	7568	829	81.52	81.52	81.52	86.39	11.24	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

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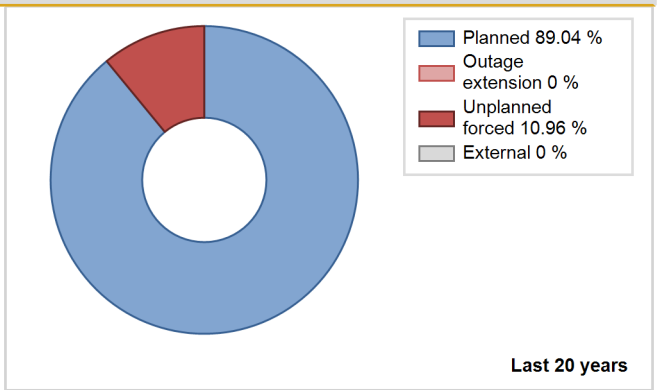
2014	7777.43	8760	874	100.00	100.00	101.58	100.00	0.00	0.00	0.00	0.00
2015	6680.66	7652	874	87.35	87.35	87.26	87.35	0.82	0.73	11.93	0.00
2016	6684.05	7617	874	86.72	86.72	87.06	86.71	3.78	3.41	9.87	0.00
2017	7750.07	8760	874	100.00	100.00	101.23	100.00	0.00	0.00	0.00	0.00
2018	6409.66	7567	874	86.37	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					196	
C. Inspection, maintenance or repair combined with refuelling				946		
D. Inspection, maintenance or repair without refuelling				52		
E. Testing of plant systems or components				2	0	
H. Nuclear regulatory requirements					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					2	
Subtotal				1000	227	4
Total		**0**			**1231**	

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Equipment Related Unplanned Full Outages, Analysis by System		
System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		1
14. Safety Systems		3
15. Reactor Cooling Systems		9
16. Steam generation systems		21
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		80
32. Feedwater and Main Steam System		17
33. Circulating Water System		1
34. Miscellaneous Systems		1
35. All other I&C Systems		2
41. Main Generator Systems		9
42. Electrical Power Supply Systems		53
Total		**208**

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2020 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	:	39 years

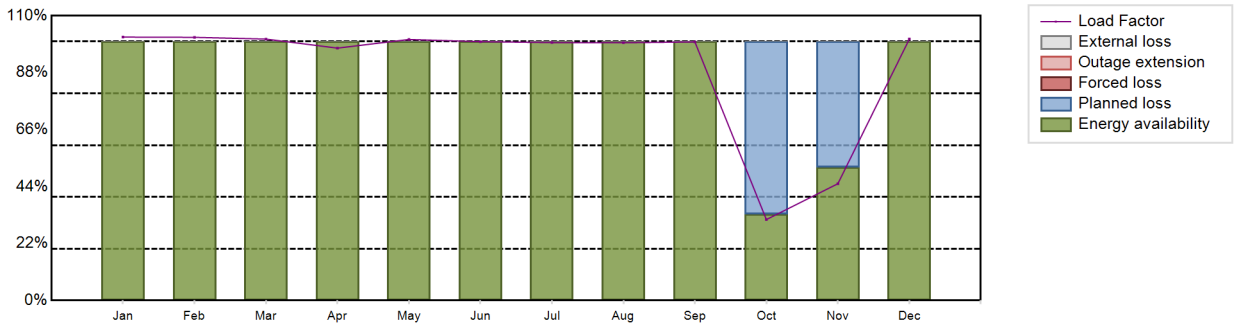
Design Characteristics

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 (2020)

Net Energy Production	:	6973.38 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	90.37 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	90.37 %	Planned Unavailability Factor (PUF)	:	9.63 %
Load Factor (LF)	:	89.91 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	90.37 %	Total off-line time	:	846 hours

Annual Summary



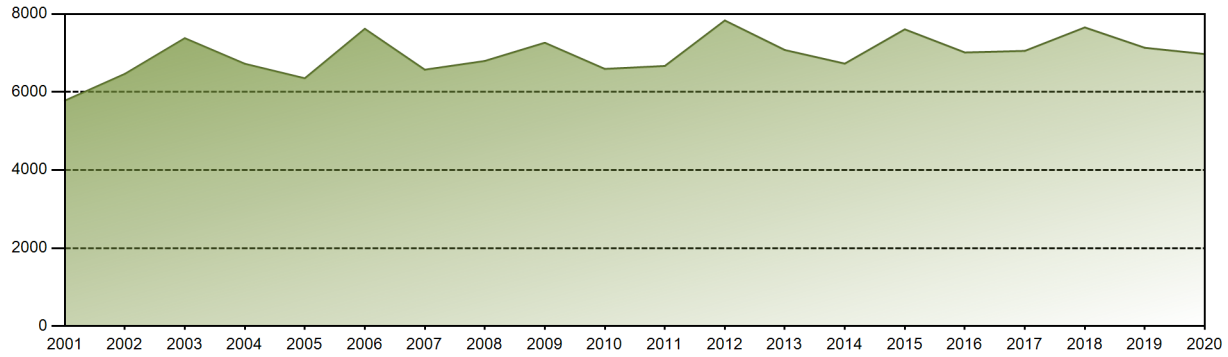
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	668.42	624.75	663.30	619.76	662.33	635.64	654.48	654.04	634.99	205.45	286.80	663.43	6973.38
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	33.33	51.44	100.00	90.37
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	33.33	51.44	100.00	90.37
LF [%]	101.75	101.66	100.97	97.48	100.82	99.98	99.62	99.56	99.88	31.27	45.11	100.99	89.91
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	33.33	51.53	100.00	90.37
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	0.00	0.00	0.00	0.00	0.00	66.67	48.56	0.00	9.63
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

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Historical Summary

Lifetime energy generation	:	237769.34 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.75 %
Cumulative Energy Availability Factor (EAF)	:	89.09 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.59 %
Cumulative Unit Capability Factor (UCF)	:	89.11 %	Cumulative Planned Unavailability Factor (PUF)	:	9.3 %
Cumulative Load Factor (LF)	:	87.48 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	88.82 %			

Electricity Production (net) [GWh]

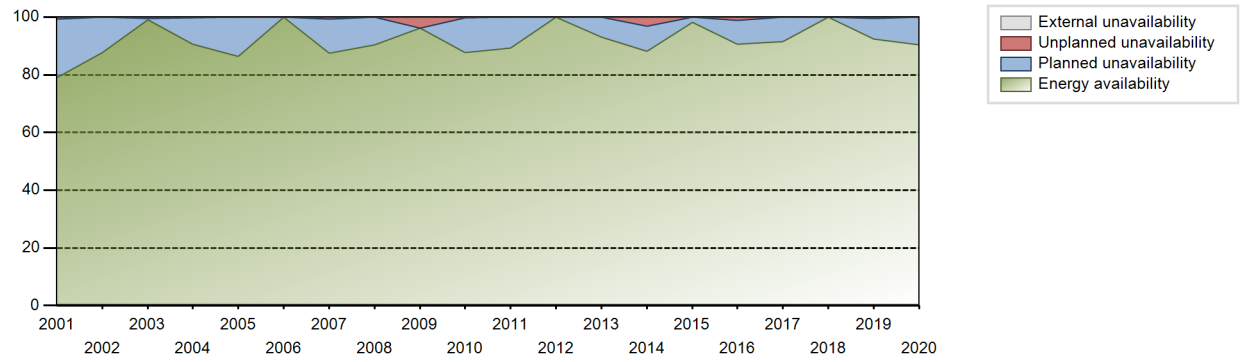


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	2920.80	3665	825	99.28	99.28	95.08	98.48	0.72	0.72	0.00	0.00
1982	5311.30	6931	814	79.41	79.41	74.49	79.12	10.30	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

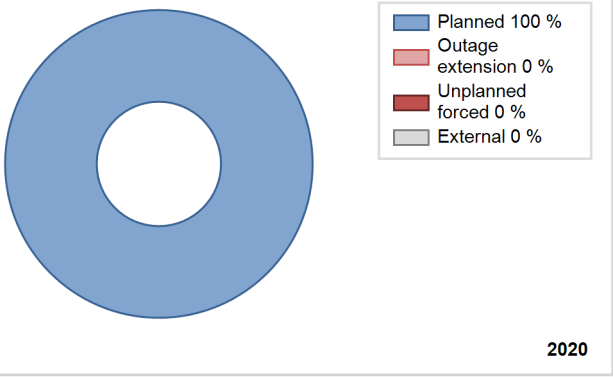
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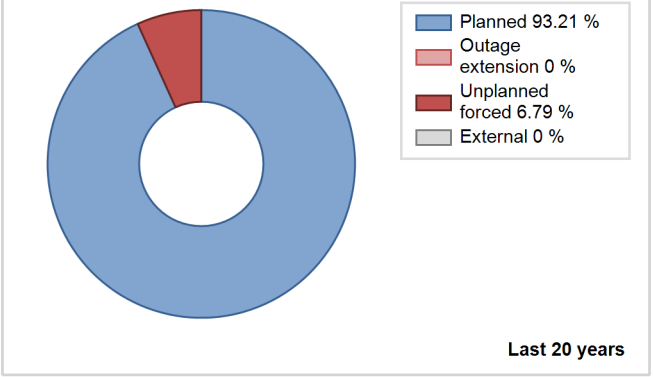
2018	7655.38	8760	883	100.00	100.00	98.97	100.00	0.00	0.00	0.00	0.00
2019	7133.77	8091	883	92.38	92.38	92.23	92.36	0.48	0.44	7.18	0.00
2020	6973.38	7938	883	90.37	90.37	89.91	90.37	0.00	0.00	9.63	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					128	
B. Refuelling without maintenance	846			21		
C. Inspection, maintenance or repair combined with refuelling				769		
D. Inspection, maintenance or repair without refuelling				32		
E. Testing of plant systems or components				6		
J. Grid limitation, failure or grid unavailability						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.)						1
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					0	
Z. Other					2	1
Subtotal	846			828	141	2
Total	**846**			**971**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		11
14. Safety Systems		15
15. Reactor Cooling Systems		35
16. Steam generation systems		20
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		11
32. Feedwater and Main Steam System		14
35. All other I&C Systems		1
41. Main Generator Systems		5
42. Electrical Power Supply Systems		4
Total		**135**

Highlights (2020)

Refueling Outage 27.

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2020 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	:	34 years

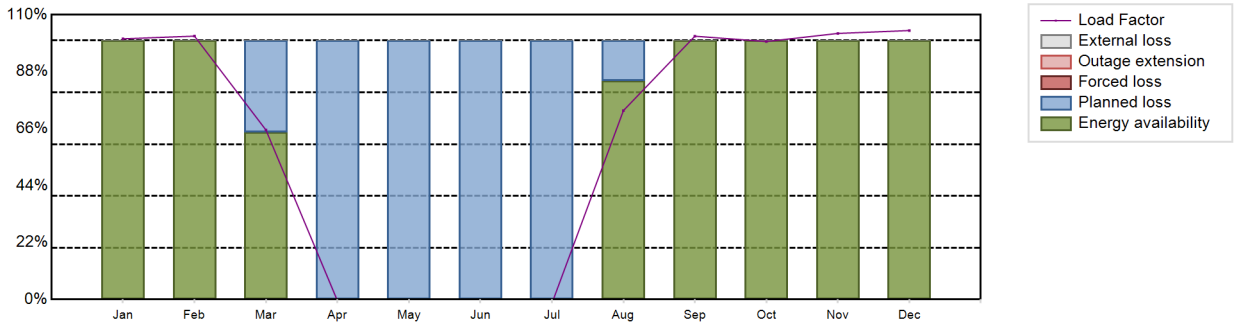
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.3
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]	:	0.44
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	25	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	19404	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	4.75	HP cylinder inlet steam pressure [MPa]	:	6.8
Active core height/length [m]	:	3.8	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	764	Primary means of condenser cooling	:	Cooling Towers
Fuel linear heat generation rate [kW/m]	:	37.73	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 (2020)

Net Energy Production	:	6070.78 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	62.35 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	62.35 %	Planned Unavailability Factor (PUF)	:	37.65 %
Load Factor (LF)	:	61.98 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	62.33 %	Total off-line time	:	3309 hours

Annual Summary



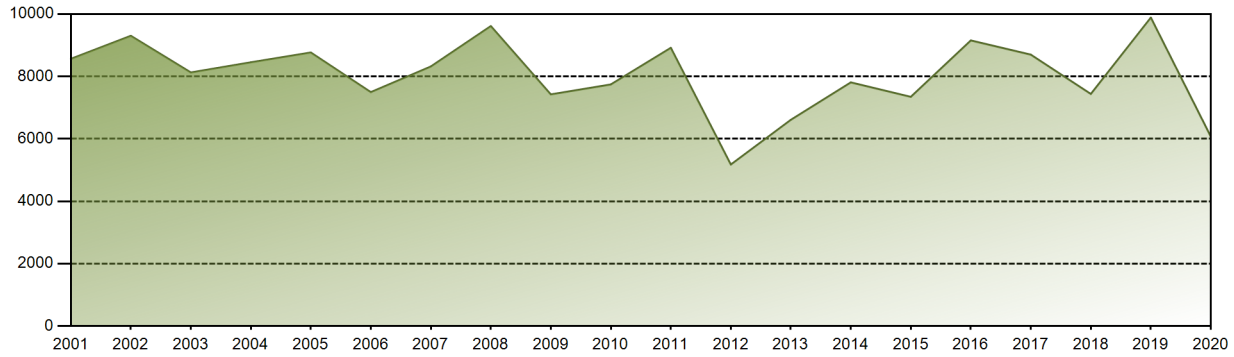
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	835.25	789.45	542.95	-4.05	-4.93	-10.77	-12.20	605.28	816.40	826.57	825.02	861.81	6070.78
EAF [%]	100.00	100.00	64.54	0.00	0.00	0.00	0.00	84.45	100.00	100.00	100.00	100.00	62.35
UCF [%]	100.00	100.00	64.54	0.00	0.00	0.00	0.00	84.45	100.00	100.00	100.00	100.00	62.35
LF [%]	100.69	101.73	65.45	-0.50	-0.59	-1.34	-1.47	72.96	101.69	99.64	102.77	103.89	61.98
OF [%]	100.00	100.00	64.38	0.00	0.00	0.00	0.00	84.41	100.00	100.00	100.00	100.00	62.33
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	0.00	35.46	100.00	100.00	100.00	100.00	15.55	0.00	0.00	0.00	0.00	37.65
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

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Historical Summary

Lifetime energy generation	:	212972.75 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	10.3 %
Cumulative Energy Availability Factor (EAF)	:	79.97 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	9.18 %
Cumulative Unit Capability Factor (UCF)	:	79.97 %	Cumulative Planned Unavailability Factor (PUF)	:	10.84 %
Cumulative Load Factor (LF)	:	76.65 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	79.78 %			

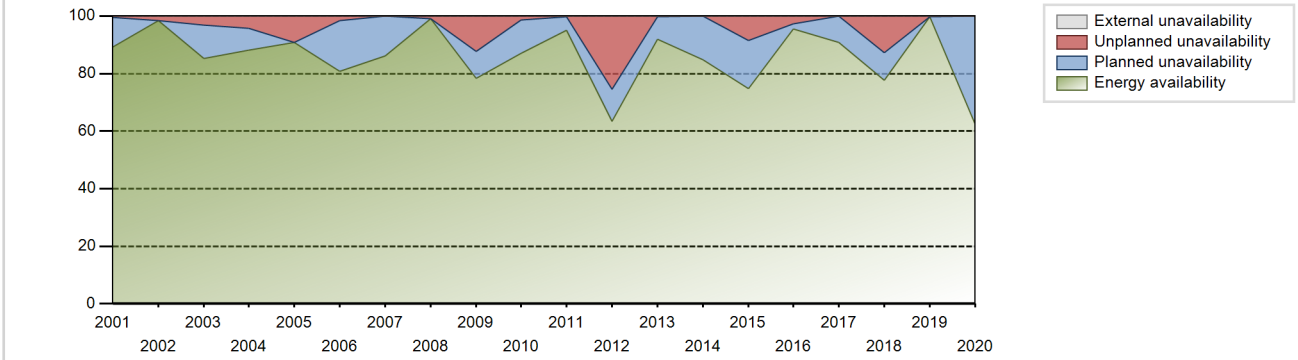
Electricity Production (net) [GWh]



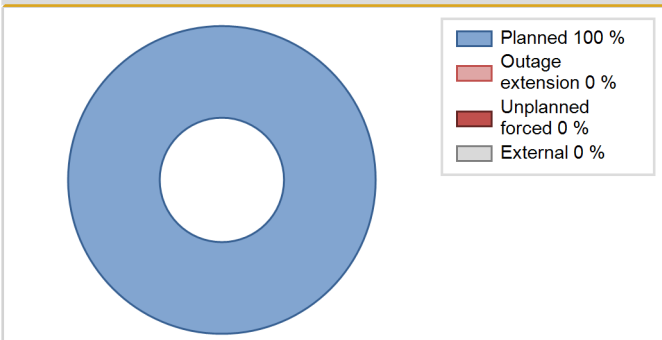
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	4060.06	4719	1093	55.90	55.90	43.95	56.13	42.89	41.98	2.11	0.00
1989	5230.72	5575	1093	63.42	63.42	54.63	63.64	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

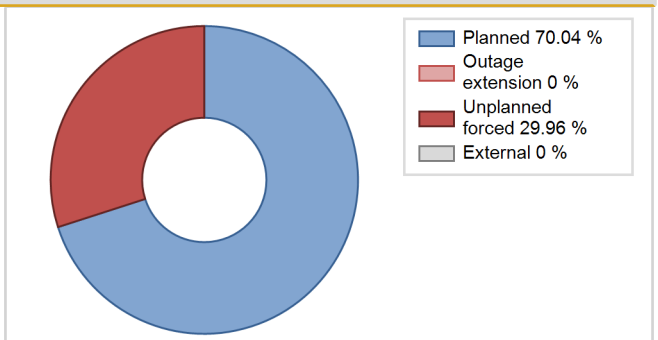
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					809	
B. Refuelling without maintenance	3571			108		
C. Inspection, maintenance or repair combined with refuelling				649		
D. Inspection, maintenance or repair without refuelling				186		
J. Grid limitation, failure or grid unavailability						12
L. Human factor related					6	
P. Fire					1	
Subtotal	3571			943	816	12
Total	**3571**			**1771**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		24
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		38
14. Safety Systems		23
15. Reactor Cooling Systems		19
17. Safety I&C Systems (excluding reactor I&C)		13
31. Turbine and auxiliaries		303
32. Feedwater and Main Steam System		28
33. Circulating Water System		2
34. Miscellaneous Systems		48
35. All other I&C Systems		10
41. Main Generator Systems		199
42. Electrical Power Supply Systems		91
Total		**813**

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Highlights (2020)
Refueling Outage 20 (RFO20)

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	2536 MWth
Gross electrical power	:	849 MWe
Reference unit power (net)	:	813 MWe

Key Dates

Construction Date	:	1968-09-01
Grid Date	:	1975-02-01
Commercial Date	:	1975-07-28
Age at end of year	:	45 years

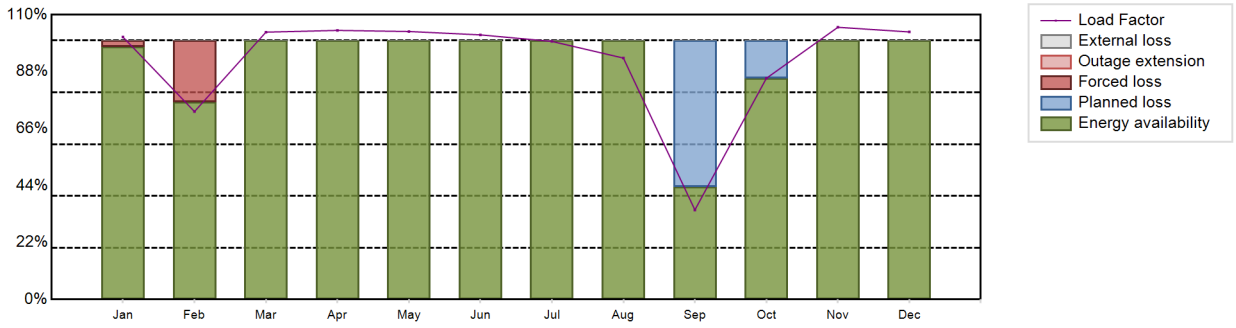
Design Characteristics

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 (2020)

Net Energy Production	:	6608.23 GW(e).h	Forced Loss Rate (FLR)	:	2.22 %
Energy Availability Factor (EAF)	:	92.03 %	Unplanned Capability Loss Factor (UCL)	:	2.09 %
Unit Capability Factor (UCF)	:	92.03 %	Planned Unavailability Factor (PUF)	:	5.87 %
Load Factor (LF)	:	92.53 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	92.02 %	Total off-line time	:	701 hours

Annual Summary



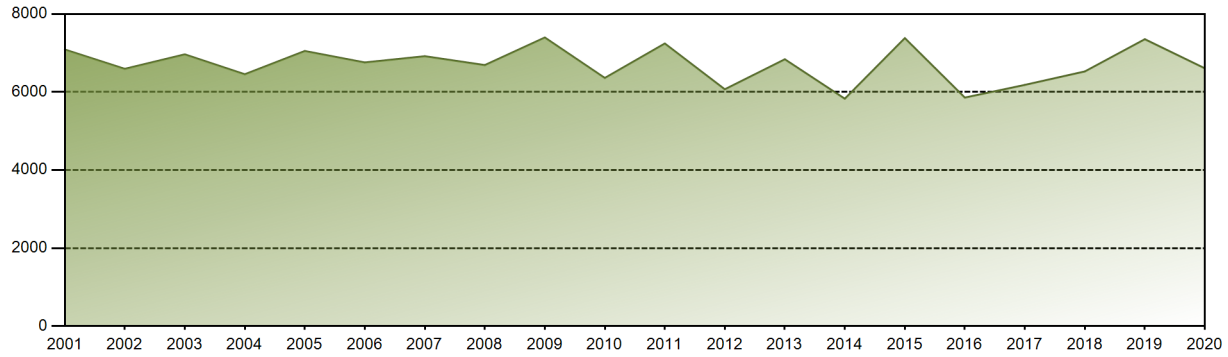
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	613.12	410.70	624.65	608.37	626.15	598.31	602.96	564.09	202.49	516.83	615.47	625.09	6608.23
EAF [%]	97.57	76.19	100.00	100.00	100.00	100.00	100.00	100.00	43.44	85.37	100.00	100.00	92.03
UCF [%]	97.57	76.19	100.00	100.00	100.00	100.00	100.00	100.00	43.44	85.37	100.00	100.00	92.03
LF [%]	101.36	72.58	103.27	103.93	103.52	102.21	99.68	93.26	34.59	85.44	105.14	103.34	92.53
OF [%]	97.58	76.15	99.87	100.00	100.00	100.00	100.00	100.00	43.47	85.35	100.00	100.00	92.02
FLR [%]	2.43	23.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22
UCL [%]	2.43	23.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.09
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	56.56	14.63	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

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Historical Summary

Lifetime energy generation	:	331284.88 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.44 %
Cumulative Energy Availability Factor (EAF)	:	81.27 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.73 %
Cumulative Unit Capability Factor (UCF)	:	81.43 %	Cumulative Planned Unavailability Factor (PUF)	:	12.84 %
Cumulative Load Factor (LF)	:	78.52 %	Cumulative Externally cause unavailability (XUF)	:	0.15 %
Cumulative Operating Factor (OF)	:	81.42 %			

Electricity Production (net) [GWh]

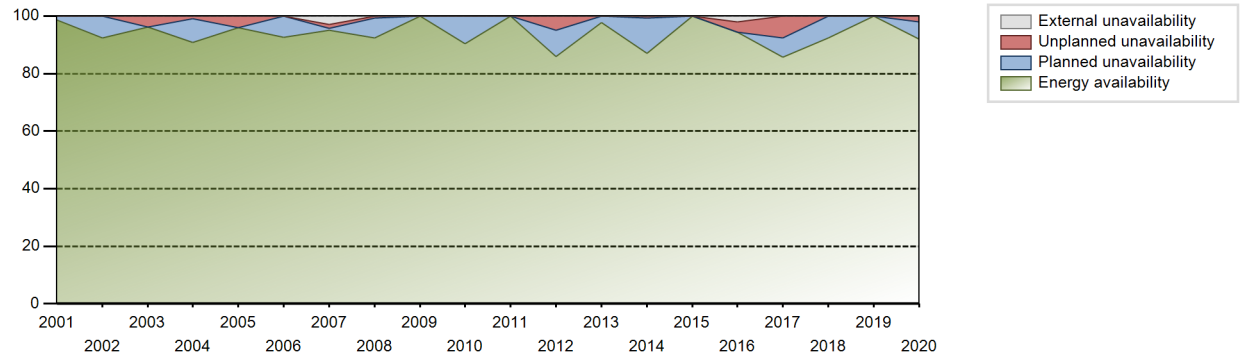


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	2153.70	4369	819	100.00	100.00	50.37	70.13	0.00	0.00	0.00	0.00
1976	4156.40	6284	670	70.45	70.45	70.62	71.54	21.74	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

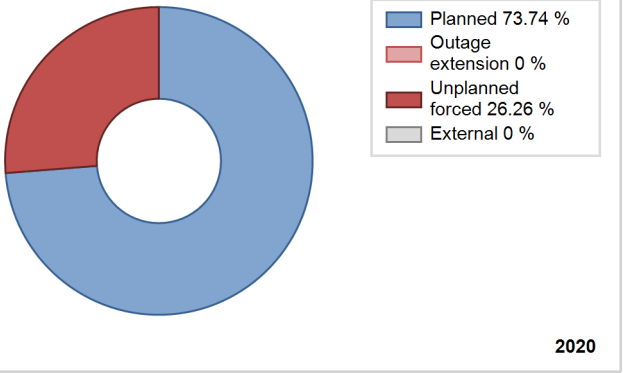
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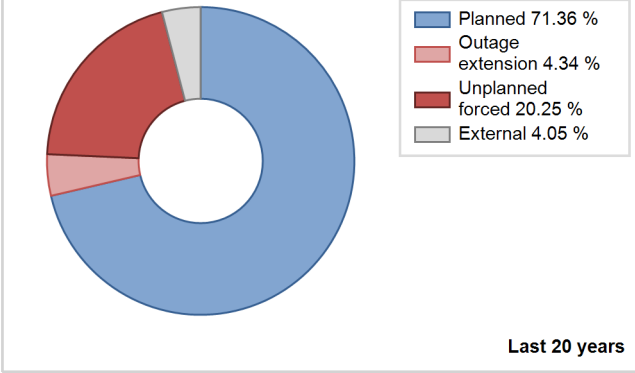
2012	6070.46	7536	813	85.81	85.81	85.00	85.79	5.48	4.97	9.22	0.00
2013	6839.79	8557	813	97.68	97.68	96.03	97.67	0.00	0.00	2.32	0.00
2014	5828.69	7627	813	87.08	87.08	81.84	87.07	0.85	0.75	12.18	0.00
2015	7382.19	8760	813	100.00	100.00	103.66	100.00	0.00	0.00	0.00	0.00
2016	5857.96	8302	813	94.50	96.49	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					334	
B.	Refuelling without maintenance	516			26		
C.	Inspection, maintenance or repair combined with refuelling				926		
D.	Inspection, maintenance or repair without refuelling				181		
E.	Testing of plant systems or components				2	3	
H.	Nuclear regulatory requirements					102	
J.	Grid limitation, failure or grid unavailability						4
L.	Human factor related					41	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						12
Z.	Other		184		3	19	
Subtotal		516	184		1138	499	16
Total			**700**			**1653**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		18
12. Reactor I&C Systems		17
13. Reactor Auxiliary Systems		6
14. Safety Systems		63
15. Reactor Cooling Systems		41
17. Safety I&C Systems (excluding reactor I&C)		0
21. Fuel Handling and Storage Facilities		15
31. Turbine and auxiliaries		53
32. Feedwater and Main Steam System		29
33. Circulating Water System		5
34. Miscellaneous Systems		25
35. All other I&C Systems		5
41. Main Generator Systems		18
42. Electrical Power Supply Systems		48
Total		**343**

Highlights (2020)

Unit was at reduced power of 38% when auto scram occurred as a result of main turbine trip on high RPV water level.

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2020 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	:	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 [%]	:	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

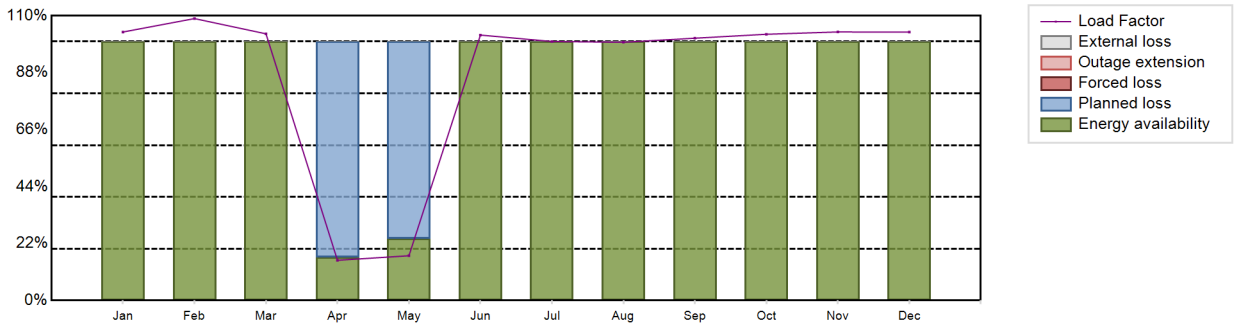
Operating coolant pressure [MPa]	:	15.82
Reactor outlet temperature [°C]	:	317
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.423
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	4353.1 GW(e).h
Energy Availability Factor (EAF)	:	86.73 %
Unit Capability Factor (UCF)	:	86.73 %
Load Factor (LF)	:	88.49 %
Operating Factor (OF)	:	86.73 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	13.27 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1166 hours

Annual Summary



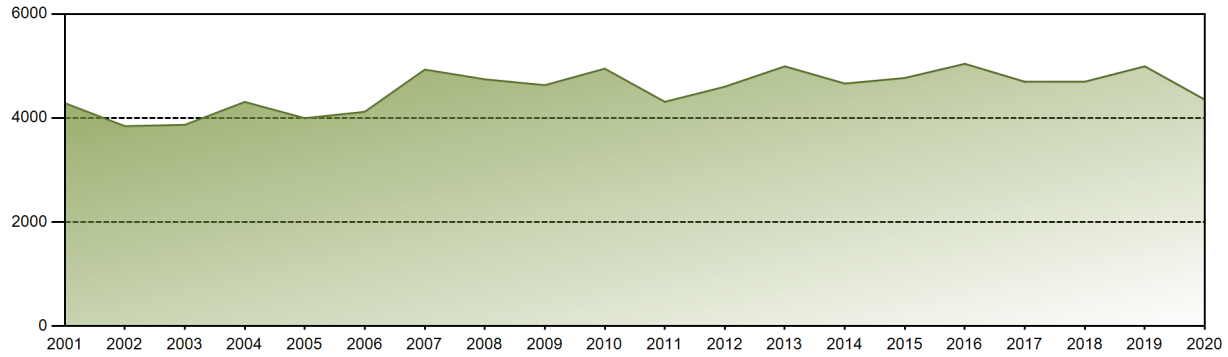
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	432.05	424.41	429.20	62.64	72.04	413.35	416.83	415.55	408.49	428.43	418.27	431.84	4353.10
EAF [%]	100.00	100.00	100.00	16.67	24.02	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.73
UCF [%]	100.00	100.00	100.00	16.67	24.02	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.73
LF [%]	103.70	108.89	103.01	15.54	17.29	102.52	100.05	99.74	101.31	102.83	103.74	103.65	88.49
OF [%]	100.00	100.00	99.87	16.67	24.06	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.73
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	0.00	83.33	75.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.27
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

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Historical Summary

Lifetime energy generation	:	190020.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.6 %
Cumulative Energy Availability Factor (EAF)	:	87.23 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.33 %
Cumulative Unit Capability Factor (UCF)	:	87.24 %	Cumulative Planned Unavailability Factor (PUF)	:	10.43 %
Cumulative Load Factor (LF)	:	85.2 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	86.3 %			

Electricity Production (net) [GWh]

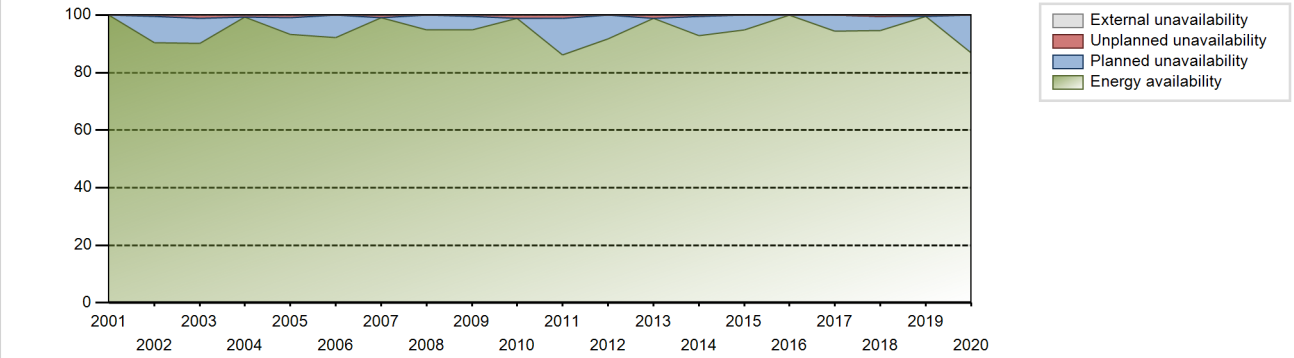


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1970	2313.00	6079	448	100.00	100.00	80.72	87.59	0.00	0.00	0.00	0.00
1971	2871.80	6592	493	100.00	100.00	66.50	75.25	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

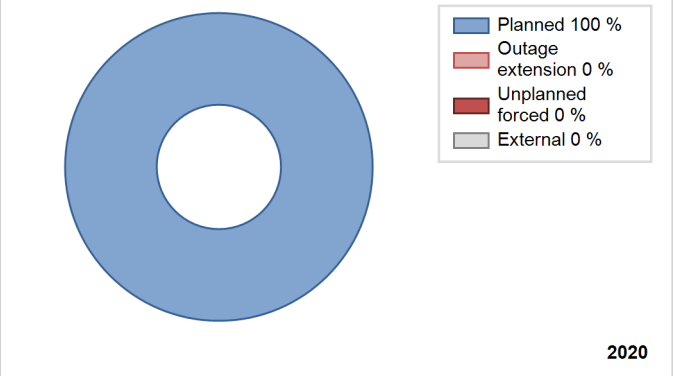
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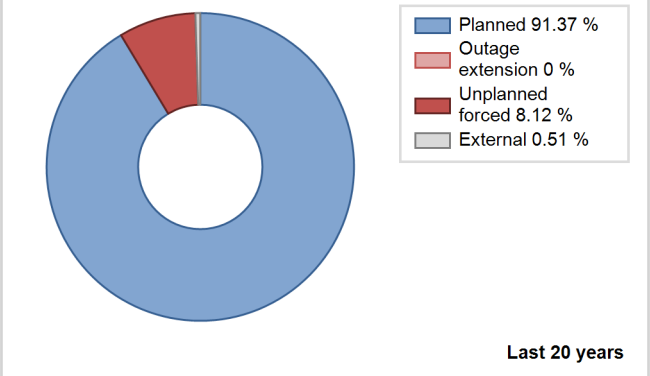
2007	4930.53	8675	560	99.15	99.15	100.51	99.03	0.85	0.85	0.00	0.00
2008	4744.00	8280	560	94.92	94.92	96.44	94.26	0.00	0.00	5.08	0.00
2009	4630.90	8235	580	94.87	94.87	91.15	94.01	0.45	0.43	4.70	0.00
2010	4948.36	8654	580	98.79	98.79	97.39	98.79	1.21	1.21	0.00	0.00
2011	4311.21	7539	580	86.08	86.08	84.85	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1970 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					163	
B. Refuelling without maintenance	1165			32		
C. Inspection, maintenance or repair combined with refuelling				917		
D. Inspection, maintenance or repair without refuelling				56		
E. Testing of plant systems or components				15	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	1165			1020	174	2
Total	**1165**			**1196**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1970 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		2
14. Safety Systems		13
15. Reactor Cooling Systems		8
16. Steam generation systems		34
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System		27
33. Circulating Water System		4
34. Miscellaneous Systems		15
35. All other I&C Systems		1
41. Main Generator Systems		2
42. Electrical Power Supply Systems		14
Total		**171**

Highlights (2020)

Refueling Outage 41.

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2020 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

Reactor type and model	:	BWR / BWR-6 (Mark 3)
Thermal power	:	4408 MWth
Gross electrical power	:	1500 MWe
Reference unit power (net)	:	1401 MWe

Key Dates

Construction Date	:	1974-05-04
Grid Date	:	1984-10-20
Commercial Date	:	1985-07-01
Age at end of year	:	36 years

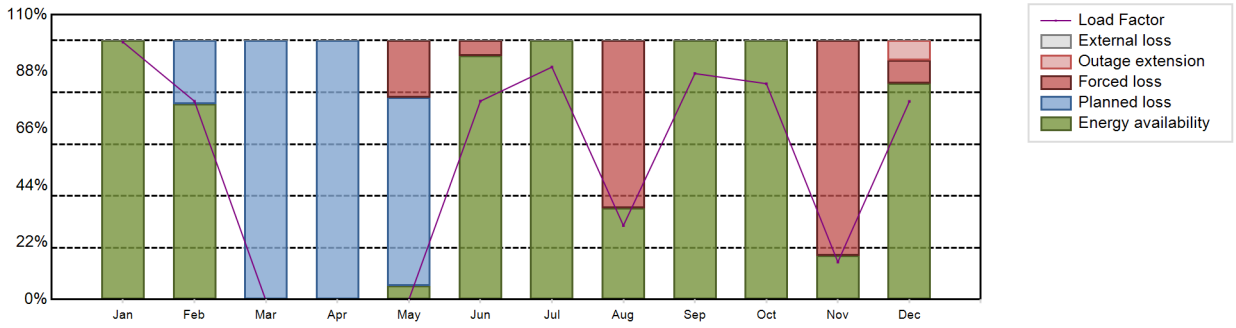
Design Characteristics

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 (2020)

Net Energy Production	:	6470.93 GW(e).h	Forced Loss Rate (FLR)	:	20.62 %
Energy Availability Factor (EAF)	:	59.21 %	Unplanned Capability Loss Factor (UCL)	:	16.02 %
Unit Capability Factor (UCF)	:	59.21 %	Planned Unavailability Factor (PUF)	:	24.77 %
Load Factor (LF)	:	52.58 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	59.22 %	Total off-line time	:	3582 hours

Annual Summary



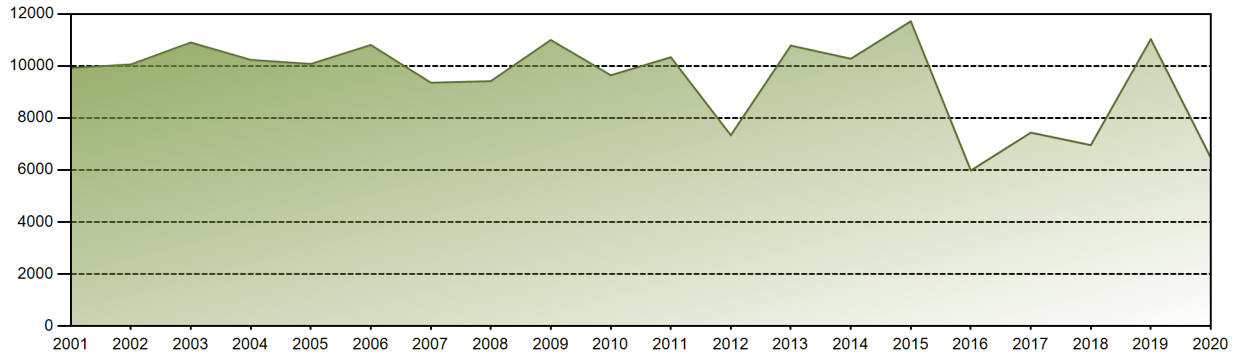
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	1036.23	746.82	-4.51	-7.06	0.41	772.96	935.85	297.81	880.38	868.89	145.99	797.18	6470.93
EAF [%]	100.00	75.43	0.13	0.00	5.22	94.25	100.00	35.30	100.00	100.00	17.03	83.40	59.21
UCF [%]	100.00	75.43	0.13	0.00	5.22	94.25	100.00	35.30	100.00	100.00	17.03	83.40	59.21
LF [%]	99.41	76.59	-0.43	-0.70	0.04	76.63	89.78	28.57	87.28	83.36	14.47	76.48	52.58
OF [%]	100.00	75.43	0.00	0.00	5.24	94.31	100.00	35.35	100.00	100.00	17.22	83.33	59.22
FLR [%]	0.00	0.00	0.00	0.00	80.79	5.75	0.00	64.70	0.00	0.00	82.97	9.80	20.62
UCL [%]	0.00	0.00	0.00	0.00	21.97	5.75	0.00	64.70	0.00	0.00	82.97	16.60	16.02
PUF [%]	0.00	24.57	99.87	100.00	72.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.77
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

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Historical Summary

Lifetime energy generation	:	356257.08 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.43 %
Cumulative Energy Availability Factor (EAF)	:	84.02 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.81 %
Cumulative Unit Capability Factor (UCF)	:	84.2 %	Cumulative Planned Unavailability Factor (PUF)	:	9.99 %
Cumulative Load Factor (LF)	:	82.76 %	Cumulative Externally cause unavailability (XUF)	:	0.17 %
Cumulative Operating Factor (OF)	:	84.6 %			

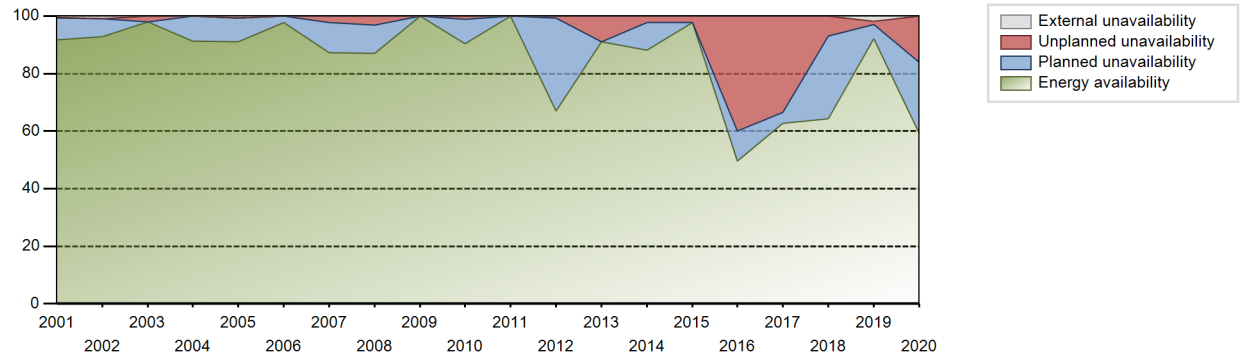
Electricity Production (net) [GWh]



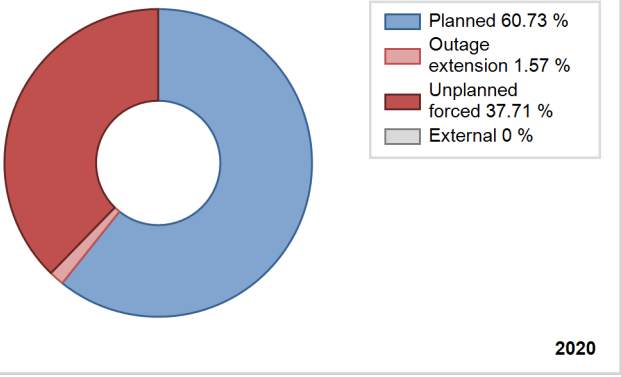
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	4316.40	5042	1108	58.70	58.70	54.23	60.92	11.21	7.41	33.89	0.00
1986	4098.05	5326	1108	60.54	60.54	42.22	60.80	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

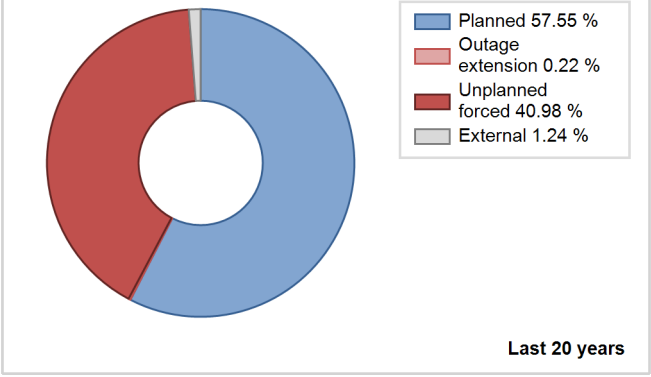
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					392	
B. Refuelling without maintenance	2176			61		
C. Inspection, maintenance or repair combined with refuelling				711	13	
D. Inspection, maintenance or repair without refuelling				101		
E. Testing of plant systems or components				0	0	
H. Nuclear regulatory requirements					1	
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					24	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						18
Z. Other		1351	56		58	4
Subtotal	2176	1351	56	873	488	24
Total		**3583**			**1385**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		22
13. Reactor Auxiliary Systems		93
14. Safety Systems		47
15. Reactor Cooling Systems		31
17. Safety I&C Systems (excluding reactor I&C)		9
31. Turbine and auxiliaries		69
32. Feedwater and Main Steam System		50
33. Circulating Water System		2
34. Miscellaneous Systems		31
35. All other I&C Systems		4
41. Main Generator Systems		30
42. Electrical Power Supply Systems		42
Total		**432**

Highlights (2020)

Automatic scram due to low flow on the generator primary water bushing.

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2020 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

Reactor type and model	:	PWR / WH 3LP (DRYAMB)
Thermal power	:	2900 MWth
Gross electrical power	:	980 MWe
Reference unit power (net)	:	964 MWe

Key Dates

Construction Date	:	1978-01-28
Grid Date	:	1987-01-19
Commercial Date	:	1987-05-02
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]	:	31500
Active core diameter [m]	:	3.03
Active core height/length [m]	:	3.66
Number of fissile fuel assemblies/bundles	:	157
Fuel linear heat generation rate [kW/m]	:	-
Number of control rod assemblies	:	52
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

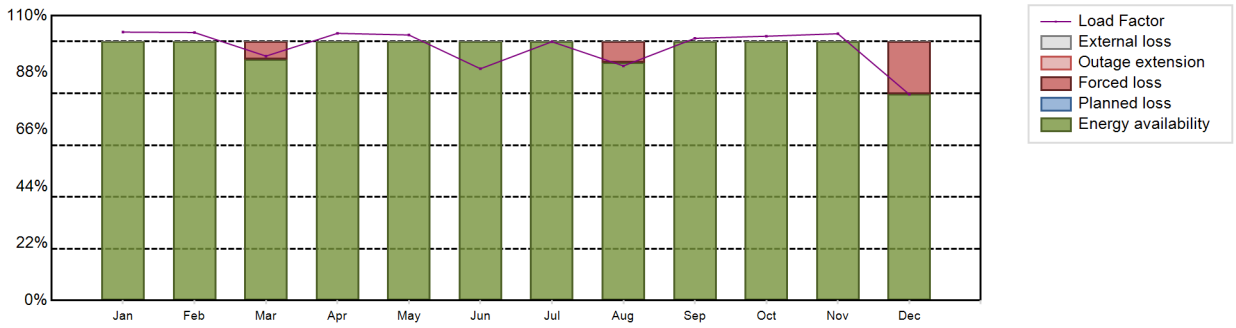
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	326
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.32
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.56
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 (2020)

Net Energy Production	:	8275.59 GW(e).h
Energy Availability Factor (EAF)	:	97.02 %
Unit Capability Factor (UCF)	:	97.02 %
Load Factor (LF)	:	97.73 %
Operating Factor (OF)	:	97.01 %

Forced Loss Rate (FLR)	:	2.98 %
Unplanned Capability Loss Factor (UCL)	:	2.98 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	263 hours

Annual Summary



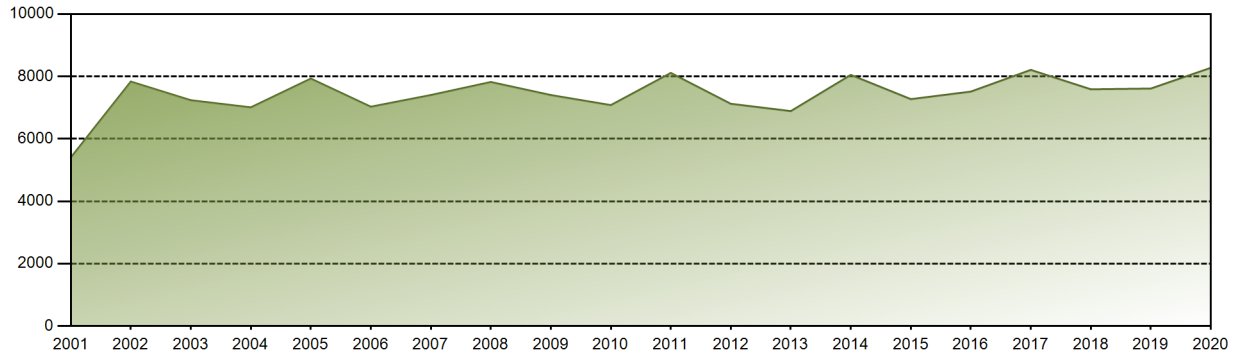
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	743.48	694.49	677.01	716.21	735.53	621.29	716.87	649.87	702.75	732.02	715.18	570.90	8275.59
EAF [%]	100.00	100.00	93.08	100.00	100.00	100.00	100.00	92.03	100.00	100.00	100.00	79.72	97.02
UCF [%]	100.00	100.00	93.08	100.00	100.00	100.00	100.00	92.03	100.00	100.00	100.00	79.72	97.02
LF [%]	103.66	103.51	94.39	103.19	102.55	89.51	99.95	90.61	101.25	102.06	103.04	79.60	97.73
OF [%]	100.00	100.00	92.88	100.00	100.00	100.00	100.00	92.07	100.00	100.00	100.00	79.70	97.01
FLR [%]	0.00	0.00	6.92	0.00	0.00	0.00	0.00	7.97	0.00	0.00	0.00	20.28	2.98
UCL [%]	0.00	0.00	6.92	0.00	0.00	0.00	0.00	7.97	0.00	0.00	0.00	20.28	2.98
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

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Historical Summary

Lifetime energy generation	:	208718.94 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.89 %
Cumulative Energy Availability Factor (EAF)	:	89.42 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.73 %
Cumulative Unit Capability Factor (UCF)	:	89.45 %	Cumulative Planned Unavailability Factor (PUF)	:	8.82 %
Cumulative Load Factor (LF)	:	89.3 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	89.27 %			

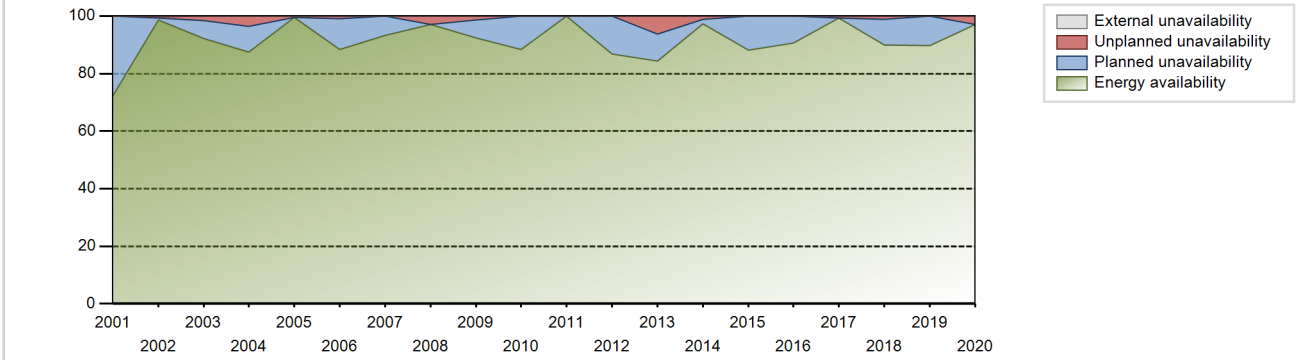
Electricity Production (net) [GWh]



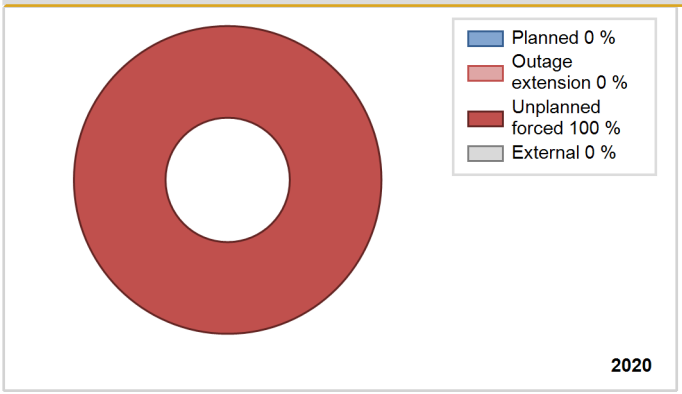
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	Data not provided										
1988	5345.56	6458	860	73.56	73.56	70.76	73.52	4.05	3.10	23.34	0.00
1989	5638.85	6873	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

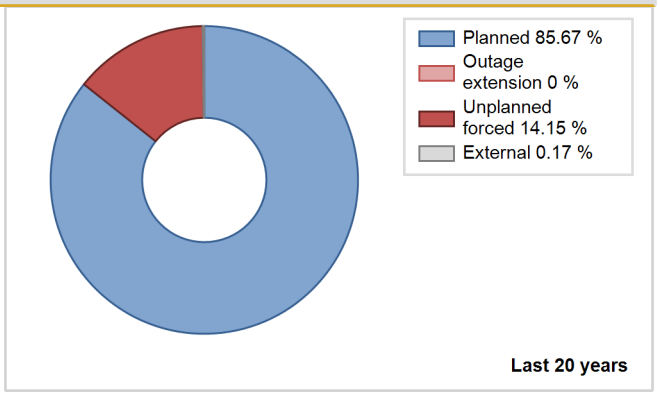
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					133	
C. Inspection, maintenance or repair combined with refuelling				733		
D. Inspection, maintenance or repair without refuelling				49		
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		262			10	
Subtotal		262		783	144	3
Total		**262**			**930**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		8
14. Safety Systems		1
15. Reactor Cooling Systems		5
16. Steam generation systems		3
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		50
32. Feedwater and Main Steam System		33
34. Miscellaneous Systems		3
41. Main Generator Systems		10
42. Electrical Power Supply Systems		4
Total		**135**

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Highlights (2020)

Automatic scram due to a fault on the non-segregated bus from the 1B aux transformer to the 1B aux bus.

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2020 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	:	46 years

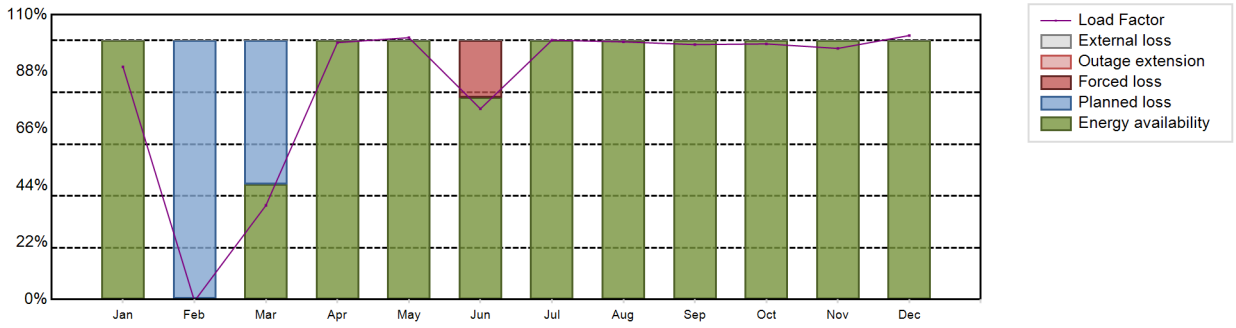
Design Characteristics

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]	:	17000	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 (2020)

Net Energy Production	:	6410.21 GW(e).h	Forced Loss Rate (FLR)	:	2.07 %
Energy Availability Factor (EAF)	:	85.6 %	Unplanned Capability Loss Factor (UCL)	:	1.81 %
Unit Capability Factor (UCF)	:	85.6 %	Planned Unavailability Factor (PUF)	:	12.59 %
Load Factor (LF)	:	83.31 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	85.59 %	Total off-line time	:	1266 hours

Annual Summary



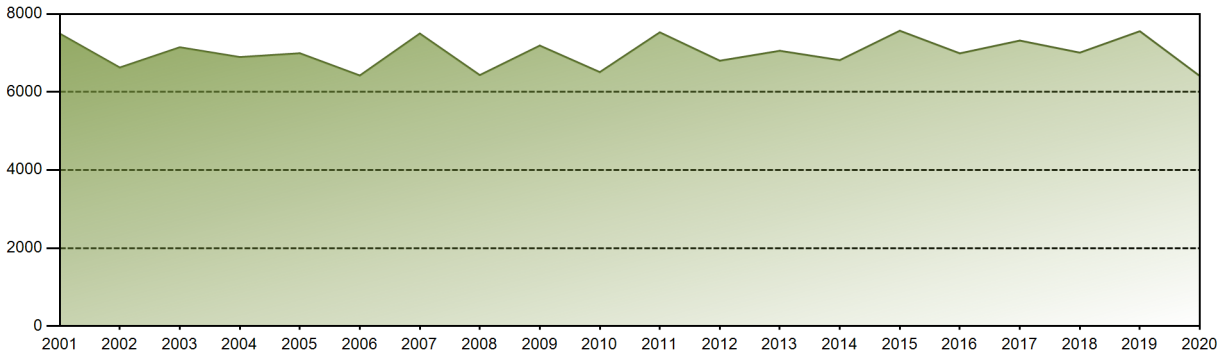
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	585.59	-3.59	237.13	625.74	659.05	464.45	652.70	648.60	620.95	643.42	611.65	664.53	6410.21
EAF [%]	100.00	0.43	44.45	100.00	100.00	77.96	100.00	100.00	100.00	100.00	100.00	100.00	85.60
UCF [%]	100.00	0.43	44.45	100.00	100.00	77.96	100.00	100.00	100.00	100.00	100.00	100.00	85.60
LF [%]	89.85	-0.59	36.38	99.21	101.12	73.64	100.15	99.52	98.45	98.72	96.98	101.96	83.31
OF [%]	100.00	0.43	44.35	100.00	100.00	77.92	100.00	100.00	100.00	100.00	100.00	100.00	85.59
FLR [%]	0.00	0.00	0.00	0.00	0.00	22.04	0.00	0.00	0.00	0.00	0.00	0.00	2.07
UCL [%]	0.00	0.00	0.00	0.00	0.00	22.04	0.00	0.00	0.00	0.00	0.00	0.00	1.81
PUF [%]	0.00	99.57	55.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.59
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

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Historical Summary

Lifetime energy generation	:	254052.46 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.02 %
Cumulative Energy Availability Factor (EAF)	:	83.73 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.42 %
Cumulative Unit Capability Factor (UCF)	:	83.75 %	Cumulative Planned Unavailability Factor (PUF)	:	11.83 %
Cumulative Load Factor (LF)	:	81.65 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	83.85 %			

Electricity Production (net) [GWh]

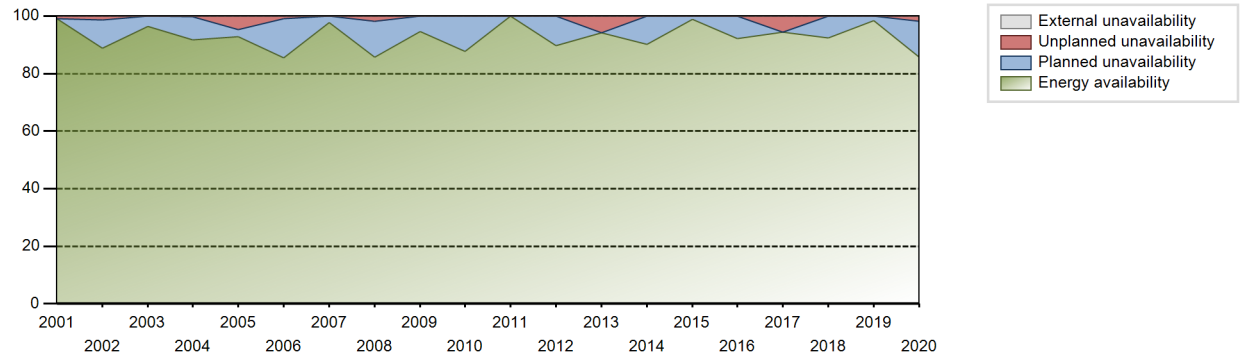


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	3095.80	6158	786	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	4133.80	7299	786	59.96	59.96	59.87	83.09	29.04	24.54	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

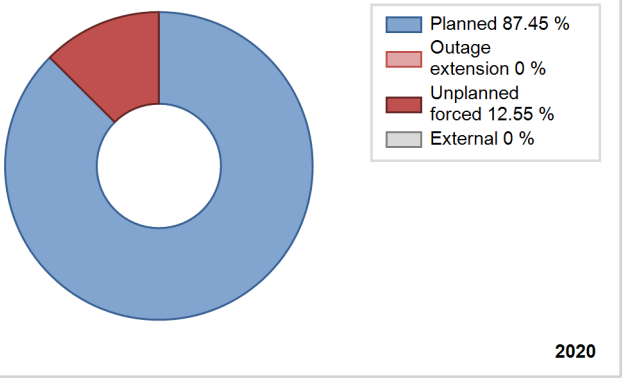
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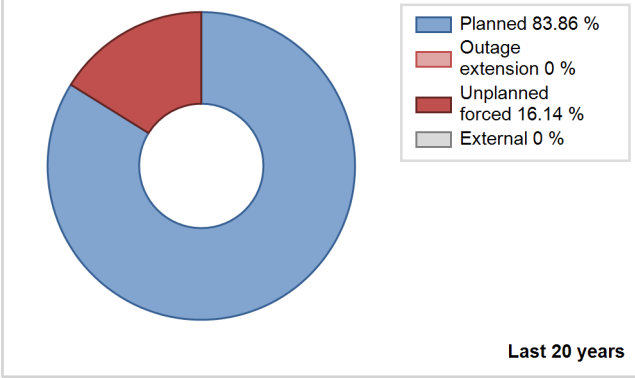
2012	6802.03	7876	876	89.69	89.69	88.40	89.66	0.00	0.00	10.31	0.00
2013	7056.54	8251	876	94.19	94.19	91.95	94.18	5.81	5.81	0.00	0.00
2014	6816.80	7901	876	90.20	90.20	88.83	90.19	0.00	0.00	9.80	0.00
2015	7570.54	8657	876	98.84	98.84	98.65	98.82	0.00	0.00	1.16	0.00
2016	6991.13	8096	876	92.16	92.16	90.86	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					290	
B. Refuelling without maintenance	1106			25		
C. Inspection, maintenance or repair combined with refuelling				927		
D. Inspection, maintenance or repair without refuelling				89		
E. Testing of plant systems or components				1	2	
J. Grid limitation, failure or grid unavailability						1
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
P. Fire					9	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					1	
Z. Other		159		2	39	
Subtotal	1106	159		1044	357	1
Total	**1265**			**1402**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		15
13. Reactor Auxiliary Systems		41
14. Safety Systems		27
15. Reactor Cooling Systems		37
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		62
32. Feedwater and Main Steam System		61
33. Circulating Water System		1
34. Miscellaneous Systems		16
35. All other I&C Systems		6
41. Main Generator Systems		22
42. Electrical Power Supply Systems		26
Total		**317**

Highlights (2020)

Refueling Outage 29

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	2804 MWth
Gross electrical power	:	921 MWe
Reference unit power (net)	:	883 MWe

Key Dates

Construction Date	:	1972-02-01
Grid Date	:	1978-09-22
Commercial Date	:	1979-09-05
Age at end of year	:	42 years

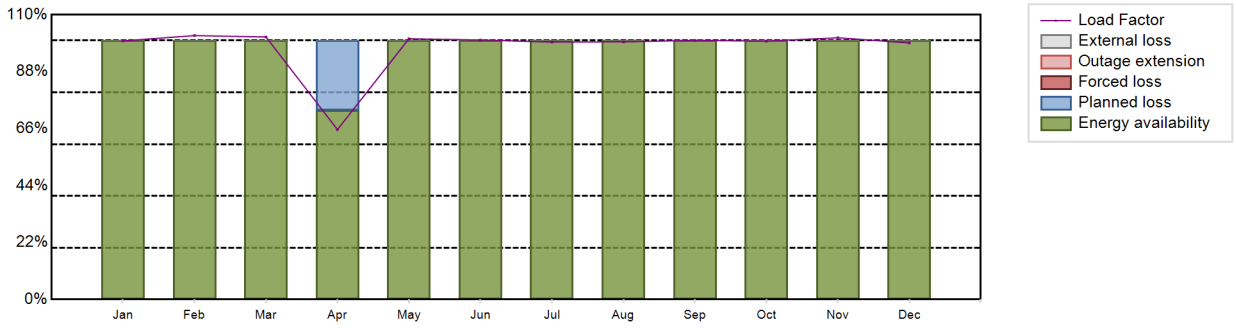
Design Characteristics

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 (2020)

Net Energy Production	:	7557.67 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	97.8 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	97.8 %	Planned Unavailability Factor (PUF)	:	2.2 %
Load Factor (LF)	:	97.44 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	97.79 %	Total off-line time	:	194 hours

Annual Summary



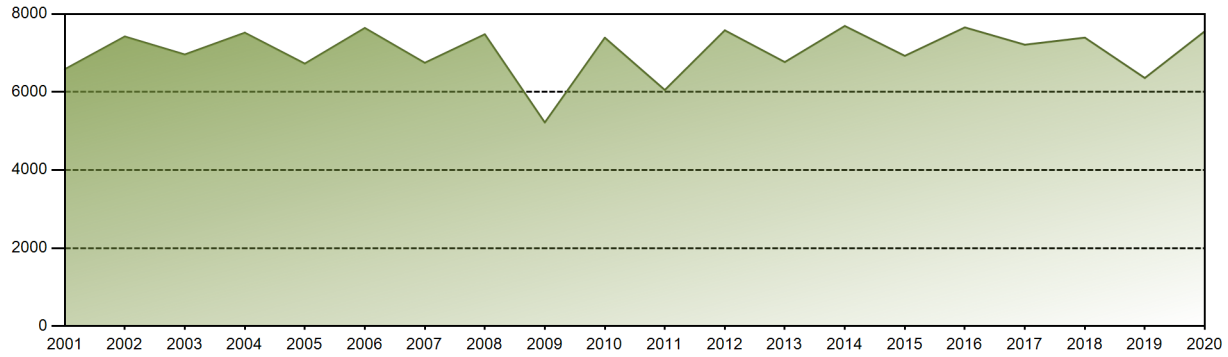
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	656.16	626.44	666.18	417.28	661.59	637.22	653.24	653.86	636.30	655.61	642.75	651.04	7557.67
EAF [%]	100.00	100.00	100.00	73.15	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.80
UCF [%]	100.00	100.00	100.00	73.15	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.80
LF [%]	99.88	101.93	101.41	65.63	100.71	100.23	99.43	99.53	100.08	99.79	101.10	99.10	97.44
OF [%]	100.00	100.00	99.87	73.19	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.79
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	26.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20
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

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Historical Summary

Lifetime energy generation	:	244831.75 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.98 %
Cumulative Energy Availability Factor (EAF)	:	85.4 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.62 %
Cumulative Unit Capability Factor (UCF)	:	85.44 %	Cumulative Planned Unavailability Factor (PUF)	:	11.94 %
Cumulative Load Factor (LF)	:	82.41 %	Cumulative Externally cause unavailability (XUF)	:	0.04 %
Cumulative Operating Factor (OF)	:	85.08 %			

Electricity Production (net) [GWh]

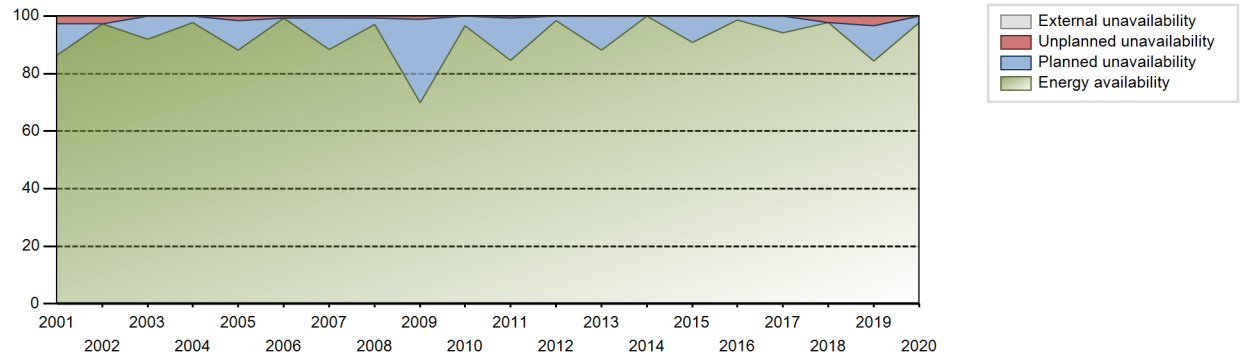


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1979	2632.60	4155	749	100.00	100.00	80.12	84.70	0.00	0.00	0.00	0.00
1980	3653.10	5269	767	59.14	61.00	54.22	59.98	9.09	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

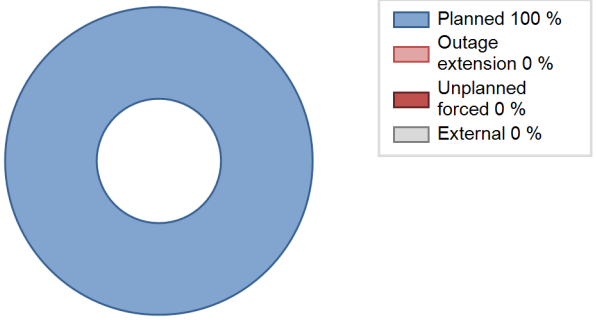
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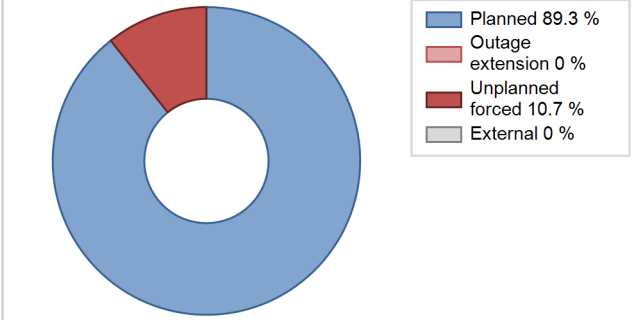
2016	7656.23	8657	883	98.55	98.55	98.71	98.55	0.00	0.00	1.45	0.00
2017	7212.21	8254	883	94.22	94.22	93.24	94.22	0.00	0.00	5.78	0.00
2018	7393.99	8562	883	97.74	97.74	95.59	97.74	2.26	2.26	0.00	0.00
2019	6358.89	7386	883	84.33	84.33	82.21	84.32	3.75	3.28	12.39	0.00
2020	7557.67	8590	883	97.80	97.80	97.44	97.79	0.00	0.00	2.20	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1979 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					186	
C. Inspection, maintenance or repair combined with refuelling				945		
D. Inspection, maintenance or repair without refuelling	193			134		
E. Testing of plant systems or components				12	66	
L. Human factor related					32	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				0		
Z. Other					29	
Subtotal	193			1091	313	
Total	**193**			**1404**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1979 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		25
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems		11
14. Safety Systems		4
15. Reactor Cooling Systems		100
31. Turbine and auxiliaries		28
32. Feedwater and Main Steam System		36
33. Circulating Water System		3
34. Miscellaneous Systems		6
41. Main Generator Systems		21
42. Electrical Power Supply Systems		11
Total		**261**

Highlights (2020)

Repair of drywell/torus vacuum breaker

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2020 Operating Experience

US-354 HOPE CREEK-1 UNITED STATES OF AMERICA

Status at end of year	:	**Operational**
Operator	:	PSEG (PSEG Nuclear, LLC)
Owner	:	PSEGPOWR (PSEG Power, 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	:	3840 MWth
Gross electrical power	:	1240 MWe
Reference unit power (net)	:	1172 MWe

Key Dates

Construction Date	:	1976-03-01
Grid Date	:	1986-08-01
Commercial Date	:	1986-12-20
Age at end of year	:	34 years

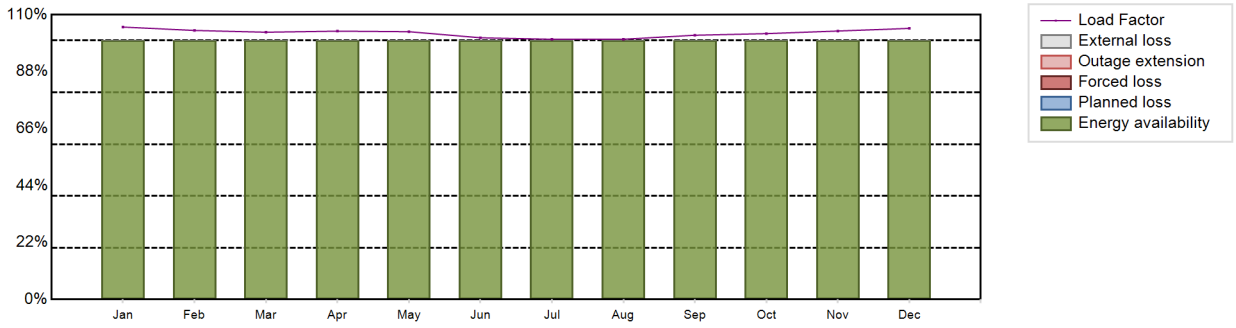
Design Characteristics

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]	:	30000
Active core diameter [m]	:	4.8
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	764
Fuel linear heat generation rate [kW/m]	:	17.52
Number of control rod assemblies	:	185
Number of external reactor coolant loops	:	2
Coolant type	:	H2O
Operating coolant pressure [MPa]	:	7.17
Reactor outlet temperature [°C]	:	287
Number of SG	:	NA
Containment type	:	Confinement
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]	:	6.56
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 (2020)

Net Energy Production	:	10592.7 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	102.89 %
Operating Factor (OF)	:	99.99 %
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	:	1 hours

Annual Summary



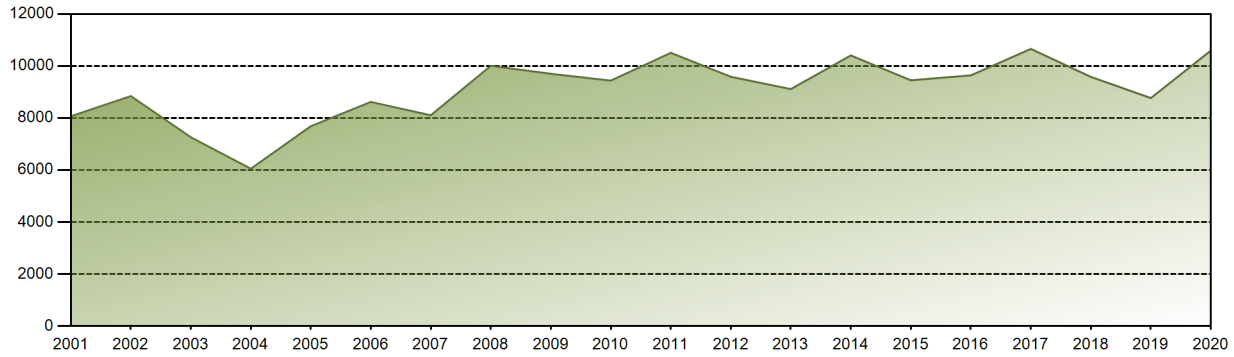
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	917.55	847.71	900.18	874.62	901.90	853.13	876.31	876.47	861.33	895.44	875.09	912.97	10592.70
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	105.23	103.92	103.24	103.65	103.43	101.10	100.50	100.52	102.07	102.69	103.70	104.70	102.89
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	296294.86 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.52 %
Cumulative Energy Availability Factor (EAF)	:	88.56 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.29 %
Cumulative Unit Capability Factor (UCF)	:	88.56 %	Cumulative Planned Unavailability Factor (PUF)	:	9.15 %
Cumulative Load Factor (LF)	:	87.72 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	87.86 %			

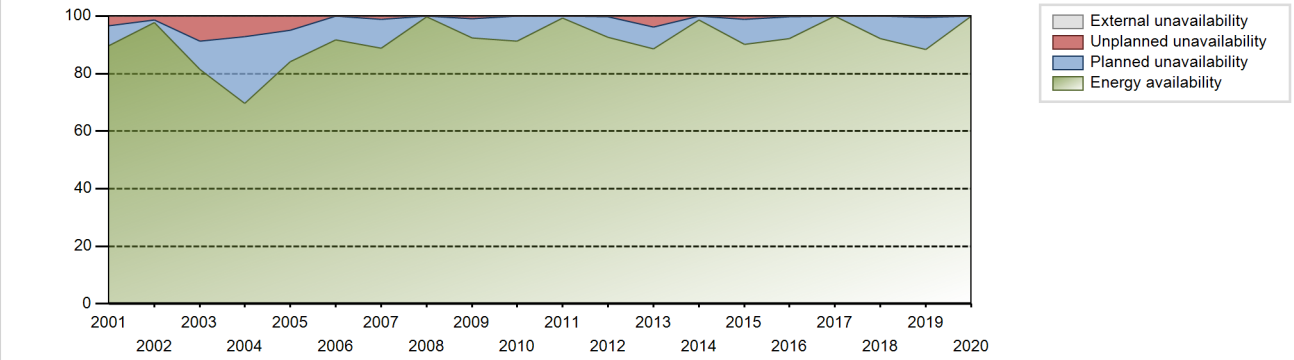
Electricity Production (net) [GWh]



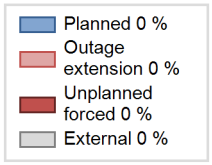
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	Data not provided										
1987	7308.74	7457	1067	92.67	92.67	78.19	85.13	4.09	3.95	3.38	0.00
1988	6470.87	6369	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

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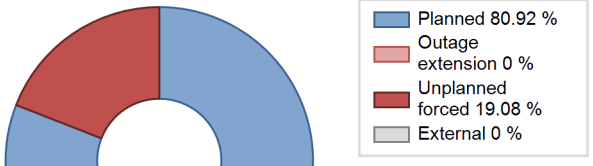
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					171	
C. Inspection, maintenance or repair combined with refuelling				728		
D. Inspection, maintenance or repair without refuelling				91		
E. Testing of plant systems or components				0		
L. Human factor related					15	
P. Fire					1	
Z. Other					3	
Subtotal				819	190	
Total		**0**			**1009**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		7
13. Reactor Auxiliary Systems		22
15. Reactor Cooling Systems		27
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		31
32. Feedwater and Main Steam System		25
33. Circulating Water System		7
34. Miscellaneous Systems		1
35. All other I&C Systems		1
41. Main Generator Systems		15
42. Electrical Power Supply Systems		24
Total		**175**

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2020 Operating Experience

US-247 INDIAN POINT-2 UNITED STATES OF AMERICA



Status at end of year	:	**Permanent Shutdown**
Operator	:	ENTERGY (Entergy Nuclear Operations, Inc.)
Owner	:	ENTERGY (Entergy Nuclear Operations, Inc.)
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	:	3216 MWth
Gross electrical power	:	1067 MWe
Reference unit power (net)	:	998 MWe

Key Dates

Construction Date	:	1966-10-14
Grid Date	:	1973-06-26
Commercial Date	:	1974-08-01
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]	:	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]	:	18.81
Number of control rod assemblies	:	29
Number of external reactor coolant loops	:	4
Coolant type	:	H2O

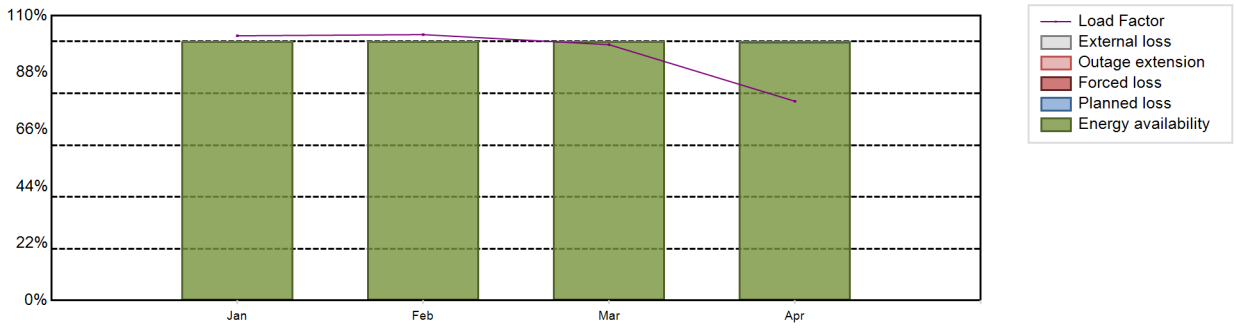
Operating coolant pressure [MPa]	:	15.82
Reactor outlet temperature [°C]	:	309
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	-
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	5.09
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 (2020)

Net Energy Production	:	2759.08 GW(e).h
Energy Availability Factor (EAF)	:	99.97 %
Unit Capability Factor (UCF)	:	99.97 %
Load Factor (LF)	:	95.2 %
Operating Factor (OF)	:	99.93 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	0.03 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	2 hours

Annual Summary



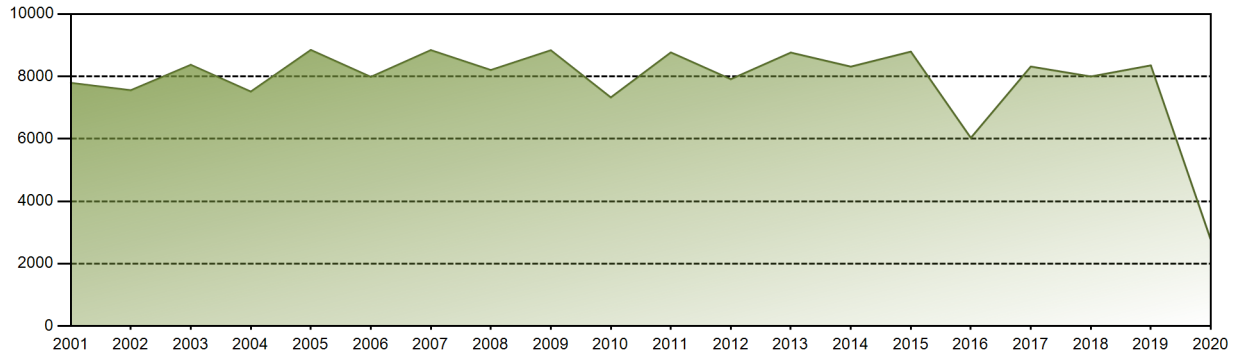
	Oct	Nov	Dec	May	Sep	Jun	Jul	Aug	Jan	Feb	Mar	Apr	Annual
GW(e)-h									759.14	713.31	733.66	552.97	2759.08
EAF [%]									100.00	100.00	100.00	99.86	99.97
UCF [%]									100.00	100.00	100.00	99.86	99.97
LF [%]									102.24	102.69	98.81	76.96	95.20
OF [%]									100.00	100.00	99.87	99.86	99.93
FLR [%]									0.00	0.00	0.00	0.00	0.00
UCL [%]									0.00	0.00	0.00	0.00	0.00
PUF [%]									0.00	0.00	0.00	0.14	0.03
XUF [%]									0.00	0.00	0.00	0.00	0.00

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Historical Summary

Lifetime energy generation	:	291542.82 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	8.99 %
Cumulative Energy Availability Factor (EAF)	:	77.36 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.65 %
Cumulative Unit Capability Factor (UCF)	:	77.42 %	Cumulative Planned Unavailability Factor (PUF)	:	14.93 %
Cumulative Load Factor (LF)	:	75.81 %	Cumulative Externally cause unavailability (XUF)	:	0.06 %
Cumulative Operating Factor (OF)	:	77.68 %			

Electricity Production (net) [GWh]

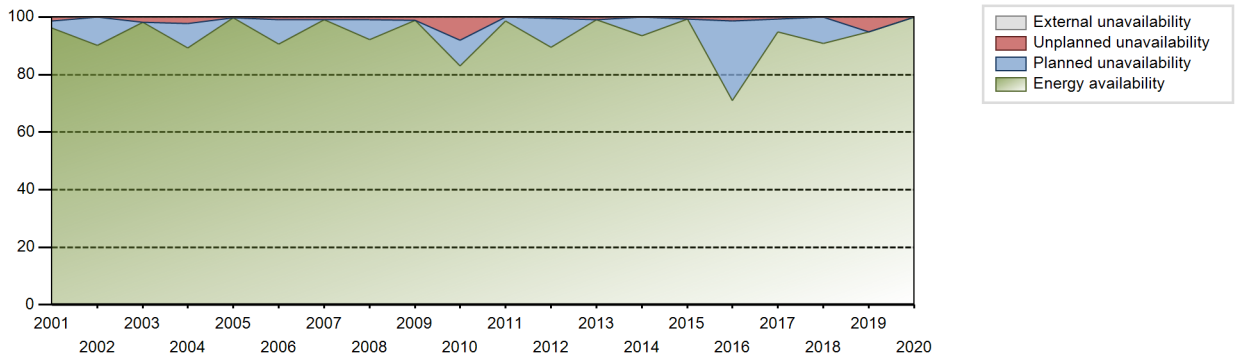


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	3329.00	5220	873	79.85	79.85	63.54	79.87	3.72	3.09	17.07	0.00
1975	4646.00	6545	865	61.32	61.32	61.31	74.71	15.45	11.20	27.48	0.00
1976	2287.10	3054	864	30.18	30.18	30.14	34.77	9.08	3.01	66.81	0.00
1977	5210.30	6626	864	68.90	68.90	68.84	75.64	19.73	16.93	14.17	0.00
1978	4372.90	5503	859	58.22	58.22	58.11	62.82	6.52	4.06	37.72	0.00
1979	4808.40	6156	856	64.07	64.07	64.12	70.27	8.64	6.06	29.87	0.00
1980	4273.20	5689	856	63.87	66.77	56.83	64.77	11.90	9.02	24.21	2.89
1981	3065.00	4027	856	44.90	44.90	40.87	45.97	21.36	12.20	42.91	0.00
1982	4458.60	5726	862	65.01	65.01	59.05	65.37	7.80	5.50	29.49	0.00
1983	5895.30	7354	859	83.49	83.49	78.34	83.95	9.94	9.21	7.30	0.00
1984	2891.63	4552	864	48.37	48.37	38.10	51.82	16.36	9.46	42.16	0.00
1985	6665.04	8382	855	95.51	95.51	88.97	95.68	3.73	3.70	0.79	0.00
1986	3827.37	4924	855	52.63	52.63	51.09	56.21	13.13	7.95	39.42	0.00
1987	5149.59	6331	852	69.77	69.77	68.94	72.27	2.16	1.54	28.69	0.00
1988	6063.99	7247	856	81.02	81.02	80.60	82.50	3.98	3.36	15.62	0.00
1989	4476.87	5556	856	60.35	60.35	59.67	63.42	2.22	1.37	38.28	0.00
1990	5222.15	5779	886	64.30	64.30	67.20	65.97	1.63	1.07	34.64	0.00
1991	3873.43	4495	929	51.22	51.22	47.60	51.31	6.87	3.78	45.01	0.00
1992	7880.64	8494	939	96.70	96.70	95.54	96.70	3.30	3.30	0.00	0.00
1993	5931.71	6570	941	75.27	75.27	71.96	75.00	3.04	2.36	22.37	0.00
1994	7634.60	8760	941	100.00	100.00	92.62	100.00	0.00	0.00	0.00	0.00
1995	4896.89	5533	941	63.62	63.62	59.41	63.16	4.88	3.26	33.12	0.00
1996	7831.79	8261	941	94.17	94.17	94.75	94.05	2.37	2.29	3.55	0.00
1997	3179.72	3639	936	41.74	41.74	38.78	41.54	48.15	38.76	19.50	0.00
1998	2512.52	2698	932	30.95	30.95	30.75	30.80	69.05	69.05	0.00	0.00
1999	7300.44	7665	937	87.60	87.60	88.88	87.50	12.40	12.40	0.00	0.00
2000	1062.31	1099	941	12.51	12.51	12.85	12.51	87.49	87.49	0.00	0.00
2001	7792.73	8429	951	96.20	96.20	94.54	96.22	1.42	1.39	2.42	0.00
2002	7556.55	7931	951	90.25	90.25	91.67	90.54	0.00	0.00	9.75	0.00
2003	8370.81	8597	956	98.12	98.12	100.30	98.14	1.88	1.88	0.00	0.00
2004	7513.09	7851	956	89.31	89.31	89.47	89.38	2.42	2.21	8.48	0.00
2005	8847.09	8730	965	99.66	99.66	104.65	99.65	0.34	0.34	0.00	0.00
2006	7984.68	7937	1020	90.63	90.63	89.36	90.61	1.03	0.94	8.42	0.00
2007	8842.64	8679	1020	99.09	99.09	98.96	99.08	0.91	0.91	0.00	0.00
2008	8205.17	8088	1020	92.09	92.09	91.58	92.08	0.99	0.92	6.99	0.00
2009	8837.44	8667	1025	98.96	98.96	98.42	98.94	1.04	1.04	0.00	0.00
2010	7325.92	7267	1022	82.94	82.94	81.83	82.96	8.75	7.96	9.10	0.00

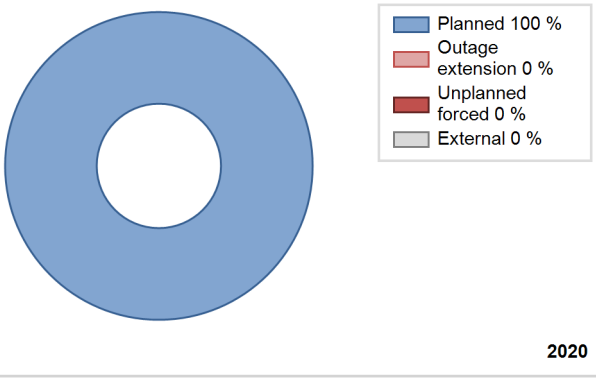
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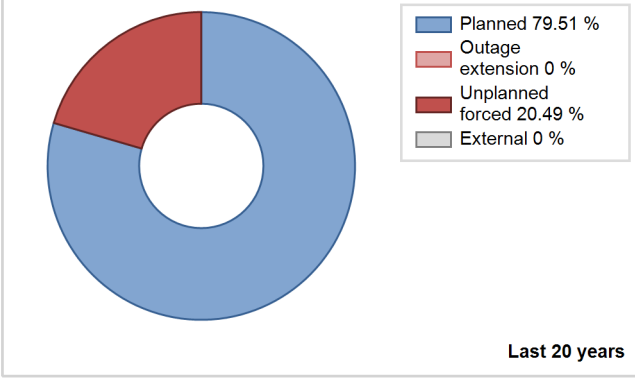
2011	8767.22	8648	1022	98.72	98.72	97.93	98.72	0.00	0.00	1.28	0.00
2012	7911.30	7867	1020	89.59	89.59	88.30	89.56	0.47	0.42	9.99	0.00
2013	8763.08	8675	1020	99.02	99.02	98.06	99.02	0.98	0.98	0.00	0.00
2014	8313.12	8194	1020	93.54	93.54	93.04	93.54	0.00	0.00	6.46	0.00
2015	8793.59	8691	1020	99.21	99.21	98.42	99.21	0.79	0.79	0.00	0.00
2016	6030.06	6226	1020	70.88	70.88	67.30	70.88	1.76	1.27	27.85	0.00
2017	8315.20	8301	1020	94.75	94.75	93.06	94.76	0.76	0.72	4.52	0.00
2018	7997.10	7957	998	90.83	90.83	91.47	90.83	0.00	0.00	9.17	0.00
2019	8352.75	8301	998	94.77	94.77	95.54	94.76	5.23	5.23	0.00	0.00
2020	2759.08	2902	998	99.97	99.97	95.20	99.93	0.00	0.00	0.03	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					800	
C. Inspection, maintenance or repair combined with refuelling				959		
D. Inspection, maintenance or repair without refuelling				234		
E. Testing of plant systems or components				20		
H. Nuclear regulatory requirements					5	
J. Grid limitation, failure or grid unavailability						6
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
Z. Other	1			4	9	
Subtotal	1			1217	821	8
Total	**1**			**2046**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		44
13. Reactor Auxiliary Systems		7
14. Safety Systems		8
15. Reactor Cooling Systems		56
16. Steam generation systems		64
17. Safety I&C Systems (excluding reactor I&C)		8
21. Fuel Handling and Storage Facilities		63
31. Turbine and auxiliaries		49
32. Feedwater and Main Steam System		263
34. Miscellaneous Systems		0
35. All other I&C Systems		2
41. Main Generator Systems		49
42. Electrical Power Supply Systems		186
Total		**801**

Highlights (2020)

Indian Point Unit 2 was permanently shut down on April 30,2020 at 2300.

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2020 Operating Experience

US-286 INDIAN POINT-3 UNITED STATES OF AMERICA



Status at end of year	:	**Permanent Shutdown**
Operator	:	ENTERGY (Entergy Nuclear Operations, Inc.)
Owner	:	ENTERGY (Entergy Nuclear Operations, Inc.)
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	:	3216 MWth
Gross electrical power	:	1085 MWe
Reference unit power (net)	:	1030 MWe

Key Dates

Construction Date	:	1968-11-01
Grid Date	:	1976-04-27
Commercial Date	:	1976-08-30
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]	:	24
Part of the core refuelled [%]	:	16
Average discharge burnup [MWd/t]	:	14000
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
Number of control rod assemblies	:	29
Number of external reactor coolant loops	:	4
Coolant type	:	H2O

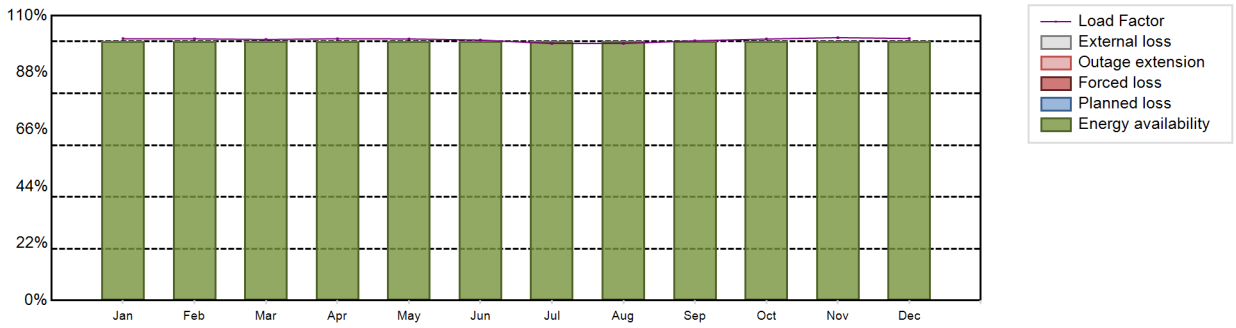
Operating coolant pressure [MPa]	:	17.47
Reactor outlet temperature [°C]	:	315.8
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.33
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	5.028
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 (2020)

Net Energy Production	:	9108.82 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	100.68 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



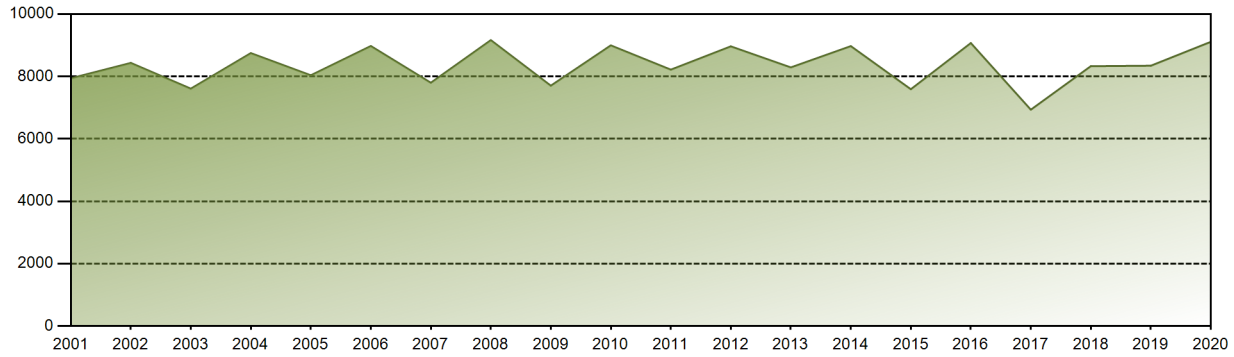
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	774.80	724.48	772.62	749.75	774.20	745.88	760.53	760.52	743.81	773.87	752.97	775.41	9108.82
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	101.11	101.06	100.82	101.10	101.03	100.58	99.24	99.24	100.30	100.99	101.53	101.19	100.68
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	284724.26 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	13.6 %
Cumulative Energy Availability Factor (EAF)	:	75.14 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.83 %
Cumulative Unit Capability Factor (UCF)	:	75.16 %	Cumulative Planned Unavailability Factor (PUF)	:	13.01 %
Cumulative Load Factor (LF)	:	72.92 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	74.74 %			

Electricity Production (net) [GWh]

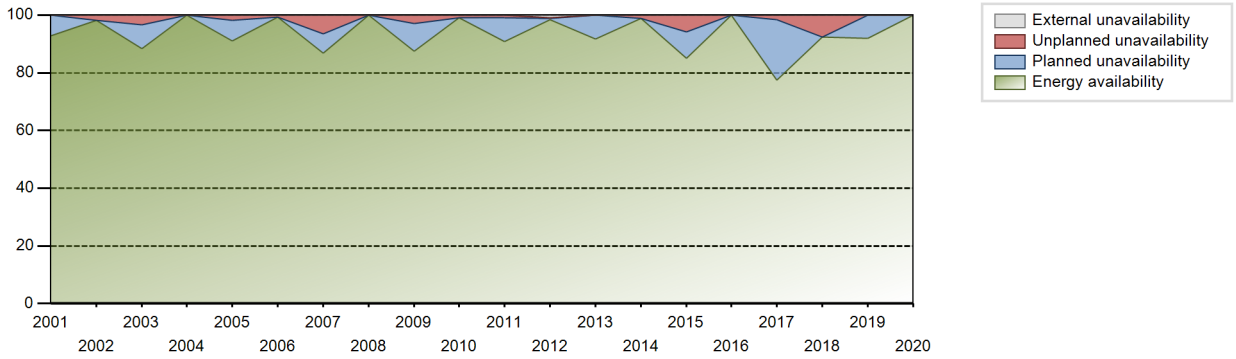


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	3072.00	4430	899	100.00	100.00	72.10	76.26	0.00	0.00	0.00	0.00
1977	5520.80	6556	873	72.11	72.11	72.19	74.84	6.36	4.90	22.99	0.00
1978	5457.60	6365	911	68.33	68.33	68.39	72.66	9.48	7.16	24.51	0.00
1979	4794.60	5824	965	56.72	56.72	56.72	66.48	8.66	5.38	37.90	0.00
1980	3070.40	4667	965	53.59	53.59	36.22	53.13	23.31	16.29	30.11	0.00
1981	3033.40	5236	965	59.44	59.44	35.88	59.77	37.25	35.29	5.27	0.00
1982	1436.10	1967	891	22.53	22.53	18.40	22.45	2.05	0.47	77.00	0.00
1983	60.70	229	934	2.37	2.37	0.74	2.61	95.80	53.98	43.65	0.00
1984	6041.69	6703	965	76.19	76.19	71.28	76.31	12.86	11.24	12.57	0.00
1985	4728.52	5782	965	65.52	65.52	55.94	66.00	2.18	1.46	33.02	0.00
1986	5525.58	6431	959	72.93	72.93	65.77	73.41	21.80	20.34	6.73	0.00
1987	4850.59	5396	950	60.47	60.47	58.25	61.60	2.77	1.72	37.80	0.00
1988	6711.90	7217	965	81.93	81.93	79.18	82.16	13.46	12.75	5.32	0.00
1989	4968.73	5279	965	59.67	59.67	58.78	60.26	0.27	0.16	40.17	0.00
1990	5031.77	5374	965	60.79	60.79	59.52	61.35	1.83	1.14	38.07	0.00
1991	7300.77	7577	965	88.75	88.75	86.36	86.50	7.99	7.71	3.54	0.00
1992	4760.60	5248	965	59.15	59.15	56.16	59.74	13.83	9.49	31.36	0.00
1993	1192.55	1292	965	13.44	13.44	14.11	14.75	86.43	85.59	0.97	0.00
1994	0.00	0	965	0.00	0.00	0.00	0.00	100.00	100.00	0.00	0.00
1995	1471.53	1696	965	18.15	18.15	17.41	19.36	81.81	81.64	0.21	0.00
1996	5872.49	6390	965	72.36	72.36	69.28	72.75	27.64	27.64	0.00	0.00
1997	4337.34	4650	965	57.44	57.44	51.31	53.08	10.87	7.00	35.56	0.00
1998	7656.52	8197	965	93.60	93.60	90.57	93.57	5.57	5.52	0.88	0.00
1999	7269.17	7659	965	87.40	87.40	85.99	87.43	1.52	1.35	11.25	0.00
2000	8432.24	8600	965	97.91	97.91	99.48	97.91	1.89	1.89	0.20	0.00
2001	7940.17	8130	965	92.78	92.78	93.93	92.81	0.00	0.00	7.22	0.00
2002	8432.65	8611	979	98.27	98.27	99.63	98.30	1.73	1.73	0.00	0.00
2003	7608.44	7748	979	88.41	88.41	88.72	88.45	3.57	3.28	8.31	0.00
2004	8747.28	8784	979	100.00	100.00	101.72	100.00	0.00	0.00	0.00	0.00
2005	8037.20	7969	985	91.00	91.00	93.15	90.97	1.85	1.72	7.28	0.00
2006	8974.52	8705	1025	99.38	99.38	99.95	99.37	0.62	0.62	0.00	0.00
2007	7797.31	7602	1025	86.79	86.79	86.84	86.78	7.00	6.53	6.68	0.00
2008	9162.73	8784	1025	100.00	100.00	101.77	100.00	0.00	0.00	0.00	0.00
2009	7703.70	7649	1040	87.53	87.53	84.56	87.32	3.16	2.85	9.62	0.00
2010	8994.71	8676	1040	99.04	99.04	98.73	99.04	0.96	0.96	0.00	0.00
2011	8217.05	7953	1040	90.80	90.80	90.19	90.79	0.93	0.85	8.34	0.00
2012	8963.07	8649	1040	98.50	99.33	98.11	98.46	0.37	0.36	0.30	0.83

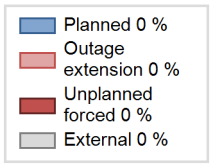
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2013	8288.93	8025	1041	91.62	91.62	90.89	91.60	0.00	0.00	8.38	0.00
2014	8971.54	8669	1040	98.96	98.96	98.48	98.96	1.04	1.04	0.00	0.00
2015	7588.92	7440	1040	84.92	84.92	83.30	84.93	6.45	5.85	9.22	0.00
2016	9069.20	8784	1040	100.00	100.00	99.28	100.00	0.00	0.00	0.00	0.00
2017	6933.65	6789	1040	77.51	77.51	76.11	77.50	2.02	1.59	20.90	0.00
2018	8328.02	8098	1030	92.44	92.44	92.30	92.44	7.56	7.56	0.00	0.00
2019	8342.71	8054	1030	91.95	91.95	92.46	91.94	0.00	0.00	8.05	0.00
2020	9108.82	8783	1030	100.00	100.00	100.68	99.99	0.00	0.00	0.00	0.00

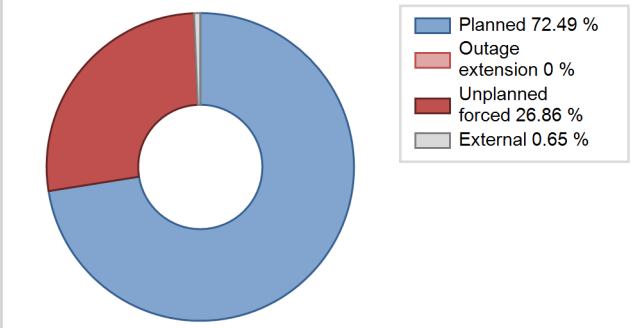
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1976 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					1013	
C. Inspection, maintenance or repair combined with refuelling				942		
D. Inspection, maintenance or repair without refuelling				209		
E. Testing of plant systems or components				2	9	
J. Grid limitation, failure or grid unavailability						4
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
P. Fire					1	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					0	
Z. Other					9	
Subtotal				1153	1036	6
Total		**0**			**2195**	

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Equipment Related Unplanned Full Outages, Analysis by System		
System	2020	1976 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		17
13. Reactor Auxiliary Systems		7
14. Safety Systems		466
15. Reactor Cooling Systems		28
16. Steam generation systems		58
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		81
32. Feedwater and Main Steam System		48
33. Circulating Water System		1
34. Miscellaneous Systems		21
41. Main Generator Systems		248
42. Electrical Power Supply Systems		50
Total		**1026**

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2020 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	:	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]	:	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

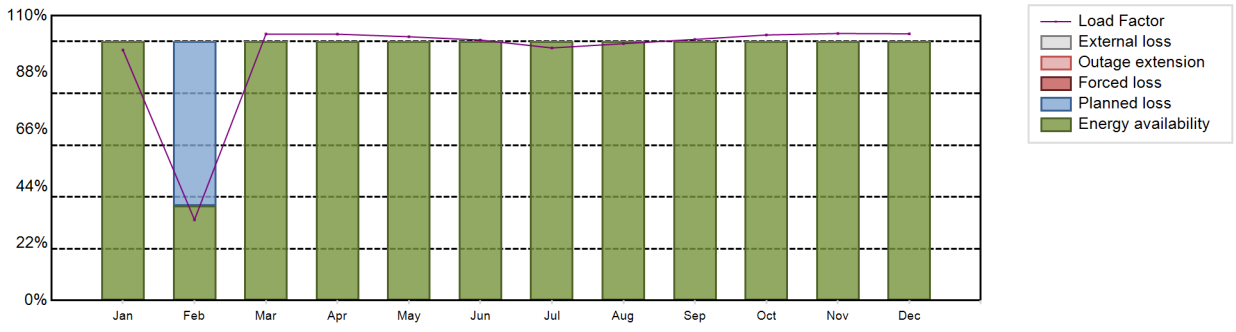
Operating coolant pressure [MPa]	:	7.1
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.41
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
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 (2020)

Net Energy Production	:	9535.89 GW(e).h
Energy Availability Factor (EAF)	:	94.98 %
Unit Capability Factor (UCF)	:	94.98 %
Load Factor (LF)	:	95.48 %
Operating Factor (OF)	:	94.97 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	5.02 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	442 hours

Annual Summary



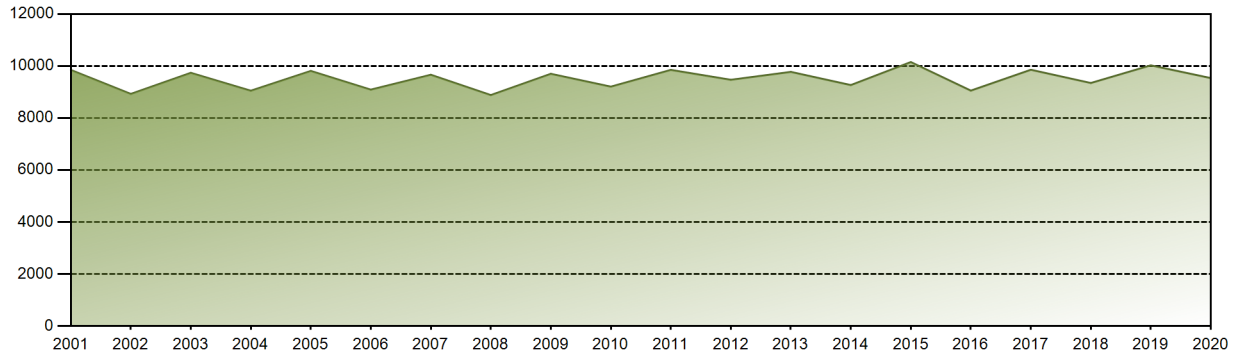
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	818.11	246.69	870.56	842.11	861.80	823.56	825.19	839.16	825.59	867.54	844.26	871.34	9535.89
EAF [%]	100.00	36.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.98
UCF [%]	100.00	36.60	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.98
LF [%]	96.71	31.17	102.91	102.87	101.88	100.60	97.55	99.20	100.85	102.55	103.13	103.00	95.48
OF [%]	100.00	36.64	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.97
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	63.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.02
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

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Historical Summary

Lifetime energy generation	:	263086.78 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.73 %
Cumulative Energy Availability Factor (EAF)	:	82.11 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.99 %
Cumulative Unit Capability Factor (UCF)	:	82.12 %	Cumulative Planned Unavailability Factor (PUF)	:	12.89 %
Cumulative Load Factor (LF)	:	80.78 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	81.44 %			

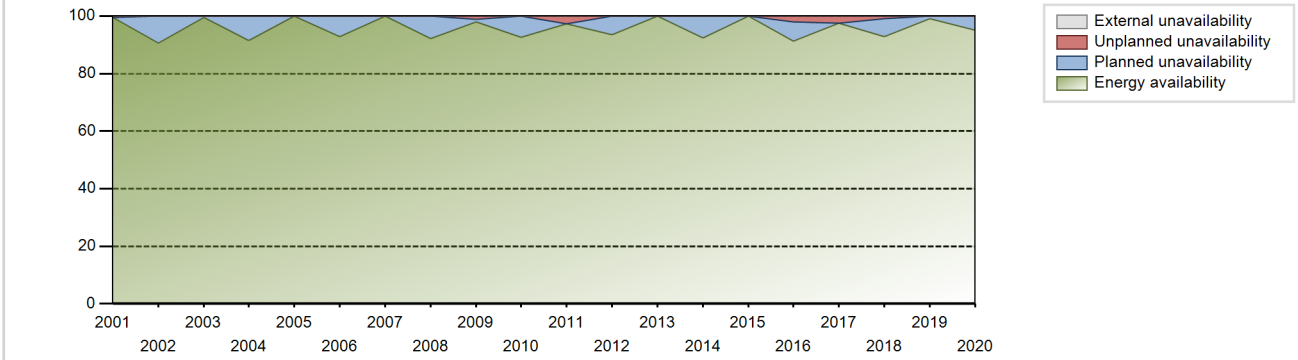
Electricity Production (net) [GWh]



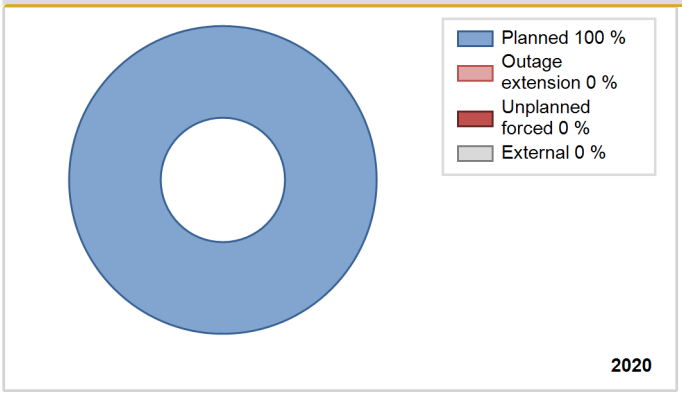
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	5206.21	6052	1078	69.43	69.43	54.99	68.91	16.31	13.53	17.04	0.00
1985	4827.46	5581	1036	63.69	64.26	53.19	63.71	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

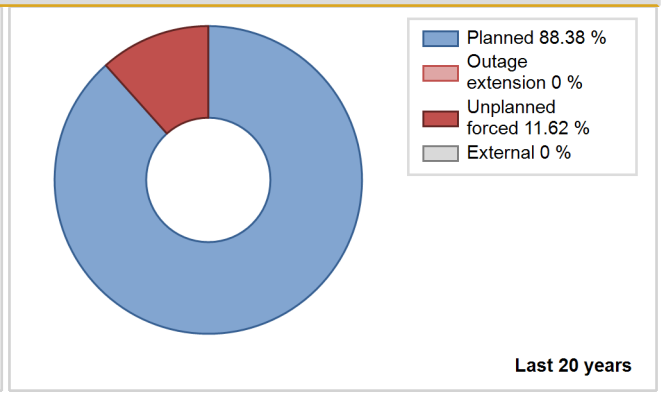
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					351	
B. Refuelling without maintenance	441			12		
C. Inspection, maintenance or repair combined with refuelling				833		
D. Inspection, maintenance or repair without refuelling				313		
E. Testing of plant systems or components				42	3	
H. Nuclear regulatory requirements					145	
J. Grid limitation, failure or grid unavailability						9
L. Human factor related					26	
Z. Other					4	
Subtotal	441			1200	529	9
Total	**441**			**1738**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		29
12. Reactor I&C Systems		25
13. Reactor Auxiliary Systems		11
14. Safety Systems		34
15. Reactor Cooling Systems		101
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		76
32. Feedwater and Main Steam System		14
33. Circulating Water System		6
34. Miscellaneous Systems		11
35. All other I&C Systems		3
41. Main Generator Systems		12
42. Electrical Power Supply Systems		33
Total		**356**

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Highlights (2020)
Refueling Outage 18

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2020 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	:	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 [%]	:	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

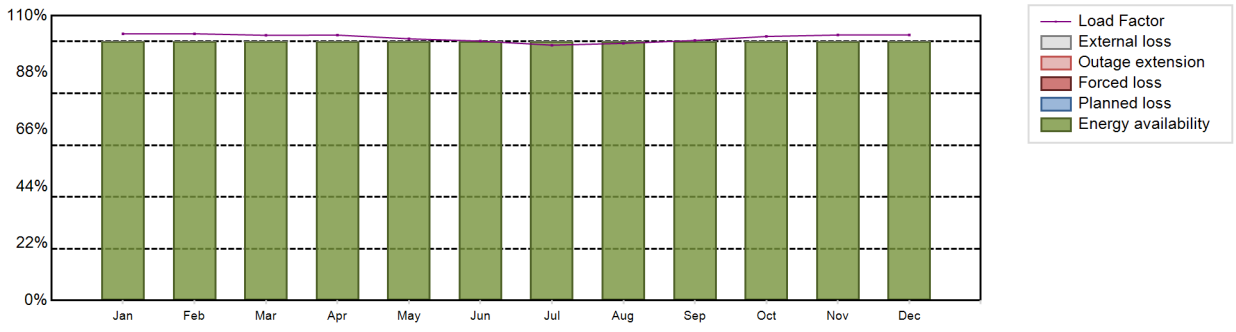
Operating coolant pressure [MPa]	:	7.1
Reactor outlet temperature [°C]	:	286
Number of SG	:	NA
Containment type	:	Confinement
Containment design pressure [MPa]	:	0.41
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
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 (2020)

Net Energy Production	:	10159.8 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	101.46 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



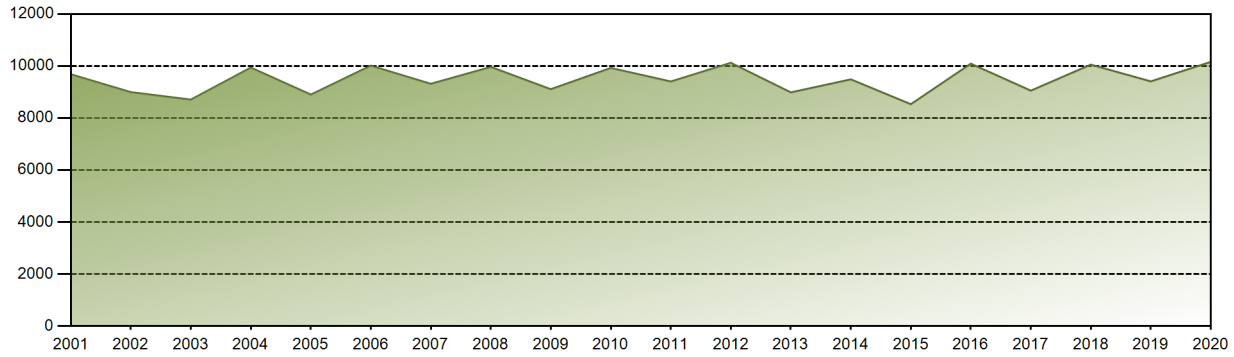
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	873.40	817.34	868.79	841.41	857.28	822.32	836.36	842.31	824.28	864.89	841.68	869.73	10159.80
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	102.98	103.01	102.43	102.51	101.08	100.18	98.61	99.31	100.42	101.97	102.54	102.54	101.46
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	282402.49 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.72 %
Cumulative Energy Availability Factor (EAF)	:	81.68 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.88 %
Cumulative Unit Capability Factor (UCF)	:	81.69 %	Cumulative Planned Unavailability Factor (PUF)	:	12.42 %
Cumulative Load Factor (LF)	:	80.89 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	81.02 %			

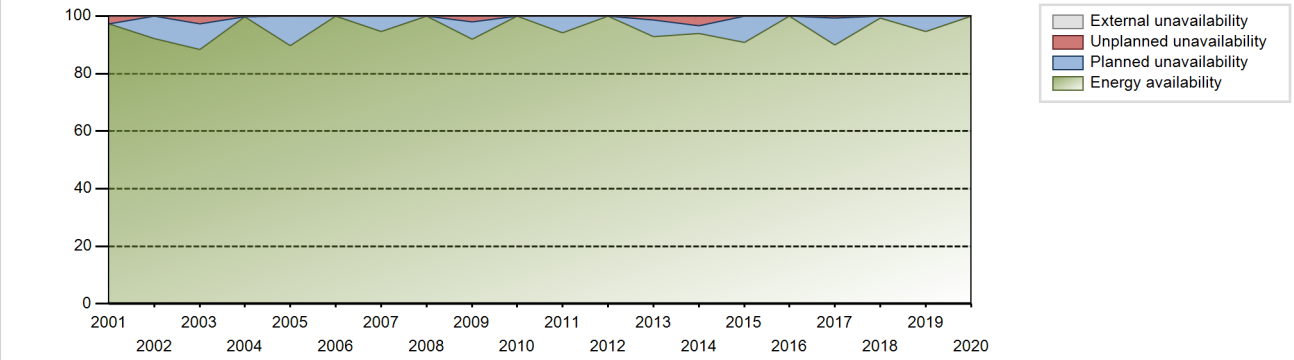
Electricity Production (net) [GWh]



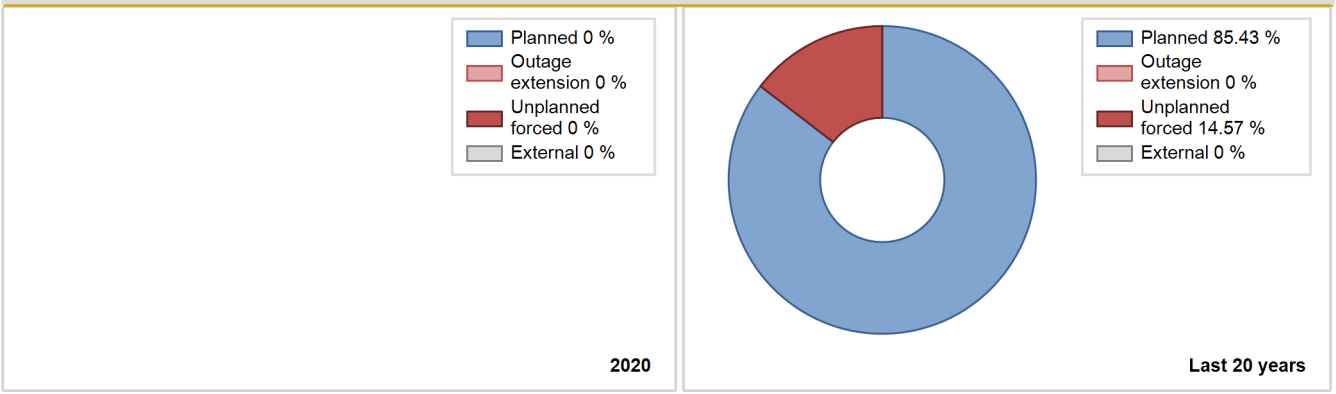
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	2735.73	4058	1039	86.57	86.57	77.10	86.68	13.43	13.43	0.00	0.00
1985	3476.96	3698	1036	41.81	41.81	38.31	42.21	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

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Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					205	
C. Inspection, maintenance or repair combined with refuelling				940		
D. Inspection, maintenance or repair without refuelling				145		
E. Testing of plant systems or components				1		
H. Nuclear regulatory requirements					312	
J. Grid limitation, failure or grid unavailability						6
L. Human factor related					6	
Z. Other					49	
Subtotal				1086	572	6
Total		**0**			**1664**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		50
12. Reactor I&C Systems		46
15. Reactor Cooling Systems		20
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		39
32. Feedwater and Main Steam System		9
34. Miscellaneous Systems		15
35. All other I&C Systems		9
41. Main Generator Systems		2
42. Electrical Power Supply Systems		17
Total		**208**

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 2)
Thermal power	:	3515 MWth
Gross electrical power	:	1194 MWe
Reference unit power (net)	:	1134 MWe

Key Dates

Construction Date	:	1974-06-19
Grid Date	:	1985-04-13
Commercial Date	:	1986-02-01
Age at end of year	:	35 years

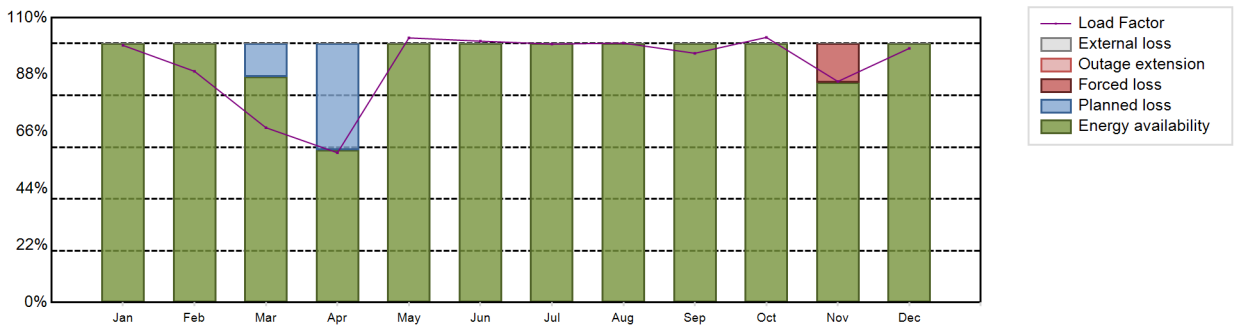
Design Characteristics

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 (2020)

Net Energy Production	:	9133.2 GW(e).h	Forced Loss Rate (FLR)	:	1.29 %
Energy Availability Factor (EAF)	:	94.3 %	Unplanned Capability Loss Factor (UCL)	:	1.24 %
Unit Capability Factor (UCF)	:	94.3 %	Planned Unavailability Factor (PUF)	:	4.47 %
Load Factor (LF)	:	91.69 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	94.3 %	Total off-line time	:	501 hours

Annual Summary



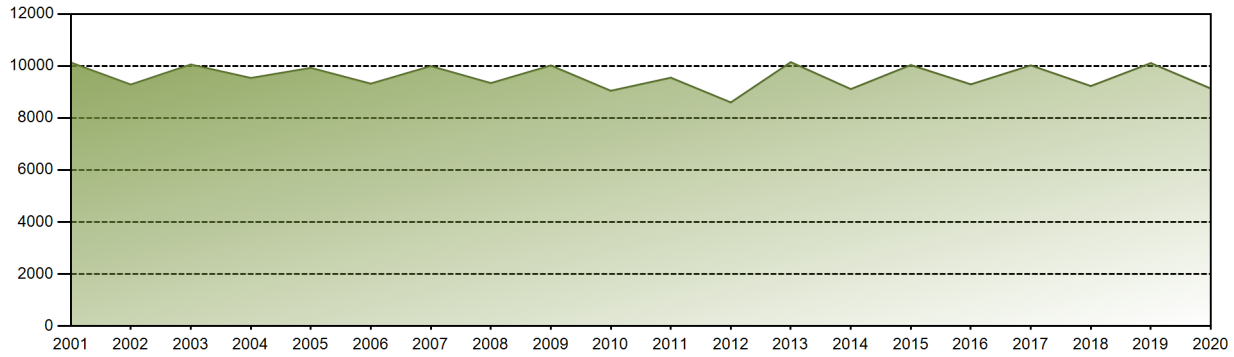
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	837.88	704.76	569.59	472.15	862.23	824.20	842.06	845.29	785.94	863.90	696.97	828.22	9133.19
EAF [%]	100.00	100.00	87.13	58.82	100.00	100.00	100.00	100.00	100.00	100.00	84.91	100.00	94.30
UCF [%]	100.00	100.00	87.13	58.82	100.00	100.00	100.00	100.00	100.00	100.00	84.91	100.00	94.30
LF [%]	99.31	89.29	67.51	57.83	102.20	100.95	99.81	100.19	96.26	102.39	85.36	98.17	91.69
OF [%]	100.00	100.00	86.96	58.89	100.00	100.00	100.00	100.00	100.00	100.00	85.00	100.00	94.30
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.09	0.00	1.29
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.09	0.00	1.24
PUF [%]	0.00	0.00	12.87	41.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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

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Historical Summary

Lifetime energy generation	:	346368.74 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.74 %
Cumulative Energy Availability Factor (EAF)	:	91.63 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.63 %
Cumulative Unit Capability Factor (UCF)	:	91.63 %	Cumulative Planned Unavailability Factor (PUF)	:	6.75 %
Cumulative Load Factor (LF)	:	89.78 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	91.24 %			

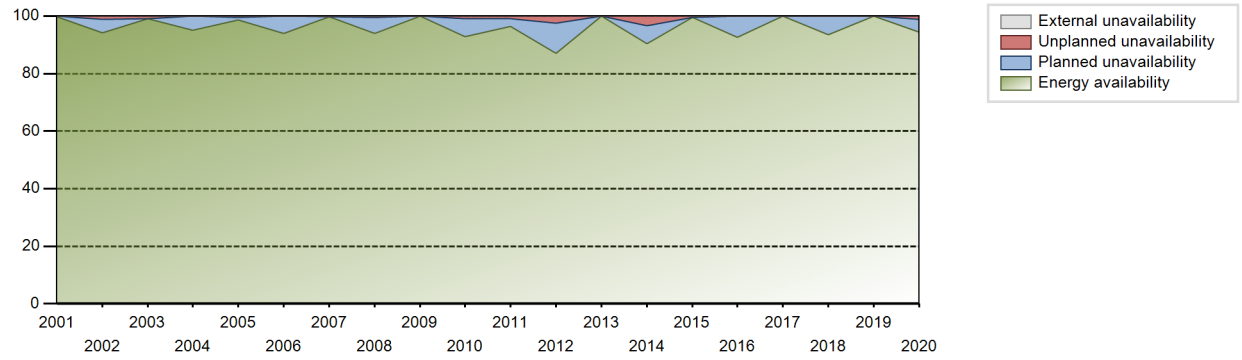
Electricity Production (net) [GWh]



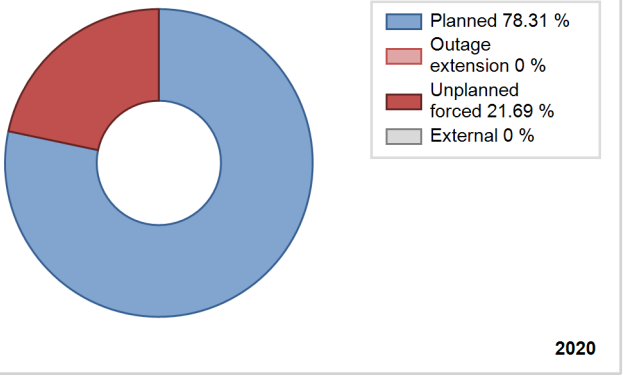
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	7210.57	7022	1055	82.79	82.79	80.99	82.76	3.46	2.97	14.25	0.00
1987	5341.32	5924	1055	67.66	67.66	57.80	67.63	4.11	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

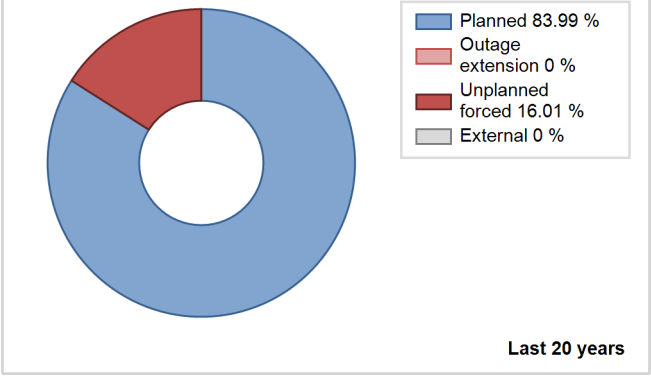
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					132	
B. Refuelling without maintenance	784			22		
C. Inspection, maintenance or repair combined with refuelling				577		
D. Inspection, maintenance or repair without refuelling				177		
E. Testing of plant systems or components				9	9	
Z. Other		109		75	29	
Subtotal	784	109		860	170	
Total	**893**			**1030**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1986 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		8
12. Reactor I&C Systems		1
13. Reactor Auxiliary Systems		6
14. Safety Systems		9
15. Reactor Cooling Systems		27
31. Turbine and auxiliaries		46
32. Feedwater and Main Steam System		9
34. Miscellaneous Systems		10
41. Main Generator Systems		8
42. Electrical Power Supply Systems		20
Total		**144**

Highlights (2020)

Rx Scram, MSIV failed closed

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 2)
Thermal power	:	3515 MWth
Gross electrical power	:	1194 MWe
Reference unit power (net)	:	1134 MWe

Key Dates

Construction Date	:	1974-06-19
Grid Date	:	1989-09-01
Commercial Date	:	1990-01-08
Age at end of year	:	31 years

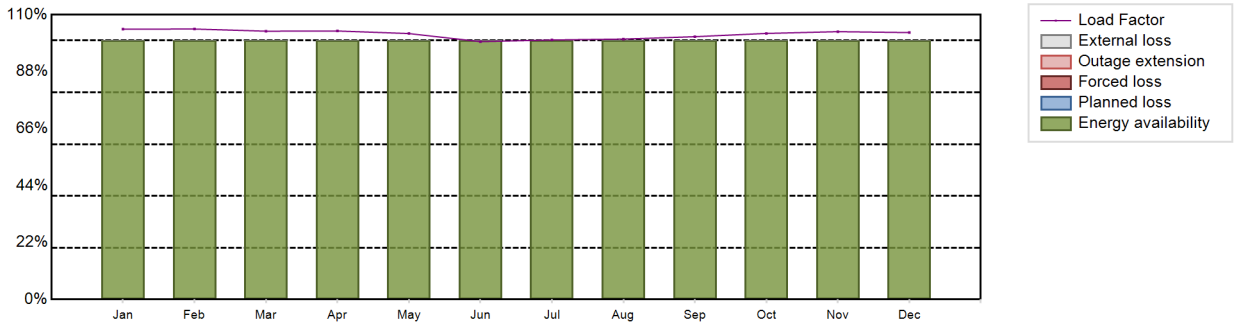
Design Characteristics

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 (2020)

Net Energy Production	:	10211.57 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)	:	102.51 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



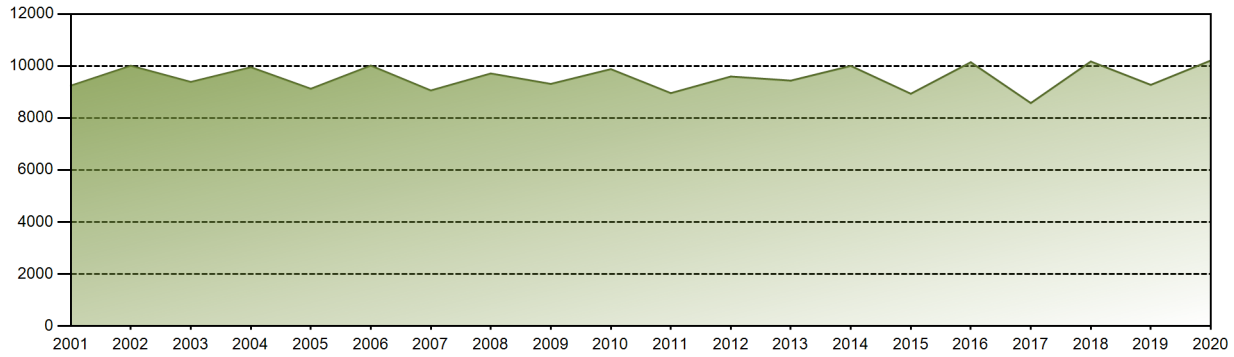
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	881.04	824.59	874.46	846.85	866.62	813.31	845.80	848.59	828.81	867.01	844.73	869.76	10211.57
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	104.43	104.48	103.65	103.72	102.72	99.61	100.25	100.58	101.51	102.76	103.46	103.09	102.51
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	270690.78 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.39 %
Cumulative Energy Availability Factor (EAF)	:	93.75 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.33 %
Cumulative Unit Capability Factor (UCF)	:	93.77 %	Cumulative Planned Unavailability Factor (PUF)	:	4.9 %
Cumulative Load Factor (LF)	:	93.21 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	93.79 %			

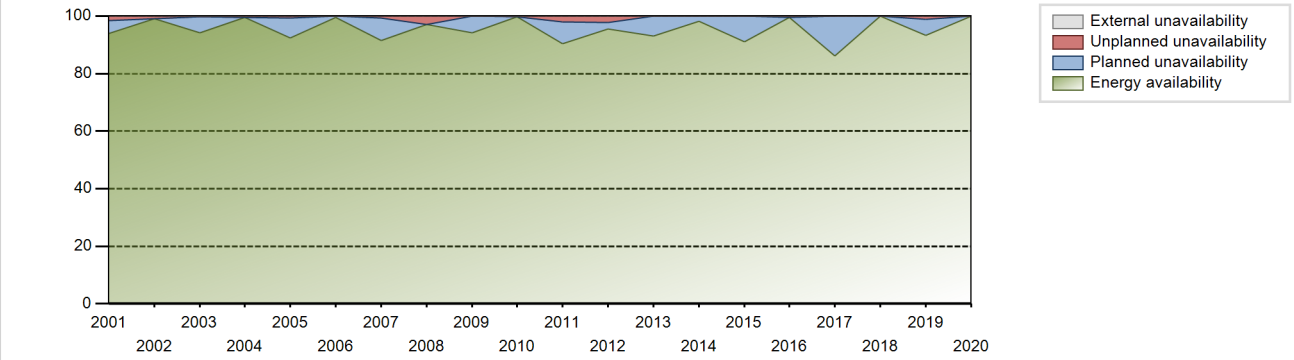
Electricity Production (net) [GWh]



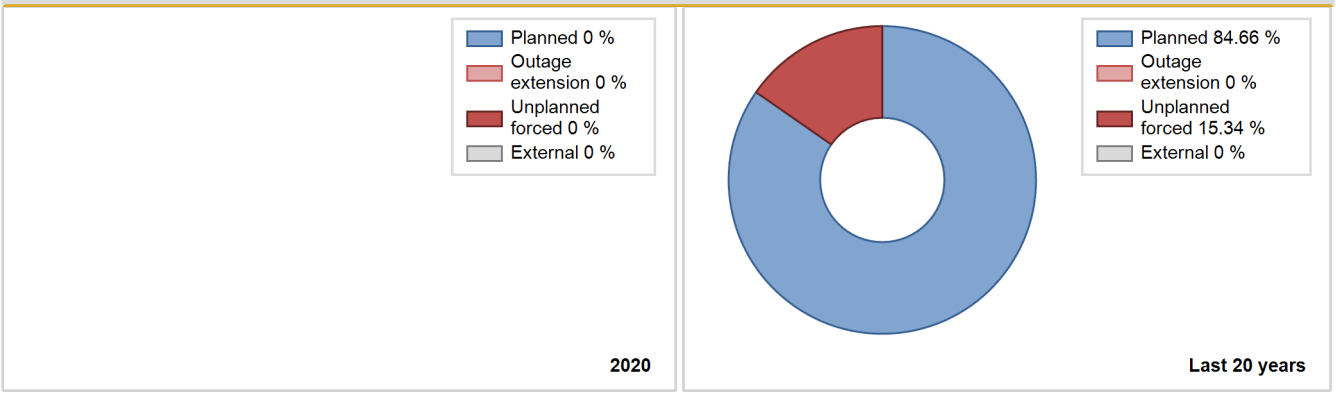
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	7232.60	7174	1055	81.81	81.81	79.79	83.50	13.12	12.35	5.84	0.00
1991	7146.91	6919	1055	77.82	77.82	77.33	78.98	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

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Key Factors in Last 20 Years [%]



Energy Losses by Type



Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1990 to 2020 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				355		
D. Inspection, maintenance or repair without refuelling				71		
E. Testing of plant systems or components				0		
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					9	
Z. Other					5	
Subtotal				426	116	2
Total		**0**			**544**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1990 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		4
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		3
15. Reactor Cooling Systems		12
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		53
32. Feedwater and Main Steam System		5
34. Miscellaneous Systems		2
35. All other I&C Systems		6
41. Main Generator Systems		10
42. Electrical Power Supply Systems		11
Total		**113**

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2020 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	:	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 [%]	:	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

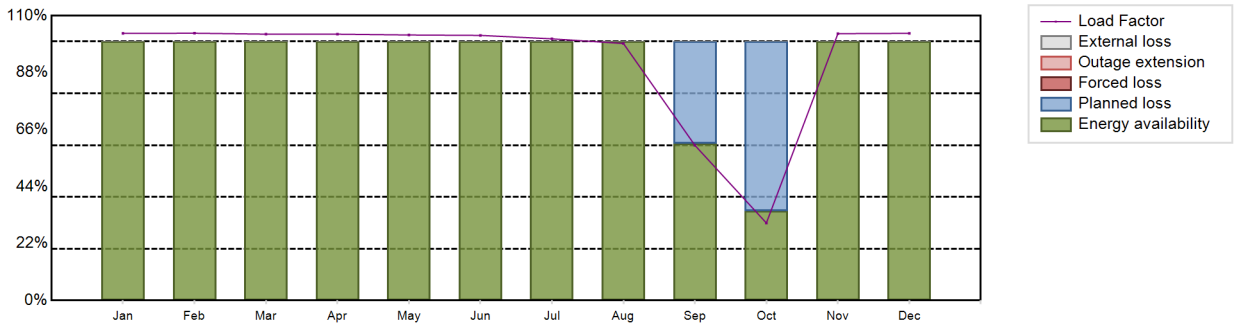
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	325
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.204
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	9434.12 GW(e).h
Energy Availability Factor (EAF)	:	91.23 %
Unit Capability Factor (UCF)	:	91.23 %
Load Factor (LF)	:	92.75 %
Operating Factor (OF)	:	91.22 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.77 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	771 hours

Annual Summary



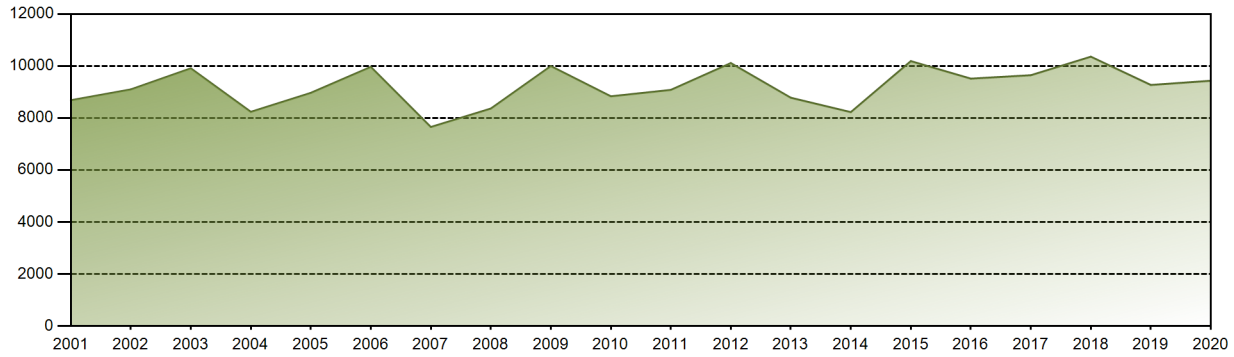
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	888.90	832.02	886.38	857.60	883.54	853.71	870.72	855.27	499.85	257.91	859.25	888.97	9434.12
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	60.56	34.65	100.00	100.00	91.23
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	60.56	34.65	100.00	100.00	91.23
LF [%]	103.17	103.23	102.88	102.86	102.55	102.39	101.06	99.27	59.95	29.94	103.06	103.18	92.75
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	60.56	34.68	100.00	100.00	91.22
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	39.44	65.35	0.00	0.00	8.77
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

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Historical Summary

Lifetime energy generation	:	364558.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.33 %
Cumulative Energy Availability Factor (EAF)	:	83.83 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.75 %
Cumulative Unit Capability Factor (UCF)	:	84.06 %	Cumulative Planned Unavailability Factor (PUF)	:	11.18 %
Cumulative Load Factor (LF)	:	81.91 %	Cumulative Externally cause unavailability (XUF)	:	0.24 %
Cumulative Operating Factor (OF)	:	83.66 %			

Electricity Production (net) [GWh]

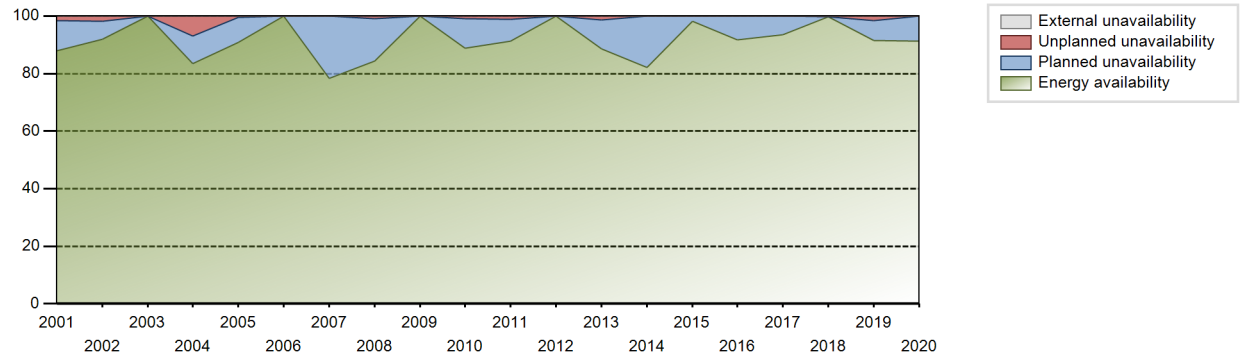


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	19.10	45	1146	10.20	10.20	2.18	6.05	89.80	89.80	0.00	0.00
1982	4302.30	7043	1180	81.62	81.62	41.62	80.40	14.80	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

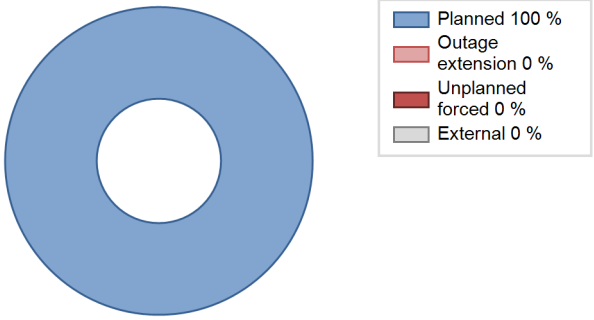
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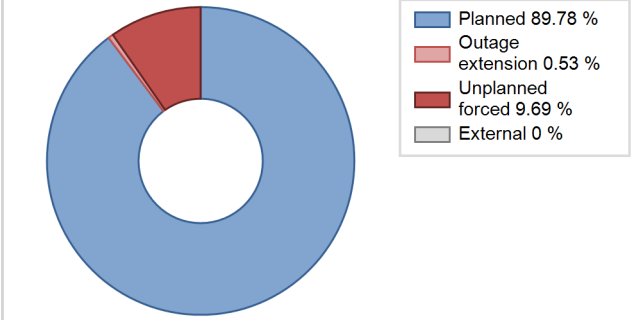
2018	10359.25	8730	1158	99.66	99.66	102.12	99.66	0.34	0.34	0.00	0.00
2019	9271.86	8022	1158	91.59	91.59	91.40	91.58	1.75	1.63	6.78	0.00
2020	9434.12	8013	1158	91.23	91.23	92.75	91.22	0.00	0.00	8.77	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					401	
B. Refuelling without maintenance	770			20		
C. Inspection, maintenance or repair combined with refuelling				829		
D. Inspection, maintenance or repair without refuelling				107	0	
E. Testing of plant systems or components				14	1	
G. Major backfitting, refurbishment or upgrading activities without refuelling				2		
H. Nuclear regulatory requirements					6	
L. Human factor related					5	
Z. Other				9	3	20
Subtotal	770			981	416	20
Total	**770**			**1417**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		30
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems		16
14. Safety Systems		21
15. Reactor Cooling Systems		58
16. Steam generation systems		60
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		39
32. Feedwater and Main Steam System		125
34. Miscellaneous Systems		20
41. Main Generator Systems		4
42. Electrical Power Supply Systems		17
Total		**408**

Highlights (2020)

Refueling Outage 27

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2020 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	:	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 [%]	:	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

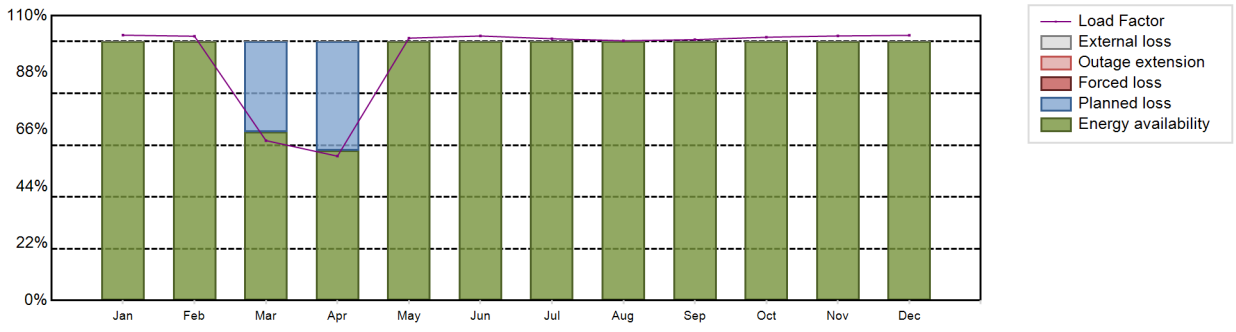
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	325
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.2
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	9612.83 GW(e).h
Energy Availability Factor (EAF)	:	93.6 %
Unit Capability Factor (UCF)	:	93.6 %
Load Factor (LF)	:	94.5 %
Operating Factor (OF)	:	93.59 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	6.4 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	563 hours

Annual Summary



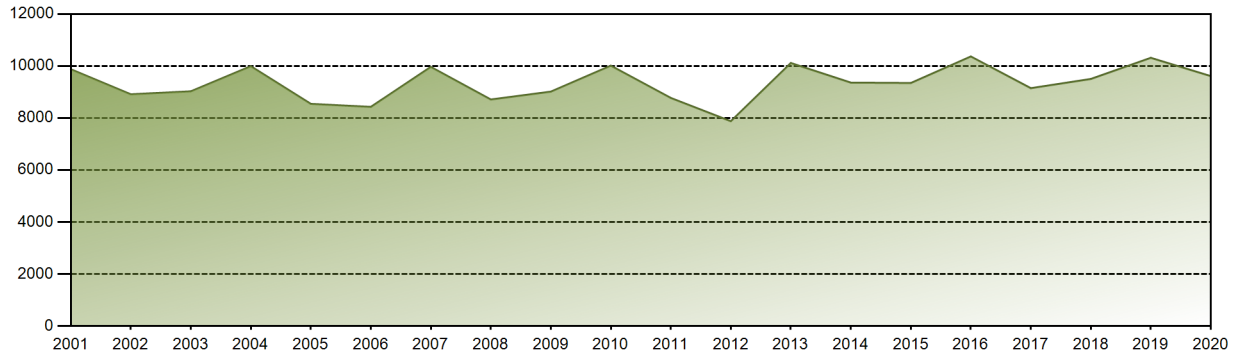
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	882.83	822.63	532.15	464.85	873.01	851.76	870.98	864.34	839.86	876.11	851.94	882.38	9612.83
EAF [%]	100.00	100.00	65.05	58.02	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.60
UCF [%]	100.00	100.00	65.05	58.02	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.60
LF [%]	102.47	102.07	61.77	55.75	101.33	102.16	101.09	100.32	100.73	101.69	102.18	102.42	94.50
OF [%]	100.00	100.00	64.92	58.06	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.59
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	34.95	41.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.40
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

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Historical Summary

Lifetime energy generation	:	323735.91 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.66 %
Cumulative Energy Availability Factor (EAF)	:	87 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.43 %
Cumulative Unit Capability Factor (UCF)	:	87 %	Cumulative Planned Unavailability Factor (PUF)	:	10.57 %
Cumulative Load Factor (LF)	:	86.84 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	86.87 %			

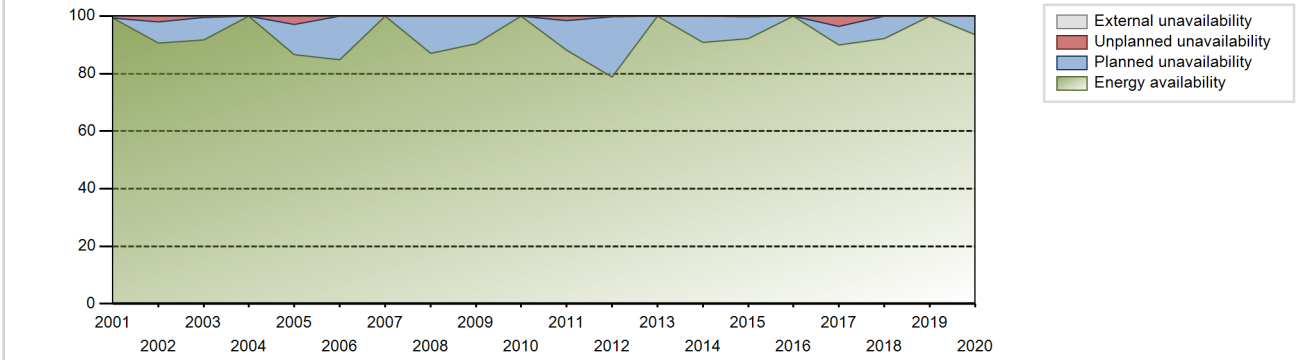
Electricity Production (net) [GWh]



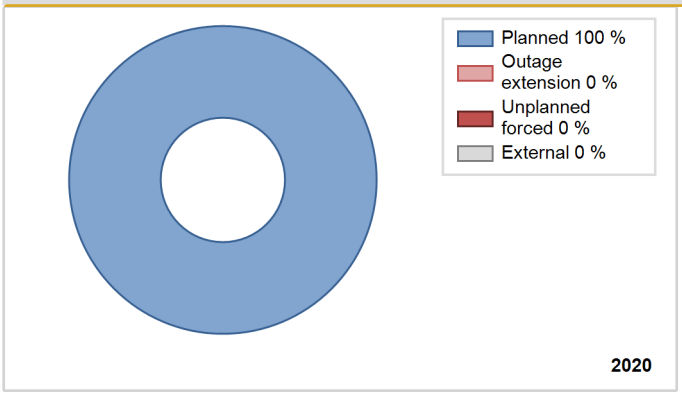
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	6557.80	6086	1171	82.97	82.97	75.67	82.87	16.04	15.85	1.18	0.00
1985	5609.29	5171	1180	61.05	61.05	54.27	59.03	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

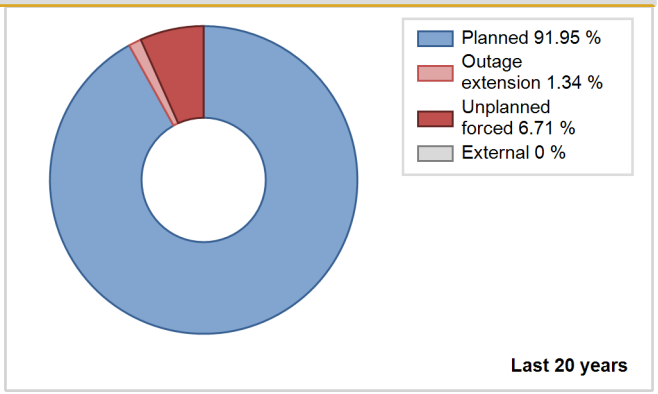
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1984 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					197	
B. Refuelling without maintenance	562			15		
C. Inspection, maintenance or repair combined with refuelling				845		
D. Inspection, maintenance or repair without refuelling				70	0	
E. Testing of plant systems or components				0	0	
H. Nuclear regulatory requirements					8	
L. Human factor related					3	
Z. Other				0	3	
Subtotal	562			930	211	
Total	**562**			**1141**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1984 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		15
14. Safety Systems		14
15. Reactor Cooling Systems		60
16. Steam generation systems		10
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		6
32. Feedwater and Main Steam System		31
34. Miscellaneous Systems		1
41. Main Generator Systems		34
42. Electrical Power Supply Systems		15
Total		**209**

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Highlights (2020)

End of Cycle 26 Refueling Outage.

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2020 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

Reactor type and model	:	PWR / CE 2LP (DRYAMB)
Thermal power	:	2700 MWth
Gross electrical power	:	918 MWe
Reference unit power (net)	:	869 MWe

Key Dates

Construction Date	:	1969-11-01
Grid Date	:	1975-11-09
Commercial Date	:	1975-12-26
Age at end of year	:	45 years

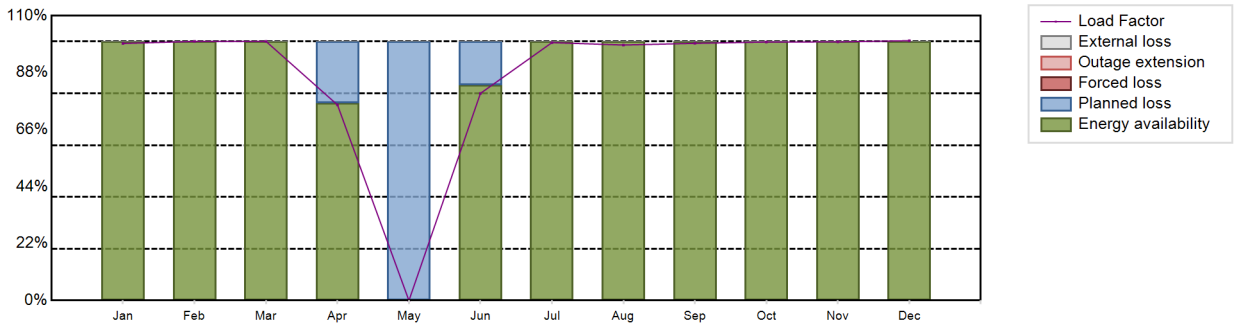
Design Characteristics

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 (2020)

Net Energy Production	:	6690.5 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	88.22 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	88.22 %	Planned Unavailability Factor (PUF)	:	11.78 %
Load Factor (LF)	:	87.65 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	88.21 %	Total off-line time	:	1036 hours

Annual Summary



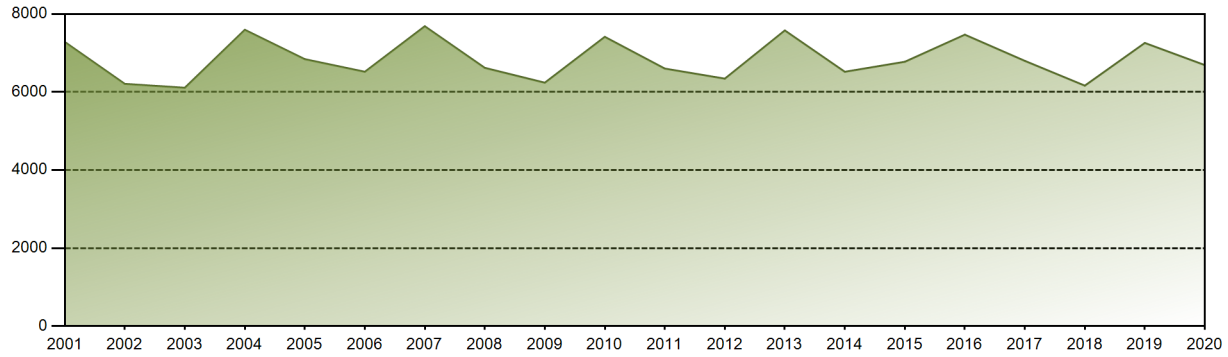
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	641.85	605.22	647.18	472.82	0.00	500.58	643.98	638.01	621.51	645.51	625.00	648.85	6690.50
EAF [%]	100.00	100.00	100.00	76.25	0.00	83.34	100.00	100.00	100.00	100.00	100.00	100.00	88.22
UCF [%]	100.00	100.00	100.00	76.25	0.00	83.34	100.00	100.00	100.00	100.00	100.00	100.00	88.22
LF [%]	99.27	100.07	100.10	75.57	0.00	80.01	99.60	98.68	99.33	99.84	99.89	100.36	87.65
OF [%]	100.00	100.00	99.87	76.25	0.00	83.33	100.00	100.00	100.00	100.00	100.00	100.00	88.21
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 [%]	0.00	0.00	0.00	23.75	100.00	16.66	0.00	0.00	0.00	0.00	0.00	0.00	11.78
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

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Historical Summary

Lifetime energy generation	:	215982.05 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	15.45 %
Cumulative Energy Availability Factor (EAF)	:	72.55 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.36 %
Cumulative Unit Capability Factor (UCF)	:	73.13 %	Cumulative Planned Unavailability Factor (PUF)	:	13.51 %
Cumulative Load Factor (LF)	:	71.17 %	Cumulative Externally cause unavailability (XUF)	:	0.59 %
Cumulative Operating Factor (OF)	:	72.83 %			

Electricity Production (net) [GWh]

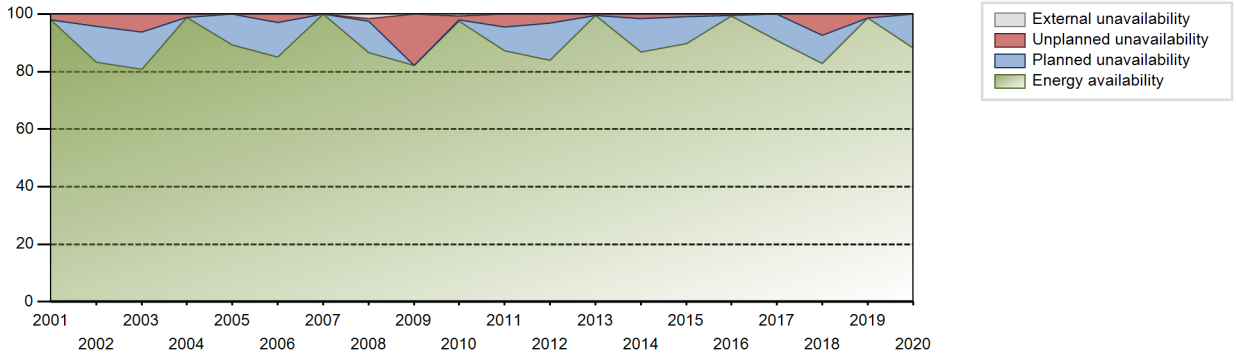


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1975	134.70	623	851	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	4543.20	6815	780	66.37	66.37	66.31	77.58	31.06	29.91	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

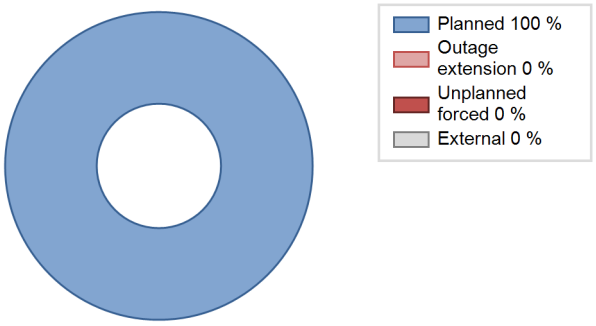
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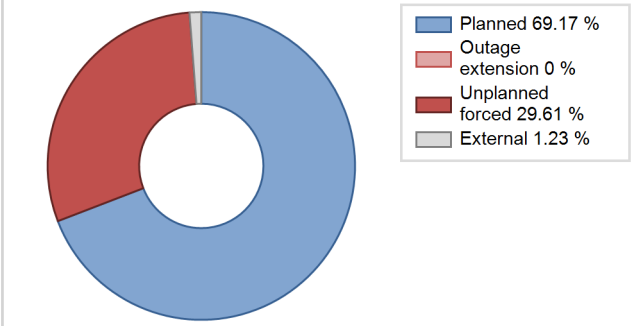
2012	6342.84	7363	869	83.85	83.85	83.09	83.82	3.66	3.18	12.97	0.00
2013	7578.99	8711	869	99.44	99.44	99.55	99.43	0.56	0.56	0.00	0.00
2014	6518.71	7534	869	86.75	86.75	85.63	86.00	1.84	1.62	11.62	0.00
2015	6775.63	7860	869	89.72	89.72	89.01	89.73	0.94	0.85	9.43	0.00
2016	7469.89	8725	869	99.33	99.33	97.86	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1975 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					481	
B. Refuelling without maintenance	1035			23		
C. Inspection, maintenance or repair combined with refuelling				1095		
D. Inspection, maintenance or repair without refuelling				38		
E. Testing of plant systems or components				7	162	
H. Nuclear regulatory requirements					490	
J. Grid limitation, failure or grid unavailability						1
L. Human factor related					21	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						28
Z. Other				19	5	
Subtotal	1035			1182	1159	29
Total	**1035**			**2370**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1975 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		2
12. Reactor I&C Systems		50
13. Reactor Auxiliary Systems		10
14. Safety Systems		13
15. Reactor Cooling Systems		98
16. Steam generation systems		74
31. Turbine and auxiliaries		65
32. Feedwater and Main Steam System		80
33. Circulating Water System		12
34. Miscellaneous Systems		176
35. All other I&C Systems		1
41. Main Generator Systems		5
42. Electrical Power Supply Systems		70
Total		**656**

Highlights (2020)

Refueling Outage 26 (2R26).

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2020 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

Reactor type and model	:	PWR / WH 4LP (DRYSUB)
Thermal power	:	3650 MWth
Gross electrical power	:	1280 MWe
Reference unit power (net)	:	1210 MWe

Key Dates

Construction Date	:	1974-08-09
Grid Date	:	1986-02-12
Commercial Date	:	1986-04-23
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]	:	33000
Active core diameter [m]	:	3.4
Active core height/length [m]	:	3.66
Number of fissile fuel assemblies/bundles	:	580
Fuel linear heat generation rate [kW/m]	:	18.2
Number of control rod assemblies	:	24
Number of external reactor coolant loops	:	4
Coolant type	:	H2O

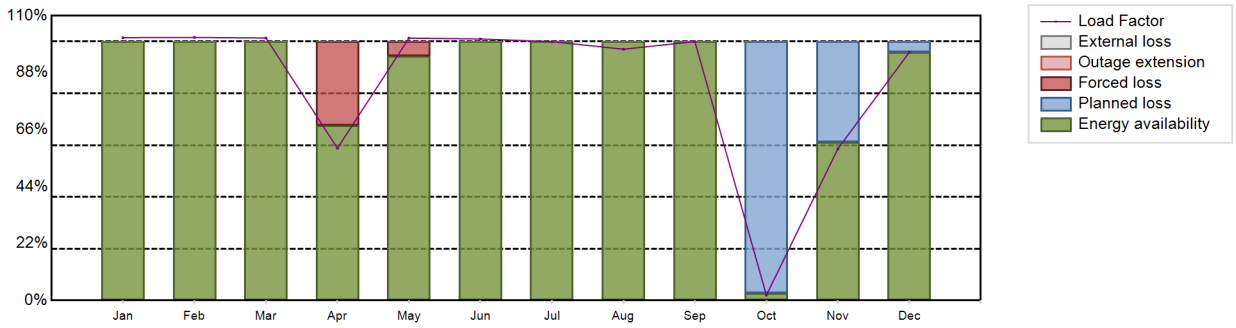
Operating coolant pressure [MPa]	:	15.9
Reactor outlet temperature [°C]	:	327
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.17
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	6.7
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 (2020)

Net Energy Production	:	9024.35 GW(e).h
Energy Availability Factor (EAF)	:	85.13 %
Unit Capability Factor (UCF)	:	85.13 %
Load Factor (LF)	:	84.91 %
Operating Factor (OF)	:	84.68 %

Forced Loss Rate (FLR)	:	3.54 %
Unplanned Capability Loss Factor (UCL)	:	3.12 %
Planned Unavailability Factor (PUF)	:	11.75 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1346 hours

Annual Summary



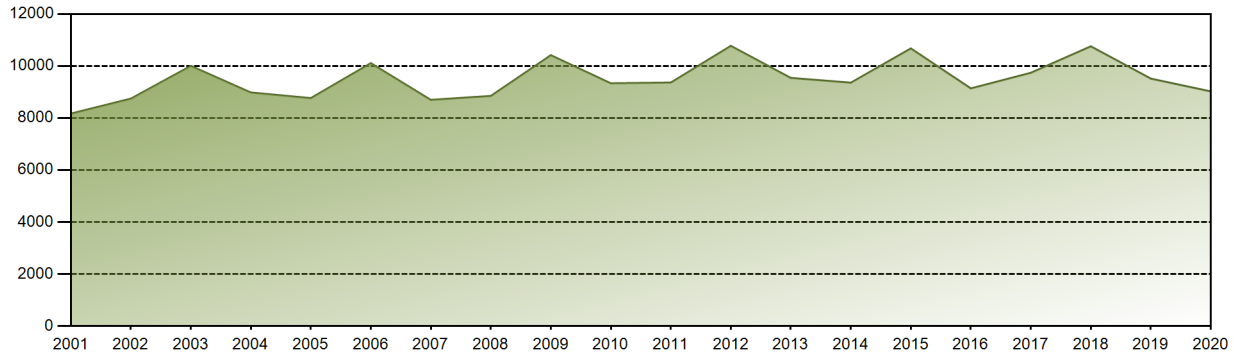
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	914.02	855.64	912.71	512.34	912.17	880.06	900.07	873.85	871.18	18.50	510.41	863.40	9024.35
EAF [%]	100.00	100.00	100.00	67.59	94.49	100.00	100.00	100.00	100.00	2.92	61.27	95.82	85.13
UCF [%]	100.00	100.00	100.00	67.59	94.49	100.00	100.00	100.00	100.00	2.92	61.27	95.82	85.13
LF [%]	101.53	101.60	101.38	58.81	101.33	101.02	99.98	97.07	100.00	2.06	58.59	95.91	84.91
OF [%]	100.00	100.00	100.00	61.94	94.49	100.00	100.00	100.00	100.00	2.96	61.39	95.83	84.68
FLR [%]	0.00	0.00	0.00	32.41	5.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.54
UCL [%]	0.00	0.00	0.00	32.41	5.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.12
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.08	38.73	4.18	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

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Historical Summary

Lifetime energy generation	:	251278.31 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	11.55 %
Cumulative Energy Availability Factor (EAF)	:	81.04 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	10.58 %
Cumulative Unit Capability Factor (UCF)	:	81.06 %	Cumulative Planned Unavailability Factor (PUF)	:	8.36 %
Cumulative Load Factor (LF)	:	79.83 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	80.56 %			

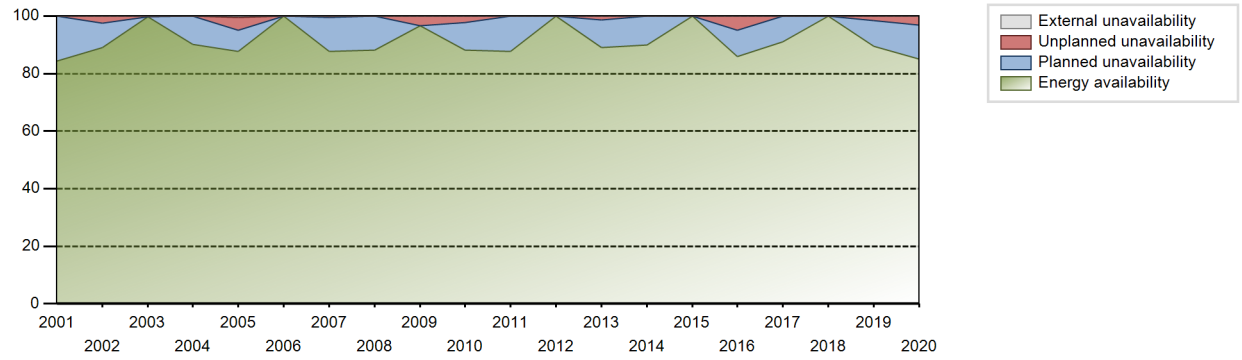
Electricity Production (net) [GWh]



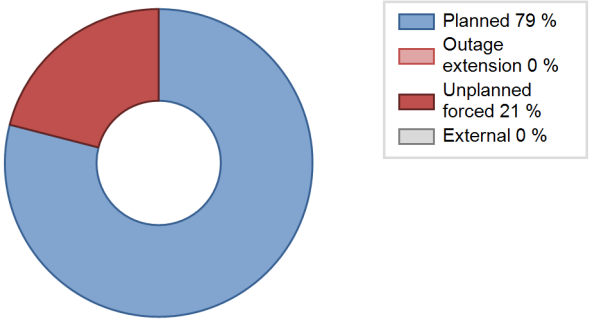
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	Data not provided										
1987	6748.20	6235	1142	71.36	71.36	67.46	71.18	5.40	4.07	24.56	0.00
1988	7683.62	6954	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

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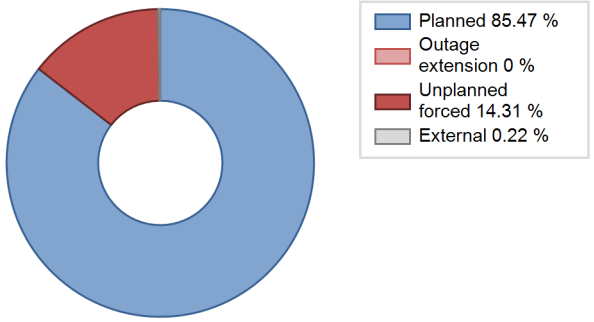
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					413	
B. Refuelling without maintenance	1280			38		
C. Inspection, maintenance or repair combined with refuelling				661		
D. Inspection, maintenance or repair without refuelling				45		
E. Testing of plant systems or components				2		
H. Nuclear regulatory requirements					258	
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.)						22
Z. Other		305			259	
Subtotal	1280	305		746	935	28
Total		**1585**			**1709**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		16
14. Safety Systems		327
15. Reactor Cooling Systems		43
16. Steam generation systems		26
17. Safety I&C Systems (excluding reactor I&C)		7
31. Turbine and auxiliaries		12
32. Feedwater and Main Steam System		15
33. Circulating Water System		18
34. Miscellaneous Systems		115
41. Main Generator Systems		21
42. Electrical Power Supply Systems		11
Total		**623**

Highlights (2020)

Refueling Outage 20.

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2020 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

Reactor type and model	:	BWR / BWR-3 (Mark 1)
Thermal power	:	2004 MWth
Gross electrical power	:	691 MWe
Reference unit power (net)	:	628 MWe

Key Dates

Construction Date	:	1967-06-19
Grid Date	:	1971-03-05
Commercial Date	:	1971-06-30
Age at end of year	:	49 years

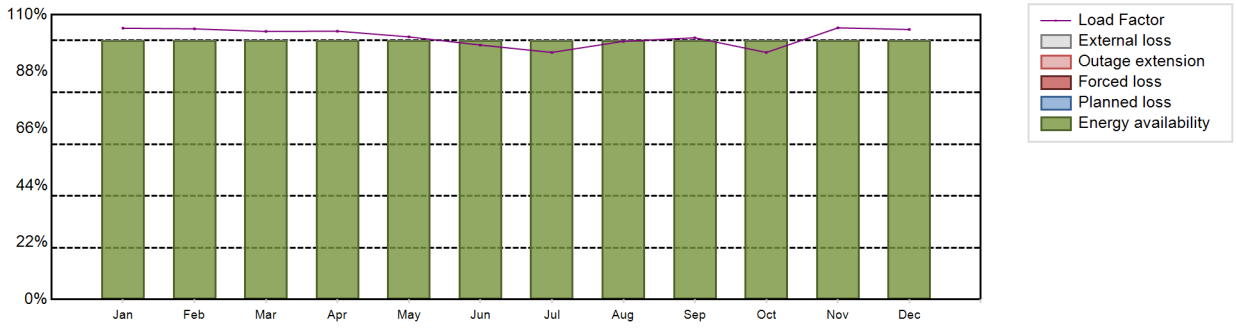
Design Characteristics

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 (2020)

Net Energy Production	:	5593.31 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)	:	101.4 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



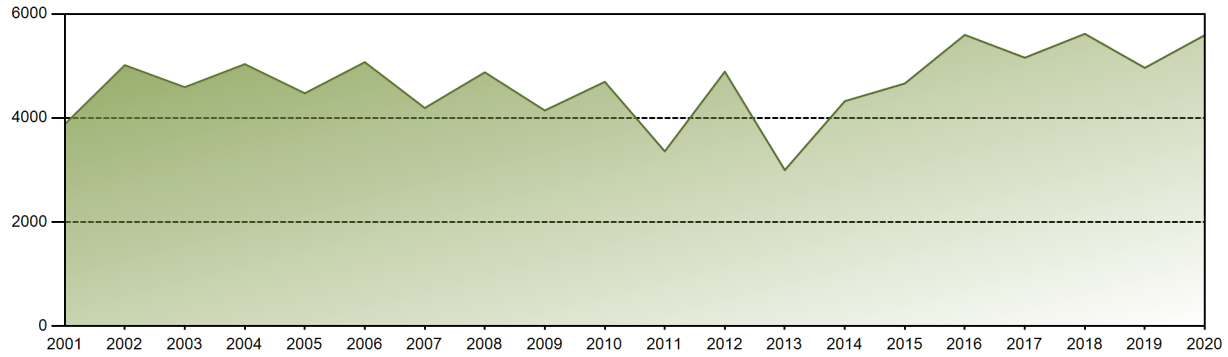
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	489.49	456.93	483.71	468.63	473.91	444.35	445.85	465.95	457.07	445.78	474.41	487.26	5593.31
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	104.76	104.54	103.53	103.64	101.43	98.27	95.42	99.72	101.09	95.41	104.92	104.29	101.40
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	204006.83 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.83 %
Cumulative Energy Availability Factor (EAF)	:	85.93 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.51 %
Cumulative Unit Capability Factor (UCF)	:	85.94 %	Cumulative Planned Unavailability Factor (PUF)	:	11.55 %
Cumulative Load Factor (LF)	:	81.92 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	84.87 %			

Electricity Production (net) [GWh]

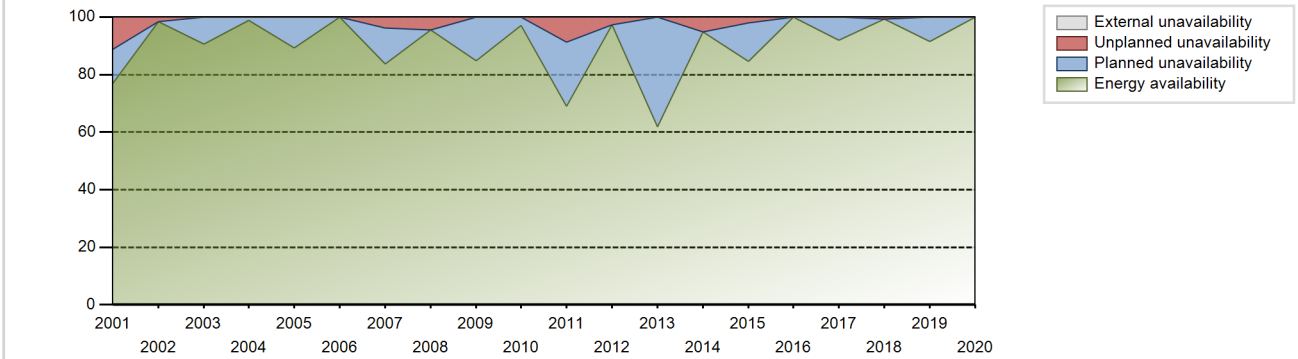


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1971	1465.90	3357	564	100.00	100.00	50.25	59.13	0.00	0.00	0.00	0.00
1972	3717.90	6975	580	100.00	100.00	72.98	79.41	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

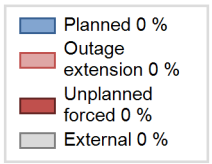
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2008	4878.02	8398	572	95.61	95.61	97.09	95.61	4.39	4.39	0.00	0.00
2009	4144.69	7421	572	84.73	84.73	82.72	84.71	0.00	0.00	15.27	0.00
2010	4695.11	8504	572	97.08	97.08	93.70	97.08	0.00	0.00	2.92	0.00
2011	3358.49	6045	572	69.04	69.04	67.03	69.01	11.16	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

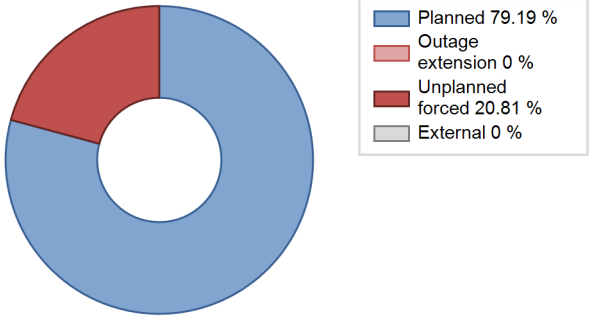
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1971 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					215	
C. Inspection, maintenance or repair combined with refuelling				924		
D. Inspection, maintenance or repair without refuelling				92		
E. Testing of plant systems or components				1	22	
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					6	
J. Grid limitation, failure or grid unavailability						1
L. Human factor related					7	
Z. Other				1	44	
Subtotal				1019	294	1
Total		**0**			**1314**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1971 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		8
12. Reactor I&C Systems		19
13. Reactor Auxiliary Systems		18
14. Safety Systems		14
15. Reactor Cooling Systems		22
16. Steam generation systems		2
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System		45
33. Circulating Water System		0
34. Miscellaneous Systems		37
35. All other I&C Systems		5
41. Main Generator Systems		12
42. Electrical Power Supply Systems		26
Total		**246**

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2020 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

Reactor type and model	:	BWR / BWR-2 (Mark 1)
Thermal power	:	1850 MWth
Gross electrical power	:	642 MWe
Reference unit power (net)	:	613 MWe

Key Dates

Construction Date	:	1965-04-12
Grid Date	:	1969-11-09
Commercial Date	:	1969-12-01
Age at end of year	:	51 years

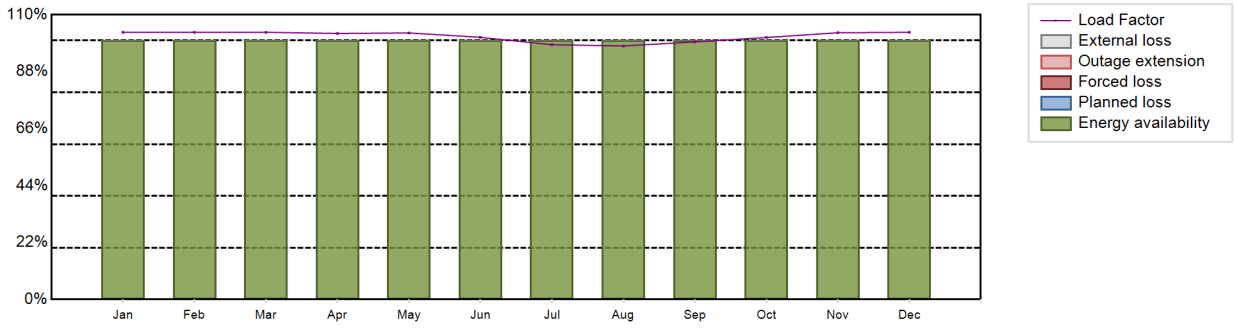
Design Characteristics

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 (2020)

Net Energy Production	:	5473 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)	:	101.64 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



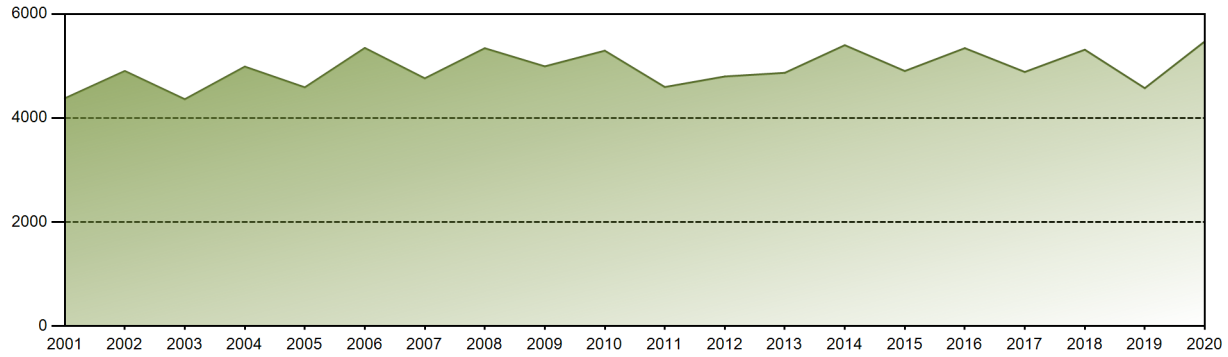
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	470.59	440.35	470.68	453.50	469.56	446.94	448.80	446.63	439.13	461.48	454.77	470.59	5473.00
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	103.18	103.21	103.20	102.75	102.96	101.26	98.41	97.93	99.50	101.18	103.04	103.18	101.64
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	201733.9 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	9.35 %
Cumulative Energy Availability Factor (EAF)	:	78.91 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	8.14 %
Cumulative Unit Capability Factor (UCF)	:	78.91 %	Cumulative Planned Unavailability Factor (PUF)	:	12.96 %
Cumulative Load Factor (LF)	:	74.93 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	77.75 %			

Electricity Production (net) [GWh]

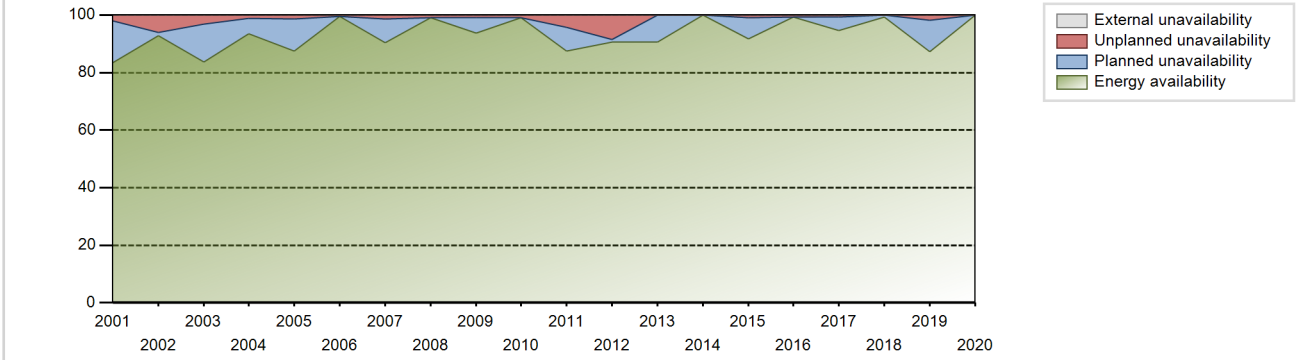


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1969	Data not provided										
1970	1581.00	3443	525	100.00	100.00	34.38	39.30	0.00	0.00	0.00	0.00
1971	3033.10	5963	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

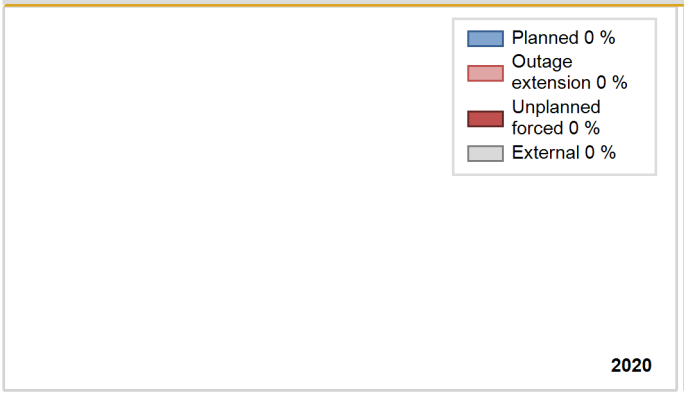
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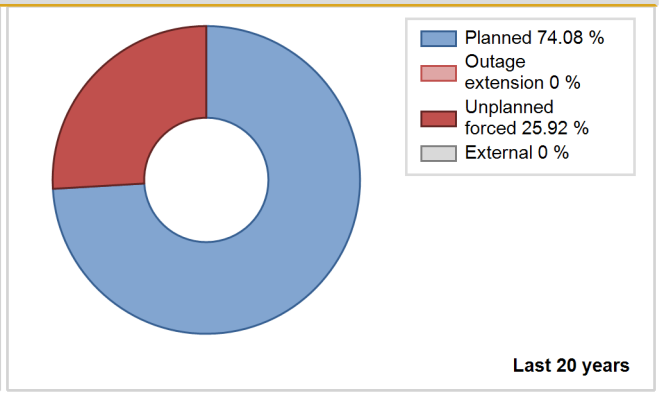
2006	5346.94	8713	621	99.47	99.47	98.29	99.46	0.53	0.53	0.00	0.00
2007	4762.88	7910	621	90.31	90.31	87.55	90.30	1.59	1.46	8.23	0.00
2008	5341.42	8707	621	99.13	99.13	97.92	99.12	0.87	0.87	0.00	0.00
2009	4992.58	8216	621	93.81	93.81	91.78	93.79	0.87	0.82	5.37	0.00
2010	5294.08	8677	621	99.06	99.06	97.32	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1969 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					588	
C. Inspection, maintenance or repair combined with refuelling				1031		
D. Inspection, maintenance or repair without refuelling				111		
E. Testing of plant systems or components				2	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				2		
H. Nuclear regulatory requirements					8	
L. Human factor related					23	
Z. Other				4	107	
Subtotal				1150	727	
Total		**0**			**1877**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1969 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		17
12. Reactor I&C Systems		29
13. Reactor Auxiliary Systems		23
14. Safety Systems		96
15. Reactor Cooling Systems		257
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		8
31. Turbine and auxiliaries		72
32. Feedwater and Main Steam System		47
34. Miscellaneous Systems		2
35. All other I&C Systems		2
41. Main Generator Systems		14
42. Electrical Power Supply Systems		25
Total		**593**

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2020 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

Reactor type and model	:	BWR / BWR-5 (Mark 2)
Thermal power	:	3988 MWth
Gross electrical power	:	1320 MWe
Reference unit power (net)	:	1277 MWe

Key Dates

Construction Date	:	1975-08-01
Grid Date	:	1987-08-08
Commercial Date	:	1988-03-11
Age at end of year	:	33 years

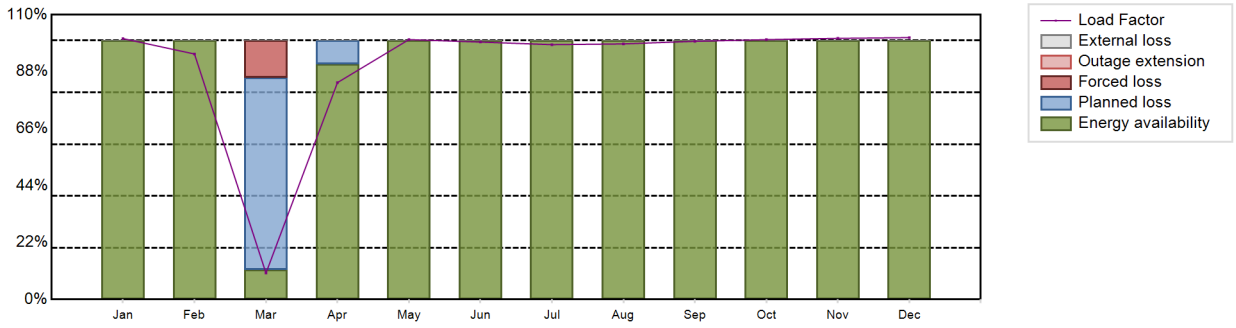
Design Characteristics

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 (2020)

Net Energy Production	:	10167.61 GW(e).h	Forced Loss Rate (FLR)	:	1.31 %
Energy Availability Factor (EAF)	:	91.75 %	Unplanned Capability Loss Factor (UCL)	:	1.22 %
Unit Capability Factor (UCF)	:	91.75 %	Planned Unavailability Factor (PUF)	:	7.03 %
Load Factor (LF)	:	90.64 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	91.75 %	Total off-line time	:	725 hours

Annual Summary



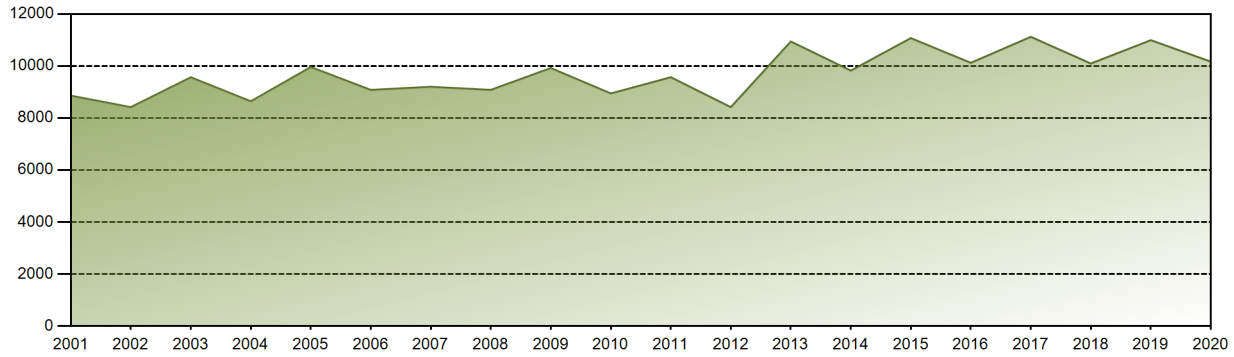
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	957.50	842.76	97.10	770.32	953.76	914.22	935.08	937.88	916.92	953.60	927.46	961.00	10167.61
EAF [%]	100.00	100.00	11.44	90.93	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.75
UCF [%]	100.00	100.00	11.44	90.93	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.75
LF [%]	100.78	94.82	10.22	83.78	100.39	99.43	98.42	98.72	99.73	100.37	100.87	101.15	90.64
OF [%]	100.00	100.00	11.29	90.97	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.75
FLR [%]	0.00	0.00	55.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31
UCL [%]	0.00	0.00	14.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.22
PUF [%]	0.00	0.00	74.19	9.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.03
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

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Historical Summary

Lifetime energy generation	:	333525.19 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.11 %
Cumulative Energy Availability Factor (EAF)	:	87.19 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.73 %
Cumulative Unit Capability Factor (UCF)	:	87.19 %	Cumulative Planned Unavailability Factor (PUF)	:	9.08 %
Cumulative Load Factor (LF)	:	85.09 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	86.18 %			

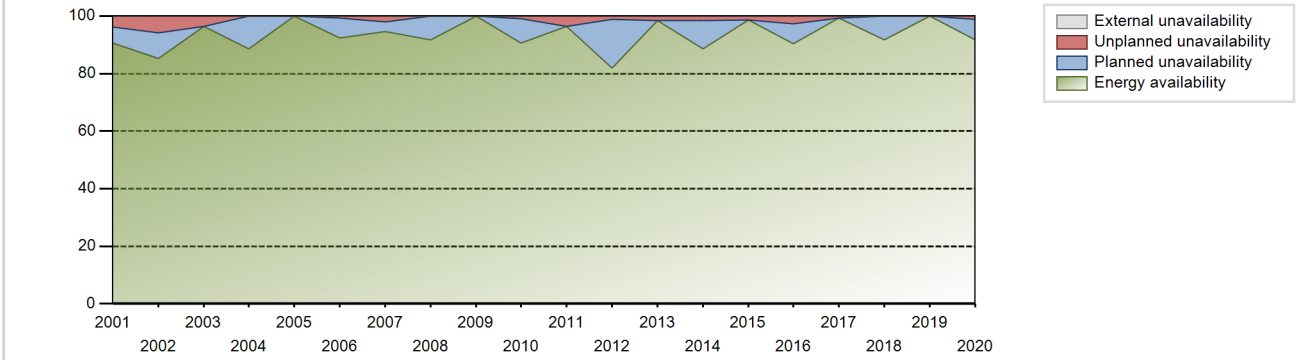
Electricity Production (net) [GWh]



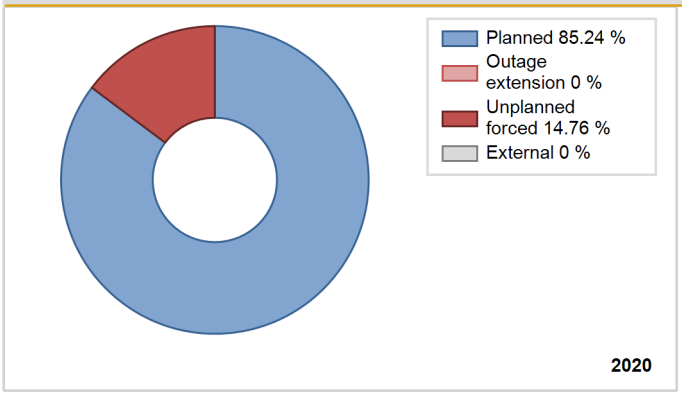
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	2540.56	2800	1040	49.12	49.12	33.61	38.64	17.46	10.39	40.48	0.00
1989	4288.28	4824	1068	56.45	56.45	45.81	55.07	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

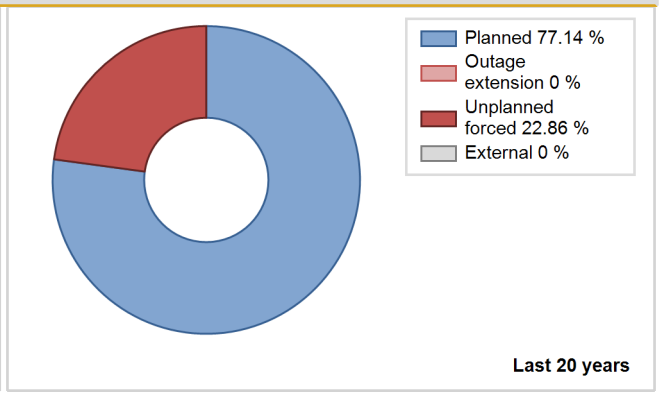
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					305	
B. Refuelling without maintenance	617			19		
C. Inspection, maintenance or repair combined with refuelling				600		
D. Inspection, maintenance or repair without refuelling				213		
E. Testing of plant systems or components				2	3	
J. Grid limitation, failure or grid unavailability						4
L. Human factor related					18	
Z. Other		107			20	
Subtotal	617	107		834	346	4
Total		**724**			**1184**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		8
12. Reactor I&C Systems		25
13. Reactor Auxiliary Systems		10
14. Safety Systems		7
15. Reactor Cooling Systems		47
16. Steam generation systems		9
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		27
32. Feedwater and Main Steam System		47
33. Circulating Water System		10
34. Miscellaneous Systems		18
35. All other I&C Systems		33
41. Main Generator Systems		22
42. Electrical Power Supply Systems		48
Total		**313**

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Highlights (2020)

EHC Leak led to manual scram. Site then commenced refueling outage (previously scheduled to begin 3/9)

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2020 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	:	42 years

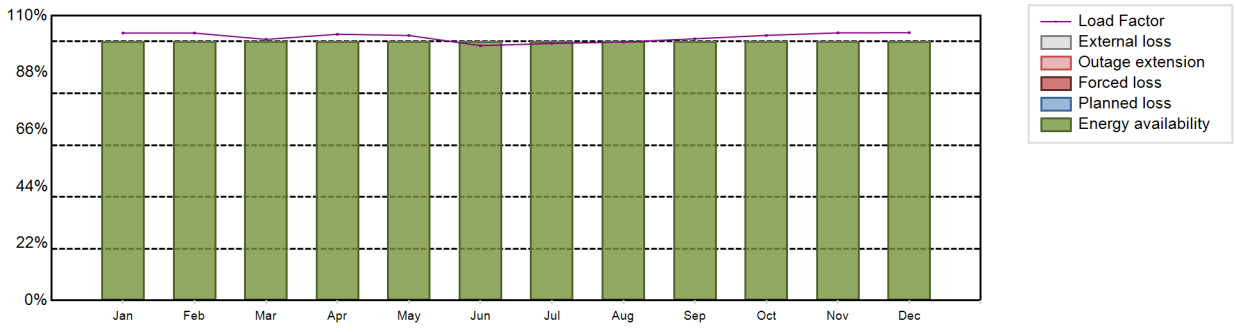
Design Characteristics

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 (2020)

Net Energy Production	:	8468.83 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)	:	101.7 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



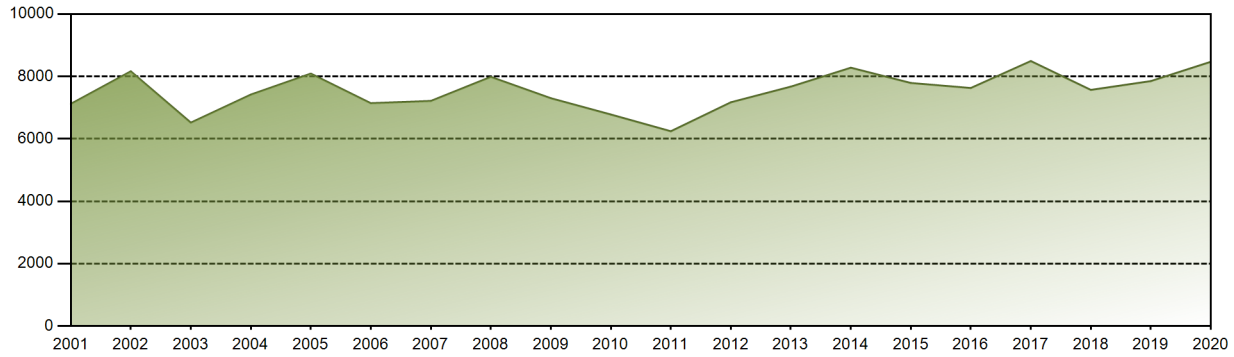
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	728.83	681.50	711.34	701.88	721.96	671.79	700.10	704.22	690.01	722.20	705.45	729.57	8468.83
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	103.33	103.29	100.86	102.83	102.36	98.42	99.26	99.84	101.09	102.39	103.35	103.44	101.70
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	328010.46 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.31 %
Cumulative Energy Availability Factor (EAF)	:	84.65 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.84 %
Cumulative Unit Capability Factor (UCF)	:	85.18 %	Cumulative Planned Unavailability Factor (PUF)	:	10.98 %
Cumulative Load Factor (LF)	:	83.23 %	Cumulative Externally cause unavailability (XUF)	:	0.54 %
Cumulative Operating Factor (OF)	:	84.72 %			

Electricity Production (net) [GWh]

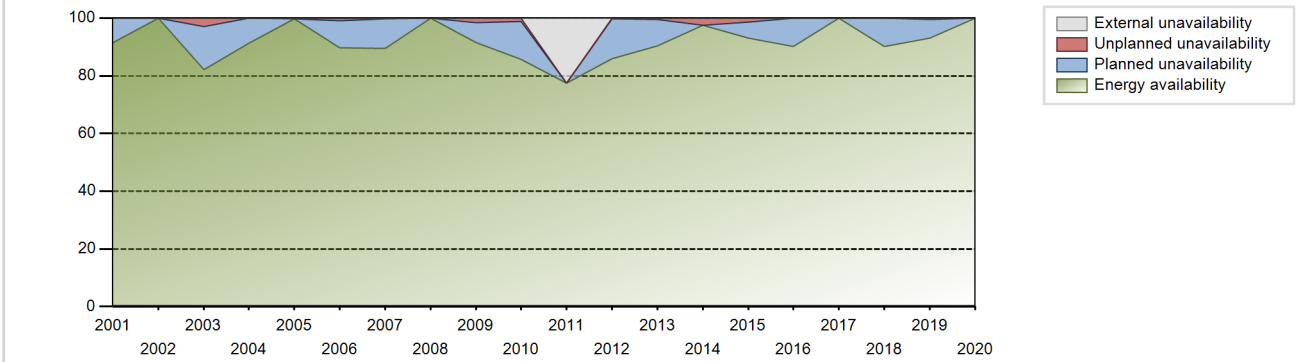


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1978	3971.50	5420	896	81.39	81.39	79.45	92.85	13.69	12.91	5.70	0.00
1979	4188.70	5399	898	53.25	53.25	53.25	61.63	21.68	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

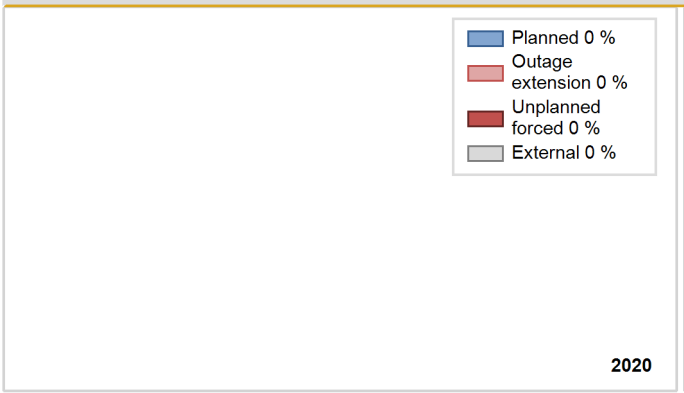
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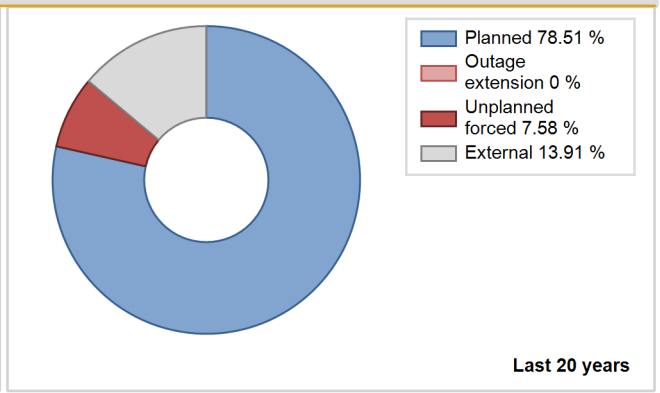
2015	7789.98	8141	948	92.96	92.96	93.80	92.93	1.54	1.46	5.58	0.00
2016	7629.40	7925	948	90.22	90.22	91.62	90.22	0.00	0.00	9.78	0.00
2017	8492.34	8760	948	100.00	100.00	102.26	100.00	0.00	0.00	0.00	0.00
2018	7568.38	7893	948	90.10	90.10	91.14	90.10	0.00	0.00	9.90	0.00
2019	7850.41	8159	948	93.16	93.16	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1978 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					314	
C. Inspection, maintenance or repair combined with refuelling				882		
D. Inspection, maintenance or repair without refuelling				85		
E. Testing of plant systems or components				6	4	
L. Human factor related					4	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						47
Z. Other				0	2	
Subtotal				973	324	47
Total	**0**			**1344**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1978 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		11
12. Reactor I&C Systems		3
13. Reactor Auxiliary Systems		9
14. Safety Systems		15
15. Reactor Cooling Systems		41
16. Steam generation systems		85
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		41
32. Feedwater and Main Steam System		16
33. Circulating Water System		3
34. Miscellaneous Systems		18
41. Main Generator Systems		9
42. Electrical Power Supply Systems		66
Total		**318**

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2020 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

Reactor type and model	:	PWR / WH 3LP (DRYSUB)
Thermal power	:	2940 MWth
Gross electrical power	:	1011 MWe
Reference unit power (net)	:	944 MWe

Key Dates

Construction Date	:	1971-02-19
Grid Date	:	1980-08-25
Commercial Date	:	1980-12-14
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 [%]	:	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

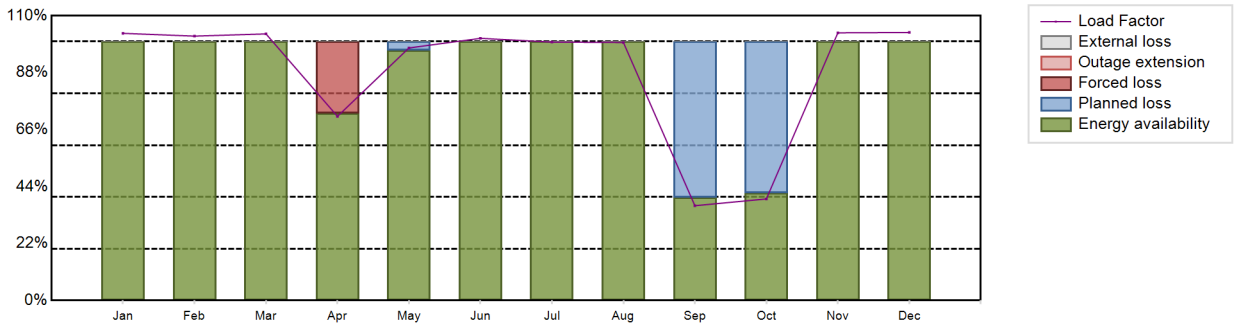
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	327
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.316
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7331.07 GW(e).h
Energy Availability Factor (EAF)	:	87.54 %
Unit Capability Factor (UCF)	:	87.54 %
Load Factor (LF)	:	88.41 %
Operating Factor (OF)	:	87.53 %

Forced Loss Rate (FLR)	:	2.53 %
Unplanned Capability Loss Factor (UCL)	:	2.27 %
Planned Unavailability Factor (PUF)	:	10.18 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1095 hours

Annual Summary



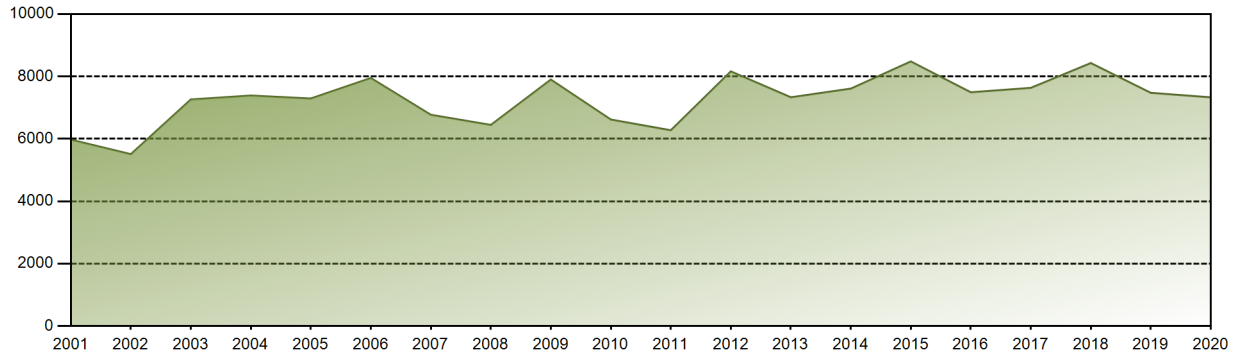
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	724.78	670.95	723.24	483.46	685.08	688.23	700.96	700.02	248.90	275.64	702.73	727.09	7331.07
EAF [%]	100.00	100.00	100.00	72.26	96.53	100.00	100.00	100.00	39.81	41.49	100.00	100.00	87.54
UCF [%]	100.00	100.00	100.00	72.26	96.53	100.00	100.00	100.00	39.81	41.49	100.00	100.00	87.54
LF [%]	103.20	102.12	102.98	71.13	97.54	101.26	99.80	99.67	36.62	39.25	103.39	103.52	88.41
OF [%]	100.00	100.00	99.87	72.22	96.51	100.00	100.00	100.00	39.86	41.53	100.00	100.00	87.53
FLR [%]	0.00	0.00	0.00	27.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.53
UCL [%]	0.00	0.00	0.00	27.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.27
PUF [%]	0.00	0.00	0.00	0.00	3.47	0.00	0.00	0.00	60.19	58.51	0.00	0.00	10.18
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

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Historical Summary

Lifetime energy generation	:	274030.07 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.44 %
Cumulative Energy Availability Factor (EAF)	:	86.88 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.12 %
Cumulative Unit Capability Factor (UCF)	:	87.54 %	Cumulative Planned Unavailability Factor (PUF)	:	9.34 %
Cumulative Load Factor (LF)	:	85.48 %	Cumulative Externally cause unavailability (XUF)	:	0.67 %
Cumulative Operating Factor (OF)	:	86.72 %			

Electricity Production (net) [GWh]

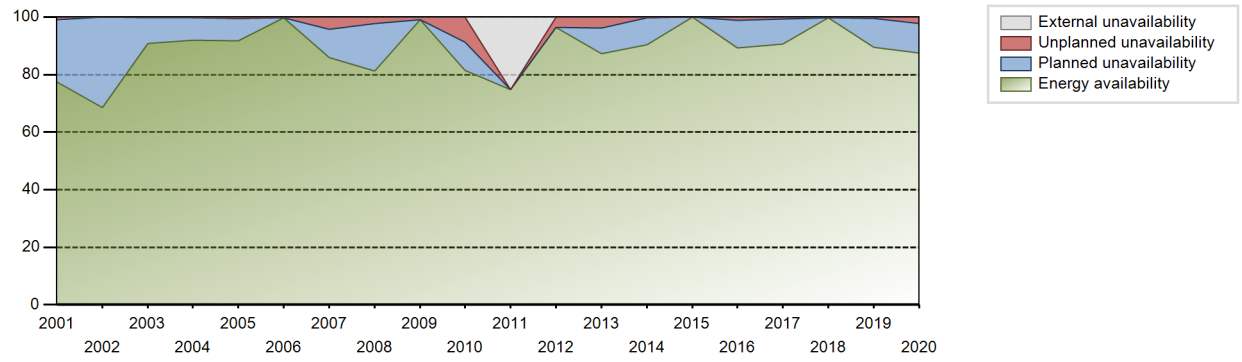


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1980	1082.50	1701	897	97.50	97.50	90.12	95.37	2.50	2.50	0.00	0.00
1981	5652.70	6813	883	78.35	78.35	73.08	77.77	19.06	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

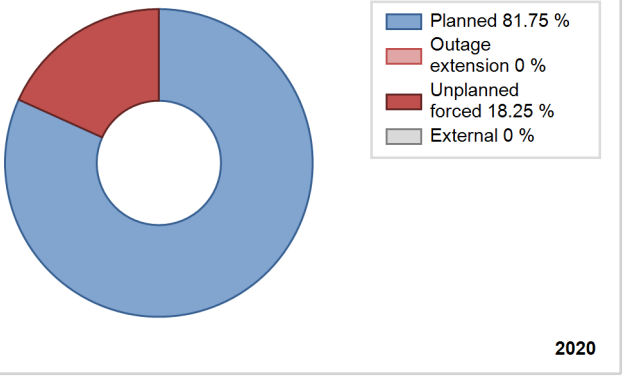
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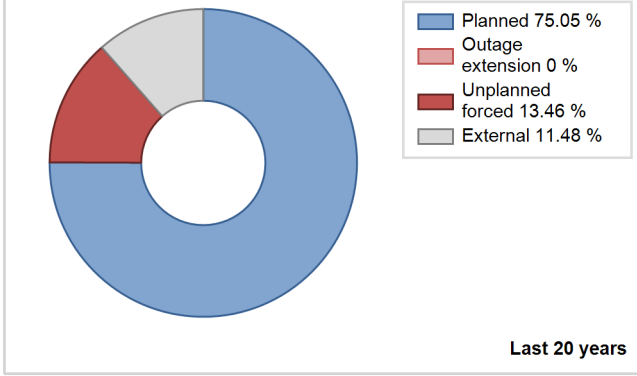
2017	7633.75	7937	944	90.62	90.62	92.31	90.61	0.70	0.64	8.75	0.00
2018	8428.87	8732	944	99.68	99.68	101.93	99.68	0.32	0.32	0.00	0.00
2019	7474.13	7828	944	89.38	89.38	90.38	89.36	0.46	0.41	10.21	0.00
2020	7331.07	7689	944	87.54	87.54	88.41	87.53	2.53	2.27	10.18	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1980 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					213	
B. Refuelling without maintenance	869			22		
C. Inspection, maintenance or repair combined with refuelling				745		
D. Inspection, maintenance or repair without refuelling	26			54		
E. Testing of plant systems or components				2		
L. Human factor related					10	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						62
Z. Other		200			50	
Subtotal	895	200		823	273	62
Total	**1095**			**1158**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1980 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		2
14. Safety Systems		16
15. Reactor Cooling Systems		26
16. Steam generation systems		72
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		7
32. Feedwater and Main Steam System		19
33. Circulating Water System		1
34. Miscellaneous Systems		13
41. Main Generator Systems		41
42. Electrical Power Supply Systems		58
Total		**260**

Highlights (2020)

2-RC-P-1A Seal Injection piping repaired

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2020 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	:	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 [%]	:	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

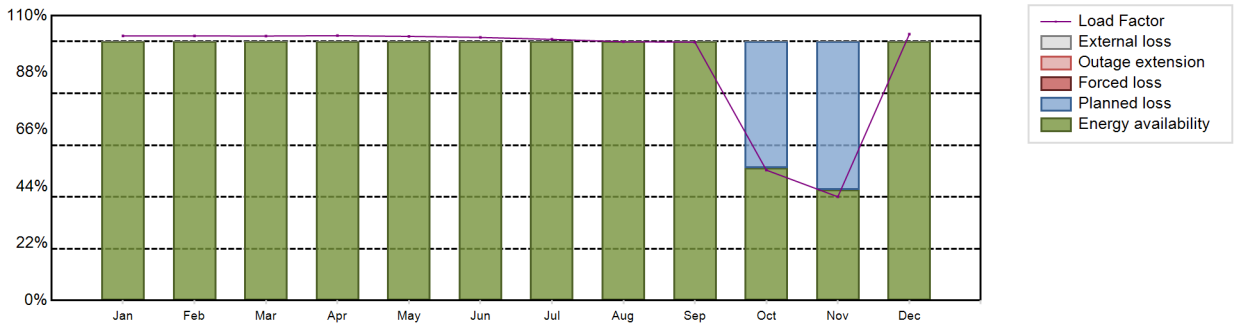
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	318
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.513
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6859.97 GW(e).h
Energy Availability Factor (EAF)	:	91.19 %
Unit Capability Factor (UCF)	:	91.19 %
Load Factor (LF)	:	92.2 %
Operating Factor (OF)	:	91.2 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.81 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	773 hours

Annual Summary



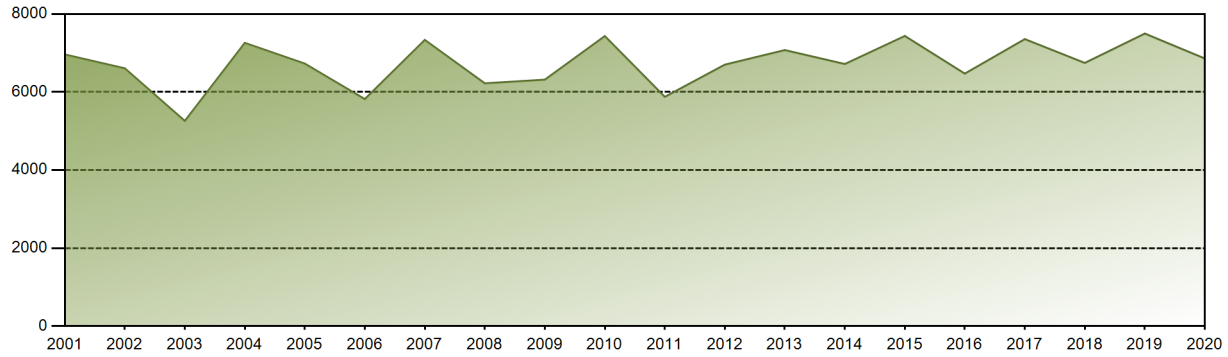
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	643.92	602.40	643.74	623.80	642.88	619.67	635.63	629.69	608.54	317.32	244.32	648.07	6859.97
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	51.34	42.85	100.00	91.19
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	51.34	42.85	100.00	91.19
LF [%]	102.18	102.19	102.15	102.29	102.02	101.61	100.87	99.92	99.79	50.35	40.06	102.84	92.20
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	51.34	43.06	100.00	91.20
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	48.66	57.15	0.00	8.81
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

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Historical Summary

Lifetime energy generation	:	289009.61 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.3 %
Cumulative Energy Availability Factor (EAF)	:	82.65 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.6 %
Cumulative Unit Capability Factor (UCF)	:	82.87 %	Cumulative Planned Unavailability Factor (PUF)	:	11.53 %
Cumulative Load Factor (LF)	:	80.34 %	Cumulative Externally cause unavailability (XUF)	:	0.22 %
Cumulative Operating Factor (OF)	:	82.3 %			

Electricity Production (net) [GWh]

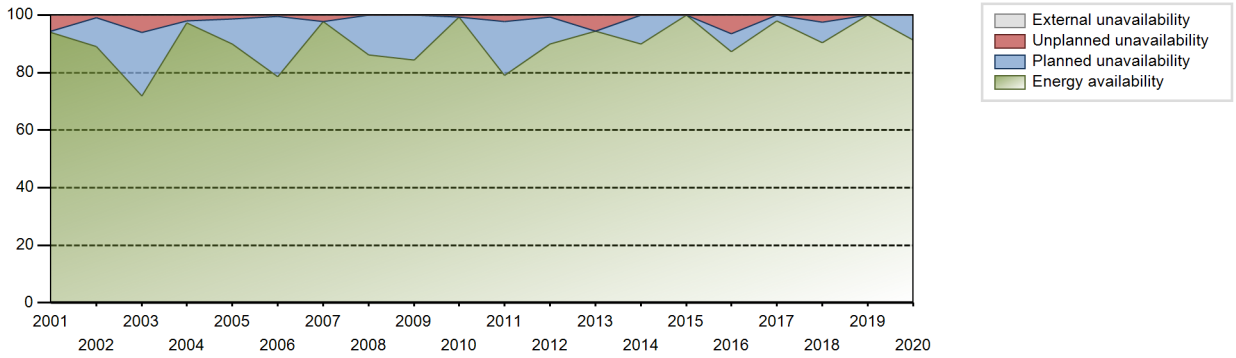


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	2200.00	4226	721	70.52	70.52	67.32	75.86	11.34	9.02	20.46	0.00
1974	4230.30	5141	920	100.00	100.00	52.49	58.69	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

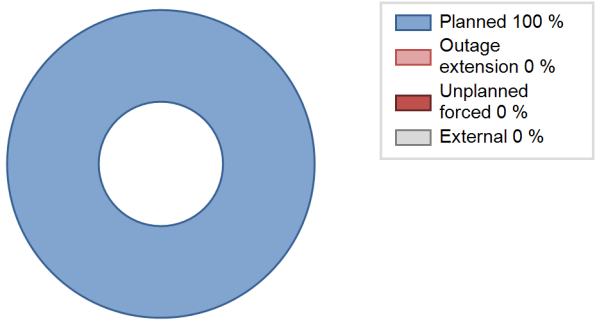
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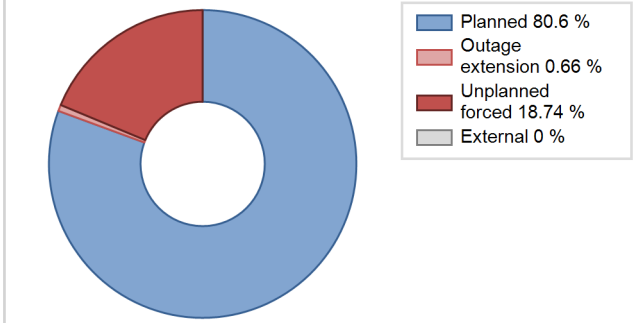
2010	7433.77	8695	846	99.27	99.27	100.31	99.26	0.73	0.73	0.00	0.00
2011	5876.33	6917	846	78.98	78.98	79.29	78.96	2.70	2.19	18.82	0.00
2012	6701.97	7902	846	89.98	89.98	90.19	89.96	0.77	0.70	9.32	0.00
2013	7075.28	8260	846	94.29	94.29	95.46	94.28	5.71	5.71	0.00	0.00
2014	6718.01	7880	846	89.95	89.95	90.65	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					449	
B. Refuelling without maintenance	774			16		
C. Inspection, maintenance or repair combined with refuelling				814		
D. Inspection, maintenance or repair without refuelling				123		
E. Testing of plant systems or components				17	3	
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					29	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L. Human factor related					1	
P. Fire					12	
Z. Other					1	
Subtotal	774			971	495	0
Total	**774**			**1466**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		34
12. Reactor I&C Systems		48
13. Reactor Auxiliary Systems		2
14. Safety Systems		40
15. Reactor Cooling Systems		96
16. Steam generation systems		125
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		4
31. Turbine and auxiliaries		37
32. Feedwater and Main Steam System		16
34. Miscellaneous Systems		30
41. Main Generator Systems		13
42. Electrical Power Supply Systems		31
Total		**477**

Highlights (2020)

Refueling Outage 31 (1EOC31)

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2020 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	:	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 [%]	:	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

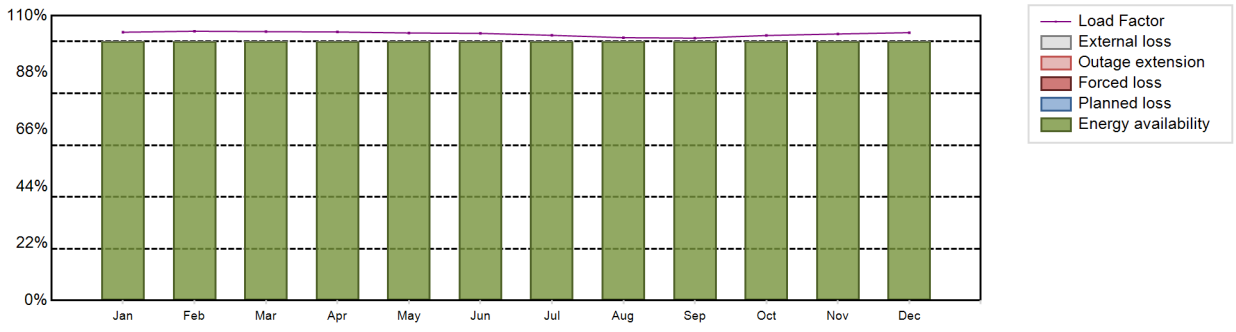
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	318
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.513
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7670.16 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	102.97 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



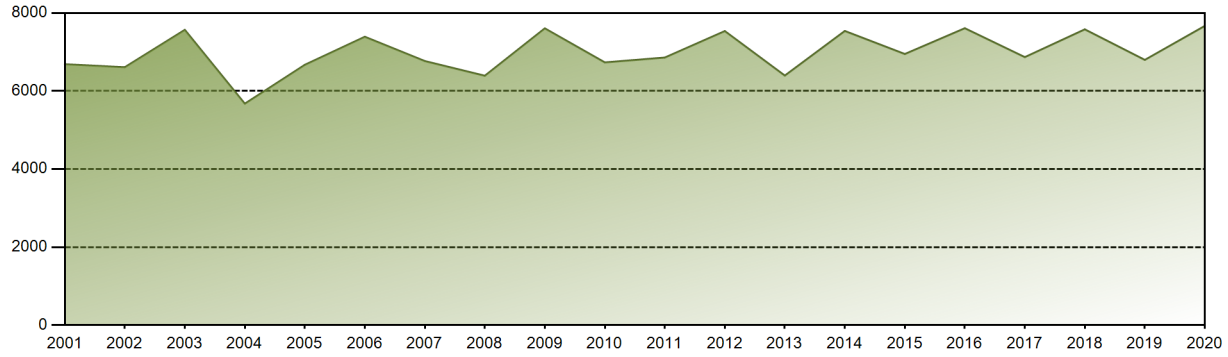
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	653.78	613.79	655.18	633.22	651.95	629.94	646.19	640.43	618.70	645.72	628.54	652.72	7670.16
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	103.62	104.00	103.85	103.71	103.34	103.17	102.42	101.51	101.33	102.35	102.95	103.46	102.97
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	291632.43 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.79 %
Cumulative Energy Availability Factor (EAF)	:	84.55 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.2 %
Cumulative Unit Capability Factor (UCF)	:	84.72 %	Cumulative Planned Unavailability Factor (PUF)	:	10.08 %
Cumulative Load Factor (LF)	:	83.16 %	Cumulative Externally cause unavailability (XUF)	:	0.17 %
Cumulative Operating Factor (OF)	:	85.08 %			

Electricity Production (net) [GWh]

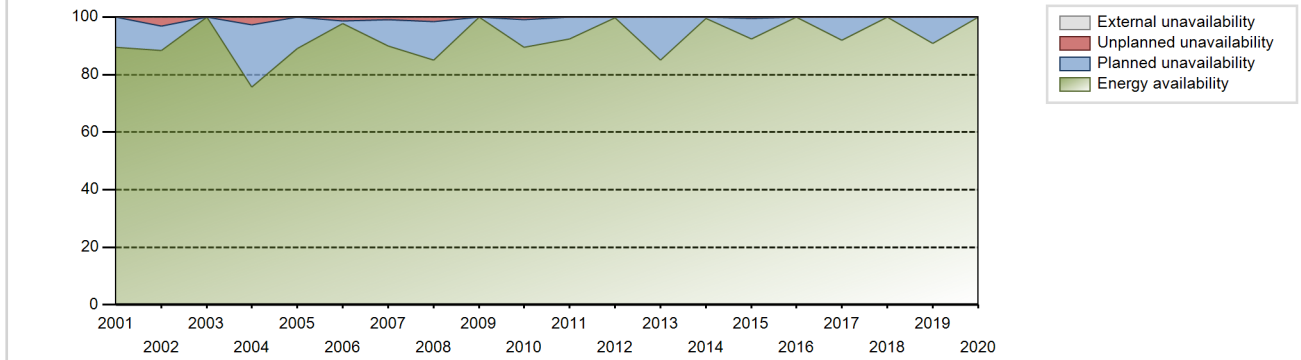


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	2115.50	2786	920	100.00	100.00	54.57	61.89	0.00	0.00	0.00	0.00
1975	4970.60	6398	871	65.21	65.21	65.15	73.04	29.64	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

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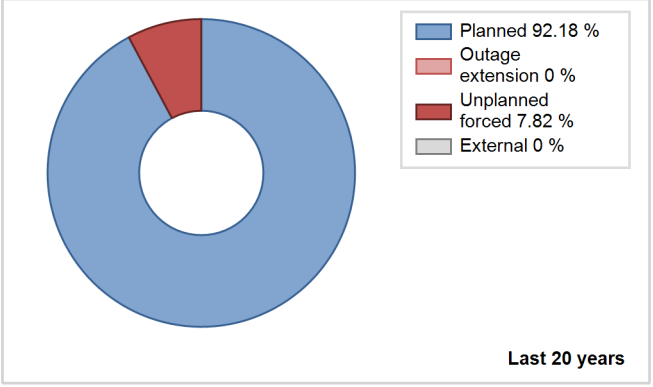
2011	6858.68	8097	846	92.45	92.45	92.55	92.43	0.00	0.00	7.55	0.00
2012	7537.01	8756	846	99.69	99.69	101.42	99.68	0.00	0.00	0.31	0.00
2013	6396.65	7455	846	85.11	85.11	86.30	85.09	0.00	0.00	14.89	0.00
2014	7539.58	8711	846	99.44	99.44	101.74	99.44	0.00	0.00	0.56	0.00
2015	6949.48	8082	848	92.28	92.28	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					418	
C. Inspection, maintenance or repair combined with refuelling				785		
D. Inspection, maintenance or repair without refuelling				52		
E. Testing of plant systems or components				4	3	
H. Nuclear regulatory requirements					22	
L. Human factor related					1	
Z. Other					0	
Subtotal				841	444	
Total		**0**			**1285**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		31
12. Reactor I&C Systems		46
13. Reactor Auxiliary Systems		8
14. Safety Systems		34
15. Reactor Cooling Systems		79
16. Steam generation systems		84
31. Turbine and auxiliaries		113
32. Feedwater and Main Steam System		6
33. Circulating Water System		2
34. Miscellaneous Systems		2
41. Main Generator Systems		5
42. Electrical Power Supply Systems		13
Total		**423**

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2020 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

Reactor type and model	:	PWR / B&W LLP (DRYAMB)
Thermal power	:	2568 MWth
Gross electrical power	:	900 MWe
Reference unit power (net)	:	859 MWe

Key Dates

Construction Date	:	1967-11-06
Grid Date	:	1974-09-18
Commercial Date	:	1974-12-16
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]	:	-
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]	:	19.06
Number of control rod assemblies	:	28
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

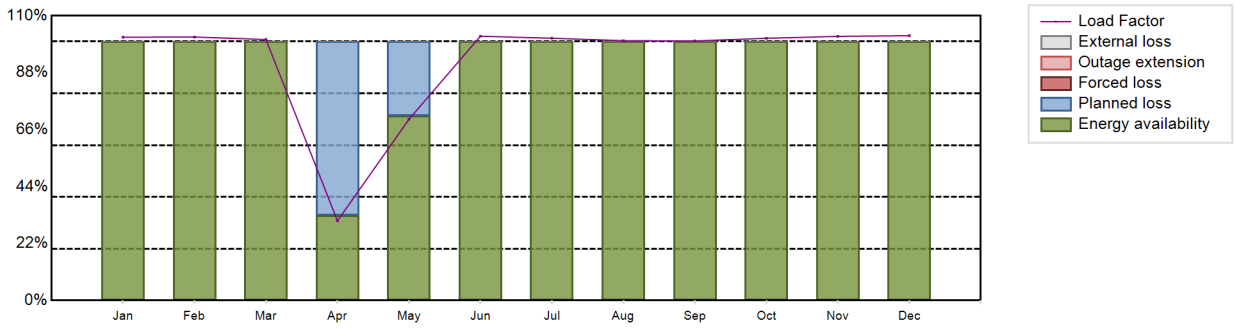
Operating coolant pressure [MPa]	:	15.5
Reactor outlet temperature [°C]	:	318
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.513
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7012.14 GW(e).h
Energy Availability Factor (EAF)	:	92.09 %
Unit Capability Factor (UCF)	:	92.09 %
Load Factor (LF)	:	92.93 %
Operating Factor (OF)	:	92.07 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	7.91 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	697 hours

Annual Summary



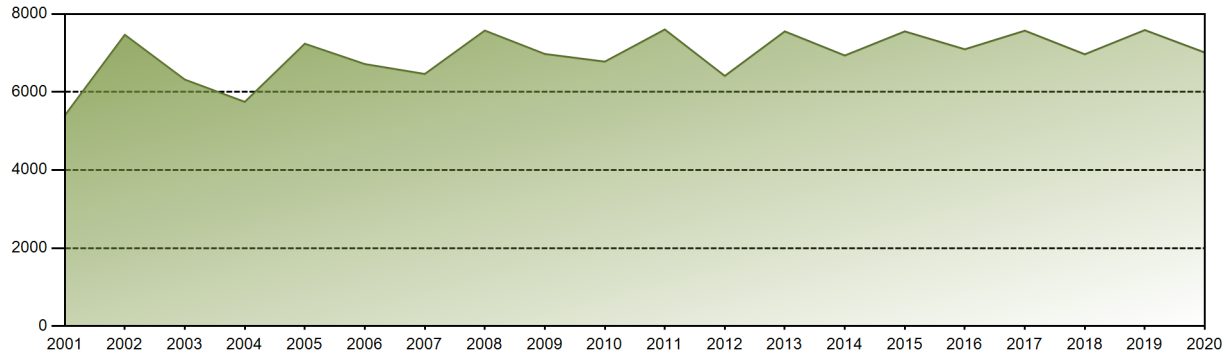
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	649.94	608.53	644.19	190.34	447.31	631.26	647.41	641.29	619.95	647.29	630.90	653.72	7012.14
EAF [%]	100.00	100.00	100.00	32.97	71.42	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.09
UCF [%]	100.00	100.00	100.00	32.97	71.42	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.09
LF [%]	101.70	101.78	100.80	30.78	69.99	102.07	101.30	100.34	100.24	101.28	102.01	102.29	92.93
OF [%]	100.00	100.00	99.87	32.92	71.37	100.00	100.00	100.00	100.00	100.00	100.00	100.00	92.07
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	67.03	28.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.91
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

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Historical Summary

Lifetime energy generation	:	290063.61 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.33 %
Cumulative Energy Availability Factor (EAF)	:	83.52 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.66 %
Cumulative Unit Capability Factor (UCF)	:	83.76 %	Cumulative Planned Unavailability Factor (PUF)	:	10.58 %
Cumulative Load Factor (LF)	:	82.94 %	Cumulative Externally cause unavailability (XUF)	:	0.24 %
Cumulative Operating Factor (OF)	:	83.86 %			

Electricity Production (net) [GWh]

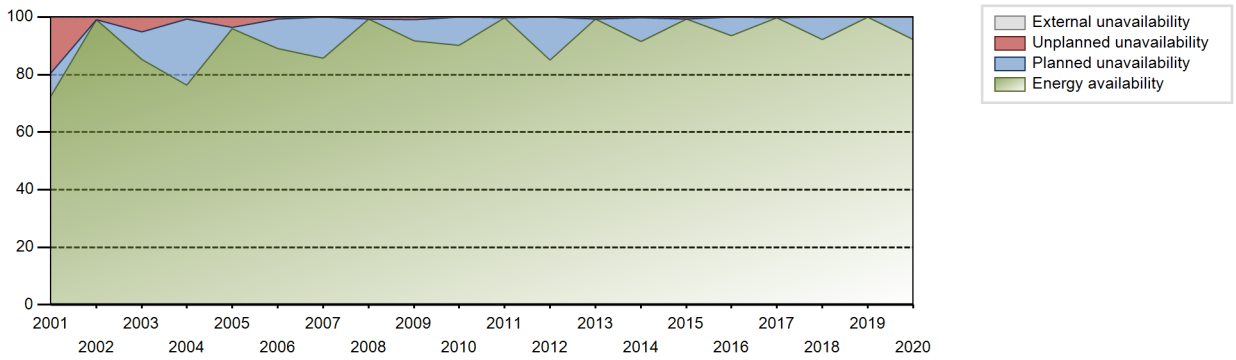


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	Data not provided										
1975	5037.40	6761	871	66.09	66.09	66.02	77.18	22.28	18.95	14.96	0.00
1976	4758.00	6072	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

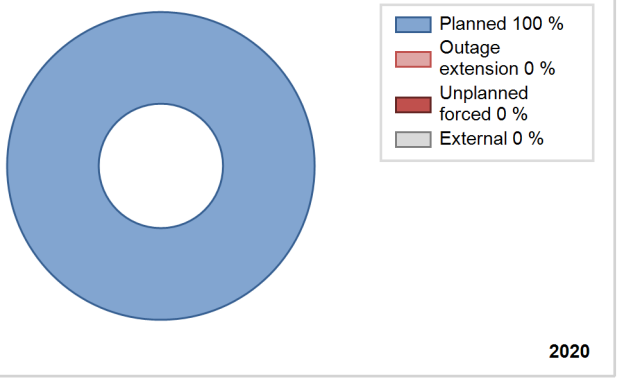
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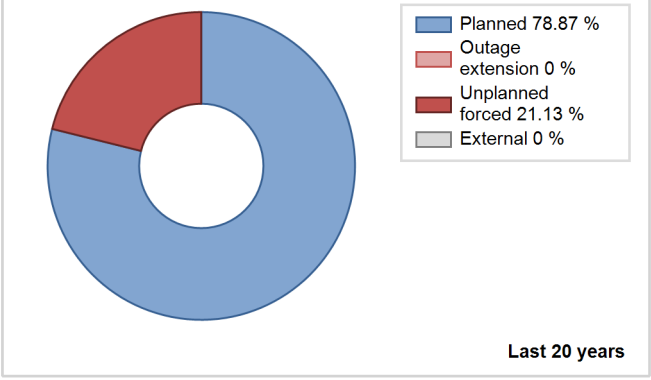
2011	7602.37	8730	846	99.66	99.66	102.58	99.66	0.34	0.34	0.00	0.00
2012	6411.91	7469	846	85.05	85.05	86.28	85.03	0.00	0.00	14.95	0.00
2013	7553.22	8700	846	99.31	99.31	101.91	99.30	0.69	0.69	0.00	0.00
2014	6935.79	8022	846	91.57	91.57	93.59	91.58	0.30	0.28	8.15	0.00
2015	7553.32	8701	859	99.33	99.33	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					390	
B. Refuelling without maintenance	695			15		
C. Inspection, maintenance or repair combined with refuelling				779		
D. Inspection, maintenance or repair without refuelling				93	0	
E. Testing of plant systems or components				9	4	
H. Nuclear regulatory requirements					81	
K. Load-following (frequency control, reserve shutdown due to reduced energy demand, reactive power)						0
L. Human factor related					3	
Z. Other				0	11	
Subtotal	695			896	489	0
Total	**695**			**1385**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		69
13. Reactor Auxiliary Systems		27
14. Safety Systems		19
15. Reactor Cooling Systems		53
16. Steam generation systems		101
21. Fuel Handling and Storage Facilities		3
31. Turbine and auxiliaries		53
32. Feedwater and Main Steam System		23
34. Miscellaneous Systems		28
41. Main Generator Systems		6
42. Electrical Power Supply Systems		5
Total		**400**

Highlights (2020)

Refueling Outage 30 (3EOC30)

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2020 Operating Experience

US-255 PALISADES — UNITED STATES OF AMERICA



Status at end of year	:	**Operational**
Operator	:	ENTERGY (Entergy Nuclear Operations, Inc.)
Owner	:	ENTERGY (Entergy Nuclear Operations, 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	:	2565 MWth
Gross electrical power	:	850 MWe
Reference unit power (net)	:	805 MWe

Key Dates

Construction Date	:	1967-03-14
Grid Date	:	1971-12-31
Commercial Date	:	1971-12-31
Age at end of year	:	49 years

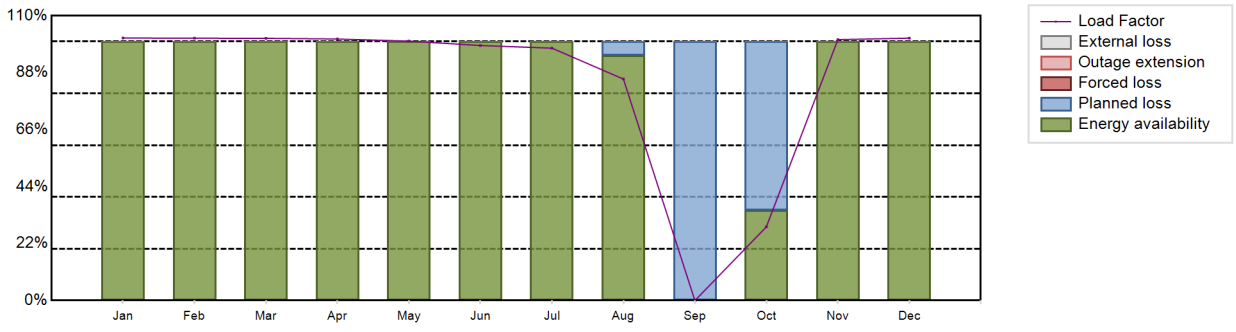
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	14.48
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	305
Fuel material	:	UO2	Number of SG	:	2
Refuelling type	:	OFF-line	Containment type	:	-
Moderator material	:	H2O	Containment design pressure [MPa]	:	0.387
Average fuel enrichment [% of U235]	:	-	**Secondary systems**		
Refuelling frequency [month]	:	18	Number of turbine-generators per unit/reactor	:	1
Part of the core refuelled [%]	:	28	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	33205	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.47	HP cylinder inlet steam pressure [MPa]	:	5.18
Active core height/length [m]	:	3.34	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	204	Primary means of condenser cooling	:	Cooling Towers
Fuel linear heat generation rate [kW/m]	:	25.73	Number of main condensate pumps	:	-
Number of control rod assemblies	:	-	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 (2020)

Net Energy Production	:	5995.12 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	85.85 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	85.85 %	Planned Unavailability Factor (PUF)	:	14.15 %
Load Factor (LF)	:	84.78 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	85.84 %	Total off-line time	:	1244 hours

Annual Summary



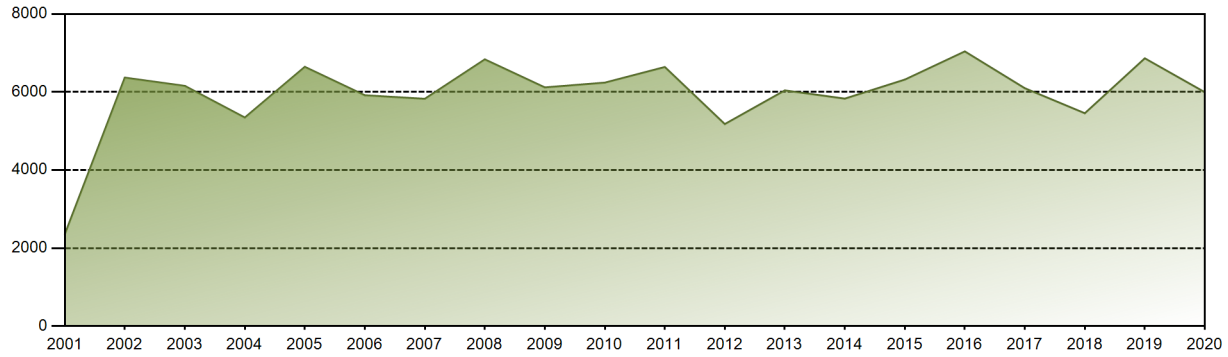
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	607.20	567.65	606.48	585.43	600.02	570.88	583.76	512.27	0.00	170.46	584.08	606.90	5995.12
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.76	0.00	34.92	100.00	100.00	85.85
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	94.76	0.00	34.92	100.00	100.00	85.85
LF [%]	101.38	101.31	101.26	101.01	100.18	98.50	97.47	85.53	0.00	28.46	100.77	101.33	84.78
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	94.76	0.00	34.95	100.00	100.00	85.84
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	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	5.24	100.00	65.08	0.00	0.00	14.15
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

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Historical Summary

Lifetime energy generation	:	227256.66 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.04 %
Cumulative Energy Availability Factor (EAF)	:	74.05 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	12.21 %
Cumulative Unit Capability Factor (UCF)	:	74.79 %	Cumulative Planned Unavailability Factor (PUF)	:	12.99 %
Cumulative Load Factor (LF)	:	71.61 %	Cumulative Externally cause unavailability (XUF)	:	0.74 %
Cumulative Operating Factor (OF)	:	70.78 %			

Electricity Production (net) [GWh]

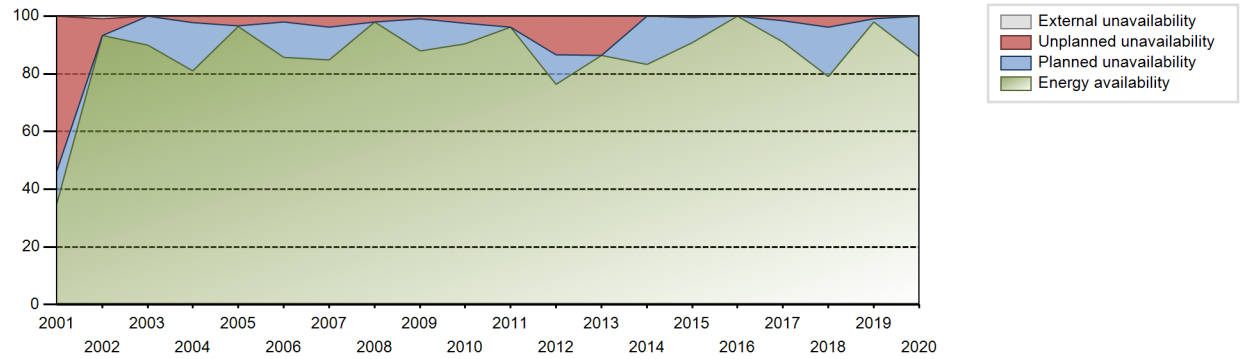


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1971	Data not provided										
1972	1899.10	4990	400	100.00	100.00	54.05	56.81	0.00	0.00	0.00	0.00
1973	2411.30	3829	700	100.00	100.00	39.32	43.71	0.00	0.00	0.00	0.00
1974	93.30	317	722	100.00	100.00	1.48	3.62	0.00	0.00	0.00	0.00
1975	2427.80	5649	684	40.52	40.52	40.52	64.49	58.12	56.23	3.24	0.00
1976	2846.90	4847	684	47.43	47.43	47.38	55.18	24.68	15.54	37.02	0.00
1977	5084.60	8004	635	90.15	90.15	91.41	91.37	6.50	6.27	3.58	0.00
1978	2624.20	4346	635	46.03	46.03	47.18	49.61	29.67	19.42	34.54	0.00
1979	3433.40	5241	635	58.73	58.73	61.72	59.83	13.81	9.41	31.86	0.00
1980	2379.10	3764	635	39.70	80.04	42.65	42.85	7.37	6.37	13.59	40.33
1981	3462.70	5009	635	55.75	55.75	62.25	57.18	15.28	10.06	34.19	0.00
1982	3345.00	4788	635	49.29	49.29	60.13	54.66	50.71	50.71	0.00	0.00
1983	3770.00	5282	635	60.12	60.12	67.77	60.30	2.01	1.23	38.65	0.00
1984	811.55	1334	635	10.02	10.02	14.55	15.19	76.28	32.22	57.76	0.00
1985	5301.80	7342	658	82.02	82.02	91.85	83.81	9.29	8.40	9.59	0.00
1986	841.24	1323	730	14.86	14.86	13.16	15.10	82.12	68.28	16.86	0.00
1987	2634.43	3980	730	45.16	45.16	41.20	45.43	48.82	43.07	11.77	0.00
1988	3435.22	4853	730	53.68	53.68	53.57	55.25	21.29	14.52	31.80	0.00
1989	3637.78	6019	730	67.36	67.36	56.89	68.71	19.70	16.53	16.11	0.00
1990	3008.09	5073	730	56.09	56.09	47.04	57.91	5.78	3.44	40.47	0.00
1991	4873.84	6693	730	75.38	75.38	76.22	76.40	4.76	3.76	20.85	0.00
1992	4865.07	6293	730	70.47	70.47	75.87	71.64	29.46	29.43	0.10	0.00
1993	3545.65	4595	730	50.37	50.37	55.45	52.45	9.14	5.06	44.57	0.00
1994	4513.83	5860	730	65.47	65.47	70.59	66.89	34.53	34.53	0.00	0.00
1995	4663.52	6491	730	73.02	73.02	72.93	74.10	26.06	25.73	1.25	0.00
1996	5314.34	7068	730	79.66	79.66	82.88	80.46	5.42	4.56	15.78	0.00
1997	5803.46	7714	730	87.60	87.60	90.75	88.06	12.40	12.40	0.00	0.00
1998	5390.58	7142	730	81.12	81.12	84.30	81.53	6.40	5.55	13.33	0.00
1999	5128.36	6910	730	78.37	78.37	80.20	78.88	2.57	2.06	19.57	0.00
2000	5748.02	7672	730	86.84	86.84	89.64	87.34	13.16	13.16	0.00	0.00
2001	2355.63	3118	730	35.15	35.15	36.84	35.59	60.37	53.56	11.29	0.00
2002	6369.37	8187	730	93.21	94.23	99.60	93.46	5.77	5.77	0.00	1.02
2003	6158.15	7914	730	89.96	89.96	96.30	90.34	0.00	0.00	10.04	0.00
2004	5346.14	7164	730	81.08	81.08	83.37	81.56	2.69	2.24	16.67	0.00
2005	6645.84	8443	767	96.38	96.38	98.90	96.37	3.35	3.34	0.27	0.00
2006	5917.11	7498	778	85.62	85.62	86.81	85.58	2.29	2.01	12.37	0.00
2007	5826.02	7427	778	84.81	84.81	85.48	84.78	4.20	3.72	11.47	0.00

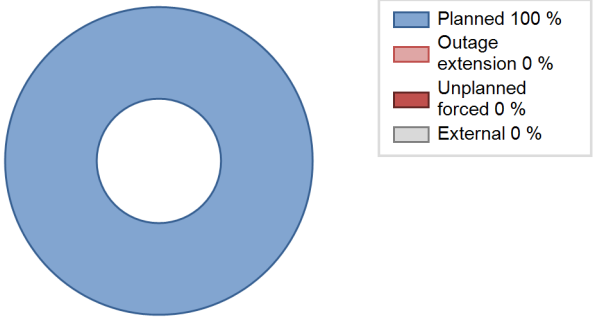
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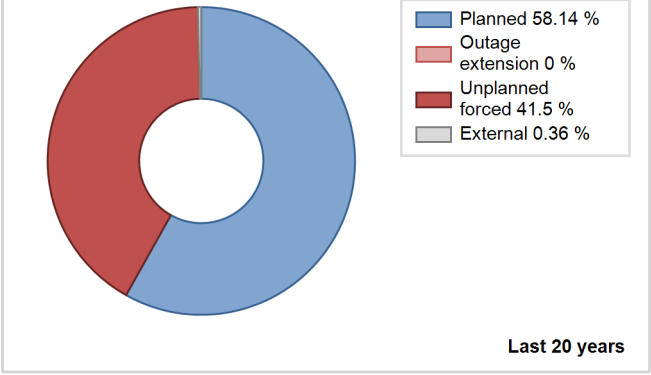
2008	6837.23	8599	778	97.91	97.91	100.05	97.89	2.09	2.09	0.00	0.00
2009	6118.71	7695	778	87.87	87.87	89.78	87.84	1.09	0.97	11.16	0.00
2010	6240.66	7915	778	90.38	90.38	91.57	90.35	2.56	2.37	7.24	0.00
2011	6641.01	8407	793	96.07	96.07	95.60	95.97	3.93	3.93	0.00	0.00
2012	5178.21	6702	793	76.35	76.35	74.34	76.30	15.01	13.48	10.17	0.00
2013	6041.70	7567	793	86.38	86.38	86.96	86.37	13.62	13.62	0.00	0.00
2014	5830.36	7286	793	83.17	83.17	83.93	83.17	0.00	0.00	16.83	0.00
2015	6318.52	7948	805	90.87	90.87	89.60	90.73	0.62	0.57	8.56	0.00
2016	7041.29	8784	805	100.00	100.00	99.58	100.00	0.00	0.00	0.00	0.00
2017	6097.50	7969	805	90.96	90.96	86.47	90.97	1.64	1.52	7.52	0.00
2018	5455.94	6863	805	79.10	79.10	77.37	78.34	4.72	3.92	16.98	0.00
2019	6864.36	8585	805	98.02	98.02	97.34	98.00	0.98	0.97	1.01	0.00
2020	5995.12	7540	805	85.85	85.85	84.78	85.84	0.00	0.00	14.15	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1971 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					1282	
B. Refuelling without maintenance	1243			25		
C. Inspection, maintenance or repair combined with refuelling				995		
D. Inspection, maintenance or repair without refuelling				126		
E. Testing of plant systems or components				1		
H. Nuclear regulatory requirements					84	
J. Grid limitation, failure or grid unavailability						5
L. Human factor related					9	
P. Fire					1	
Z. Other					19	
Subtotal	1243			1147	1395	5
Total	**1243**			**2547**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1971 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		133
13. Reactor Auxiliary Systems		108
14. Safety Systems		107
15. Reactor Cooling Systems		132
16. Steam generation systems		323
31. Turbine and auxiliaries		103
32. Feedwater and Main Steam System		79
33. Circulating Water System		26
34. Miscellaneous Systems		19
35. All other I&C Systems		0
41. Main Generator Systems		46
42. Electrical Power Supply Systems		213
Total		**1289**

Highlights (2020)

Refueling Outage 27. On 8/30/2020 at 09:00, Palisades manually shutdown the reactor to commence the planned 1R27 refueling outage.

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2020 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

Reactor type and model	:	PWR / CE80 2LP (DRYAMB)
Thermal power	:	3990 MWth
Gross electrical power	:	1414 MWe
Reference unit power (net)	:	1311 MWe

Key Dates

Construction Date	:	1976-05-25
Grid Date	:	1985-06-10
Commercial Date	:	1986-01-28
Age at end of year	:	35 years

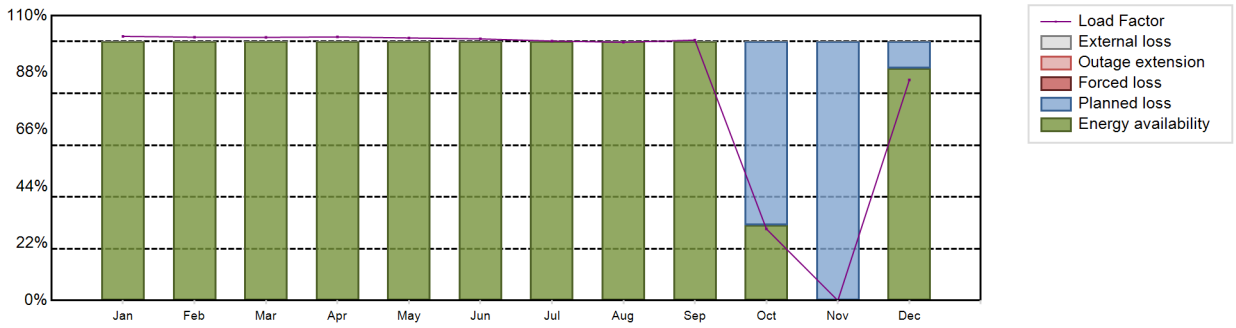
Design Characteristics

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 (2020)

Net Energy Production	:	9818.48 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	84.93 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	84.93 %	Planned Unavailability Factor (PUF)	:	15.07 %
Load Factor (LF)	:	85.26 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	84.93 %	Total off-line time	:	1324 hours

Annual Summary



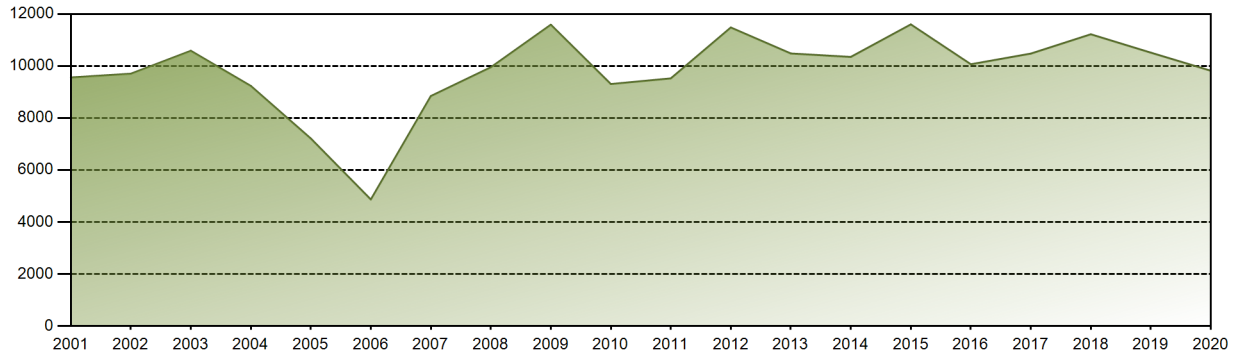
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	995.02	927.99	991.35	960.89	989.13	953.86	977.45	972.94	949.34	269.85	0.00	830.65	9818.48
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	29.03	0.00	89.77	84.93
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	29.03	0.00	89.77	84.93
LF [%]	102.01	101.70	101.64	101.80	101.41	101.05	100.21	99.75	100.57	27.67	0.00	85.16	85.26
OF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	29.03	0.00	89.78	84.93
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	70.97	100.00	10.23	15.07
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

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Historical Summary

Lifetime energy generation	:	340830.91 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.68 %
Cumulative Energy Availability Factor (EAF)	:	82.16 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.04 %
Cumulative Unit Capability Factor (UCF)	:	82.29 %	Cumulative Planned Unavailability Factor (PUF)	:	13.66 %
Cumulative Load Factor (LF)	:	80.77 %	Cumulative Externally cause unavailability (XUF)	:	0.14 %
Cumulative Operating Factor (OF)	:	82.23 %			

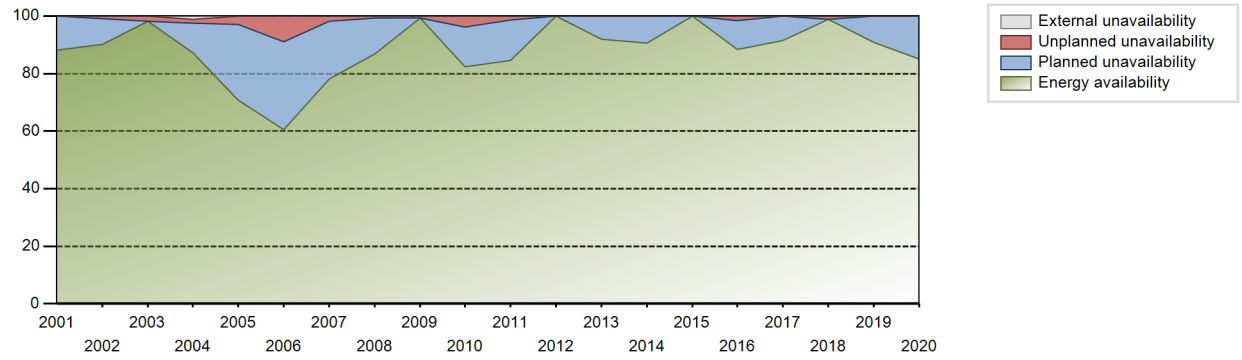
Electricity Production (net) [GWh]



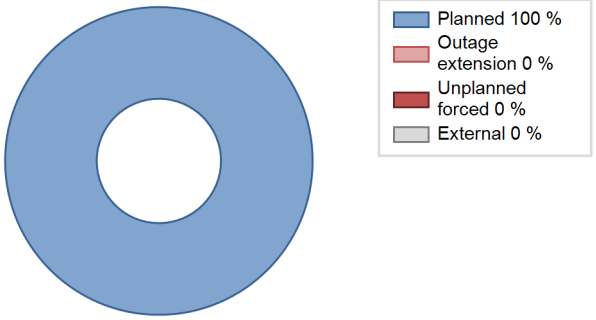
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	6264.75	5349	1221	63.26	63.26	62.16	64.51	36.74	36.74	0.00	0.00
1987	5268.27	4500	1221	50.89	50.89	49.26	51.38	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

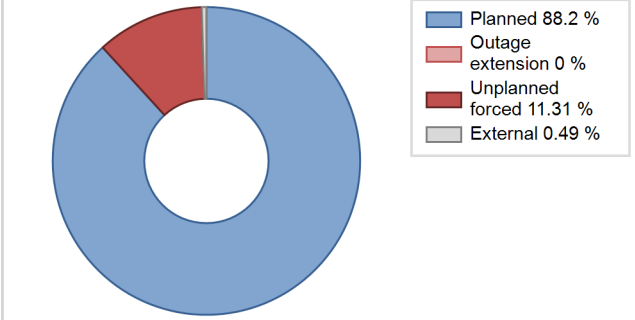
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					405	
B. Refuelling without maintenance	1324			38		
C. Inspection, maintenance or repair combined with refuelling				1010		
D. Inspection, maintenance or repair without refuelling				138		
E. Testing of plant systems or components				3	8	
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.)						8
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					2	
Z. Other					14	
Subtotal	1324			1189	434	12
Total	**1324**			**1635**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		74
13. Reactor Auxiliary Systems		3
14. Safety Systems		12
15. Reactor Cooling Systems		61
16. Steam generation systems		34
31. Turbine and auxiliaries		5
32. Feedwater and Main Steam System		89
33. Circulating Water System		24
34. Miscellaneous Systems		38
35. All other I&C Systems		2
41. Main Generator Systems		11
42. Electrical Power Supply Systems		58
Total		**412**

Highlights (2020)

Refueling Outage 22

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2020 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

Reactor type and model	:	PWR / CE80 2LP (DRYAMB)
Thermal power	:	3990 MWth
Gross electrical power	:	1414 MWe
Reference unit power (net)	:	1314 MWe

Key Dates

Construction Date	:	1976-06-01
Grid Date	:	1986-05-20
Commercial Date	:	1986-09-19
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 [%]	:	33.3
Average discharge burnup [MWd/t]	:	38000
Active core diameter [m]	:	3.65
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	241
Fuel linear heat generation rate [kW/m]	:	18.21
Number of control rod assemblies	:	76
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

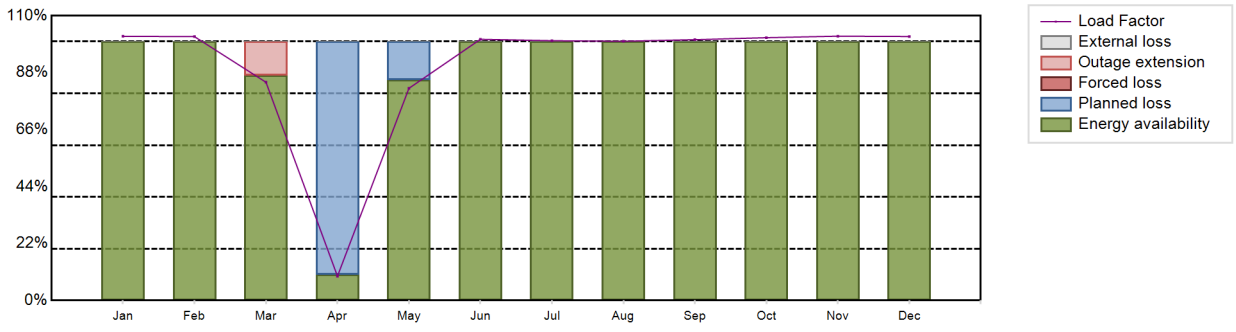
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	327
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.45
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	7
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 (2020)

Net Energy Production	:	10466.37 GW(e).h
Energy Availability Factor (EAF)	:	90.26 %
Unit Capability Factor (UCF)	:	90.26 %
Load Factor (LF)	:	90.68 %
Operating Factor (OF)	:	90.27 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	1.11 %
Planned Unavailability Factor (PUF)	:	8.62 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	855 hours

Annual Summary



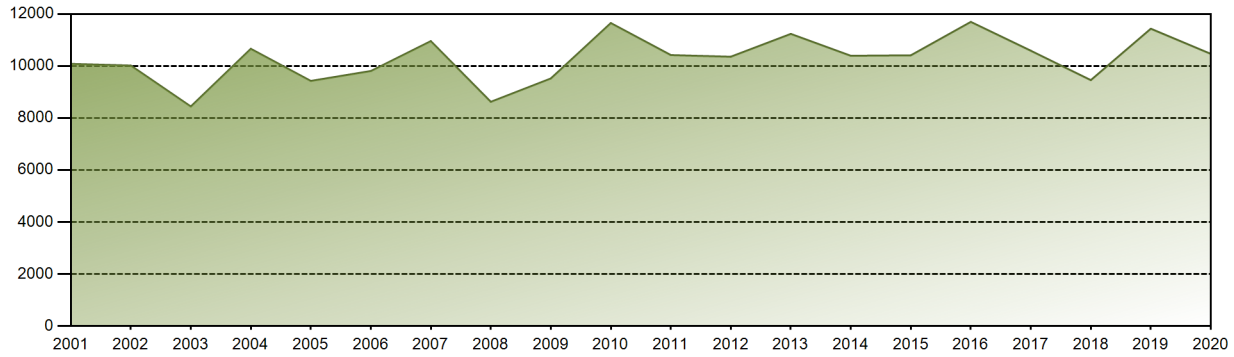
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	997.55	932.02	824.25	88.82	801.30	954.48	980.91	978.85	953.10	992.46	965.80	996.83	10466.37
EAF [%]	100.00	100.00	86.85	9.98	85.30	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.26
UCF [%]	100.00	100.00	86.85	9.98	85.30	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.26
LF [%]	102.04	101.91	84.31	9.39	81.97	100.89	100.34	100.13	100.74	101.52	102.08	101.97	90.68
OF [%]	100.00	100.00	86.83	10.00	85.35	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.27
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	13.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11
PUF [%]	0.00	0.00	0.00	90.02	14.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.62
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

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Historical Summary

Lifetime energy generation	:	341064.94 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.33 %
Cumulative Energy Availability Factor (EAF)	:	84.46 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.06 %
Cumulative Unit Capability Factor (UCF)	:	84.53 %	Cumulative Planned Unavailability Factor (PUF)	:	13.41 %
Cumulative Load Factor (LF)	:	84.26 %	Cumulative Externally cause unavailability (XUF)	:	0.07 %
Cumulative Operating Factor (OF)	:	84.48 %			

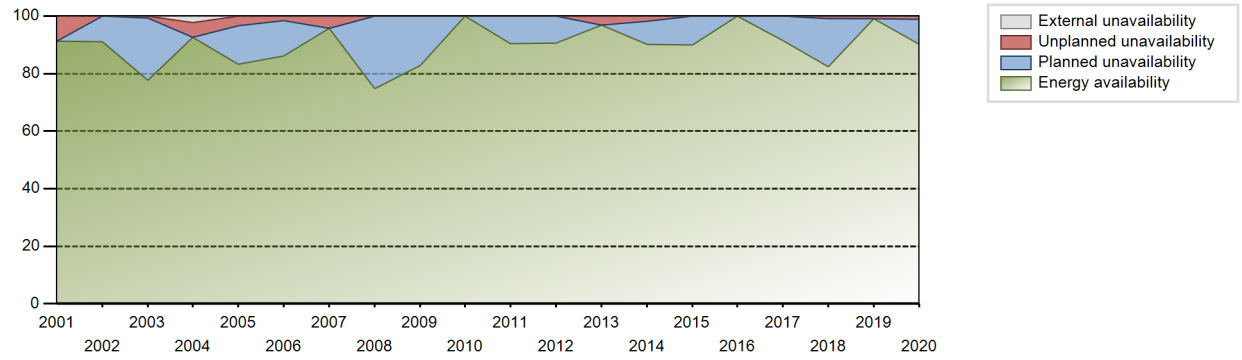
Electricity Production (net) [GWh]



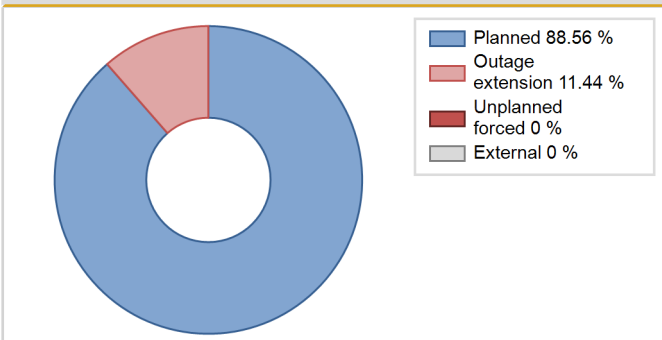
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	Data not provided										
1987	8190.04	6860	1221	77.59	77.59	76.57	78.31	6.73	5.60	16.81	0.00
1988	6747.17	5613	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

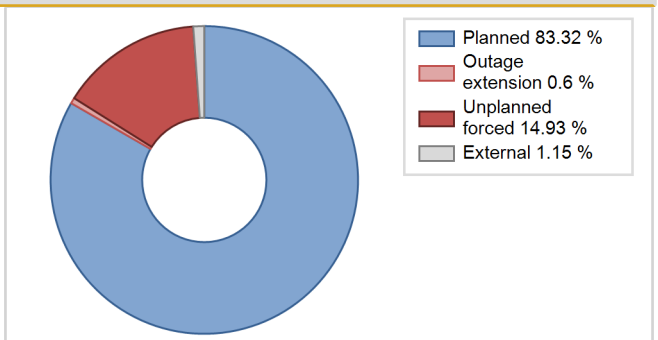
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					141	
B. Refuelling without maintenance	758			22		
C. Inspection, maintenance or repair combined with refuelling				910		
D. Inspection, maintenance or repair without refuelling				163		
E. Testing of plant systems or components				0		
H. Nuclear regulatory requirements					21	
J. Grid limitation, failure or grid unavailability						4
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			98	77	6	3
Subtotal	758		98	1172	178	9
Total	**856**			**1359**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		22
13. Reactor Auxiliary Systems		5
14. Safety Systems		20
15. Reactor Cooling Systems		15
16. Steam generation systems		21
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		16
32. Feedwater and Main Steam System		15
34. Miscellaneous Systems		32
35. All other I&C Systems		1
41. Main Generator Systems		4
42. Electrical Power Supply Systems		15
Total		**169**

Highlights (2020)

Unplanned automatic RX trip due to Auxiliary Feedwater Pumps (AFAS1 & AFAS2) actuated on low SG level following trip of both Main Feedwater Pumps (MFWPs) during restoration of power to MFWP lube oil control panel.

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2020 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

Reactor type and model	:	PWR / CE80 2LP (DRYAMB)
Thermal power	:	3990 MWth
Gross electrical power	:	1414 MWe
Reference unit power (net)	:	1312 MWe

Key Dates

Construction Date	:	1976-06-01
Grid Date	:	1987-11-28
Commercial Date	:	1988-01-08
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]	:	38000
Active core diameter [m]	:	3.65
Active core height/length [m]	:	3.81
Number of fissile fuel assemblies/bundles	:	241
Fuel linear heat generation rate [kW/m]	:	18.37
Number of control rod assemblies	:	76
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

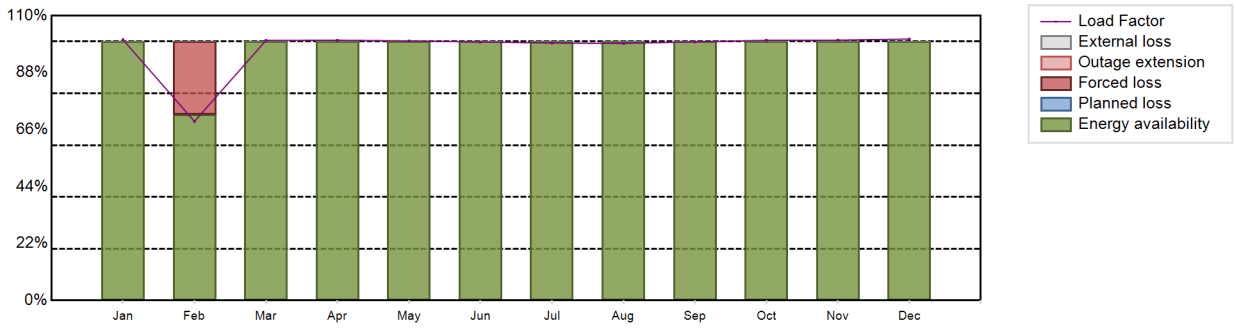
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	327
Number of SG	:	2
Containment type	:	Single
Containment design pressure [MPa]	:	0.45
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	7
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 (2020)

Net Energy Production	:	11267.58 GW(e).h
Energy Availability Factor (EAF)	:	97.76 %
Unit Capability Factor (UCF)	:	97.76 %
Load Factor (LF)	:	97.77 %
Operating Factor (OF)	:	97.76 %

Forced Loss Rate (FLR)	:	2.24 %
Unplanned Capability Loss Factor (UCL)	:	2.24 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	197 hours

Annual Summary



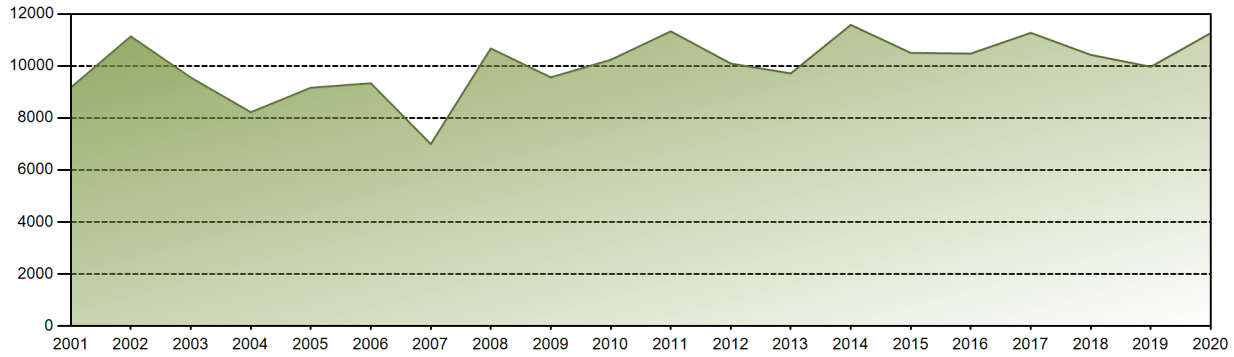
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	983.42	631.60	980.59	949.59	978.83	943.22	970.70	969.28	943.86	980.86	949.80	985.82	11267.58
EAF [%]	100.00	71.70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.76
UCF [%]	100.00	71.70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.76
LF [%]	100.75	69.17	100.46	100.52	100.28	99.85	99.44	99.30	99.92	100.48	100.55	100.99	97.77
OF [%]	100.00	71.70	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	97.76
FLR [%]	0.00	28.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.24
UCL [%]	0.00	28.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.24
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

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Historical Summary

Lifetime energy generation	:	314934.65 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.96 %
Cumulative Energy Availability Factor (EAF)	:	86.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.73 %
Cumulative Unit Capability Factor (UCF)	:	86.48 %	Cumulative Planned Unavailability Factor (PUF)	:	11.79 %
Cumulative Load Factor (LF)	:	85.73 %	Cumulative Externally cause unavailability (XUF)	:	0.2 %
Cumulative Operating Factor (OF)	:	86.29 %			

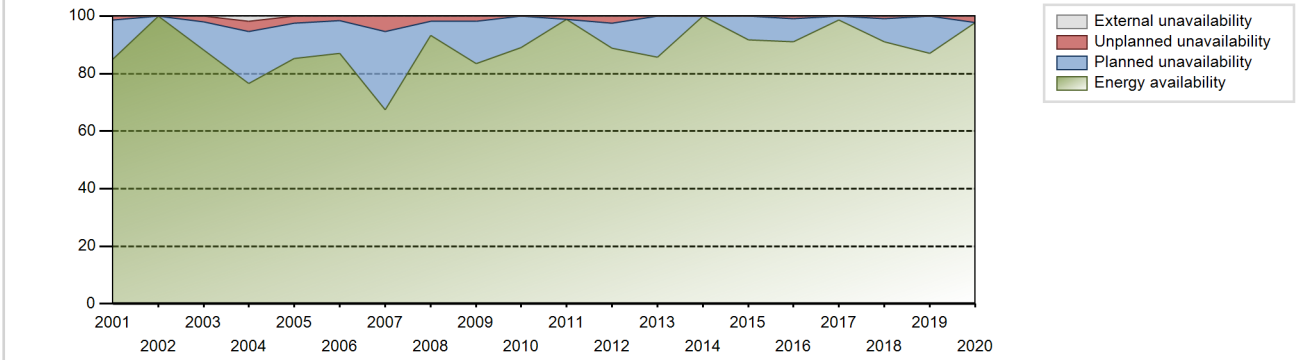
Electricity Production (net) [GWh]



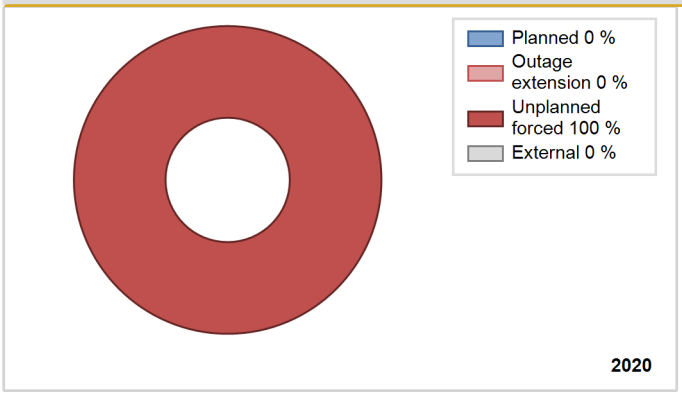
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	10035.48	8177	1221	94.92	94.92	95.39	94.90	5.08	5.08	0.00	0.00
1989	1327.99	1096	1221	9.01	9.01	12.42	12.51	40.97	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

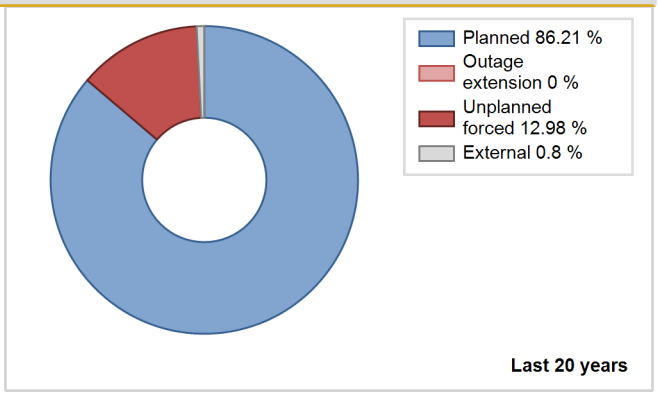
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					123	
C. Inspection, maintenance or repair combined with refuelling				940		
D. Inspection, maintenance or repair without refuelling				86		
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					2	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						25
Z. Other		197			7	0
Subtotal		197		1030	140	30
Total		**197**			**1200**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		10
13. Reactor Auxiliary Systems		4
14. Safety Systems		18
16. Steam generation systems		3
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		27
32. Feedwater and Main Steam System		15
34. Miscellaneous Systems		20
41. Main Generator Systems		9
42. Electrical Power Supply Systems		45
Total		**152**

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Highlights (2020)

Unplanned manual reactor shutdown due to degradation of the 1B RCP seal.

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	3951 MWth
Gross electrical power	:	1412 MWe
Reference unit power (net)	:	1300 MWe

Key Dates

Construction Date	:	1968-01-31
Grid Date	:	1974-02-18
Commercial Date	:	1974-07-05
Age at end of year	:	46 years

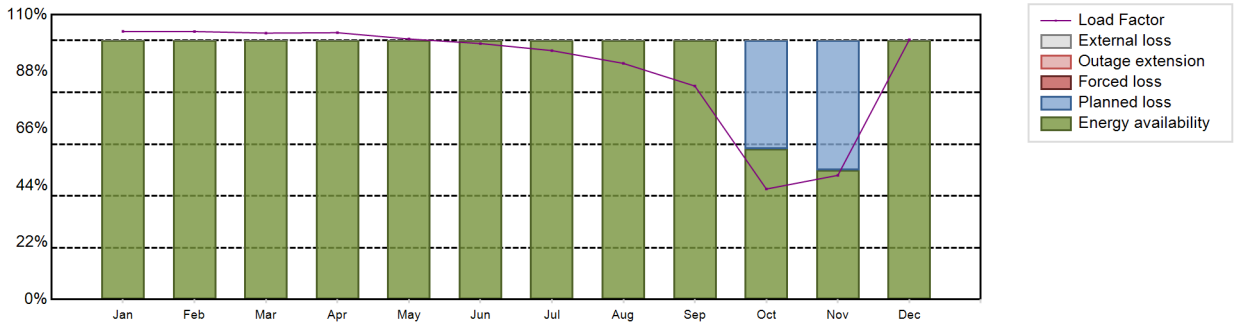
Design Characteristics

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 (2020)

Net Energy Production	:	10211.82 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	92.34 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	92.34 %	Planned Unavailability Factor (PUF)	:	7.66 %
Load Factor (LF)	:	89.43 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	92.34 %	Total off-line time	:	673 hours

Annual Summary



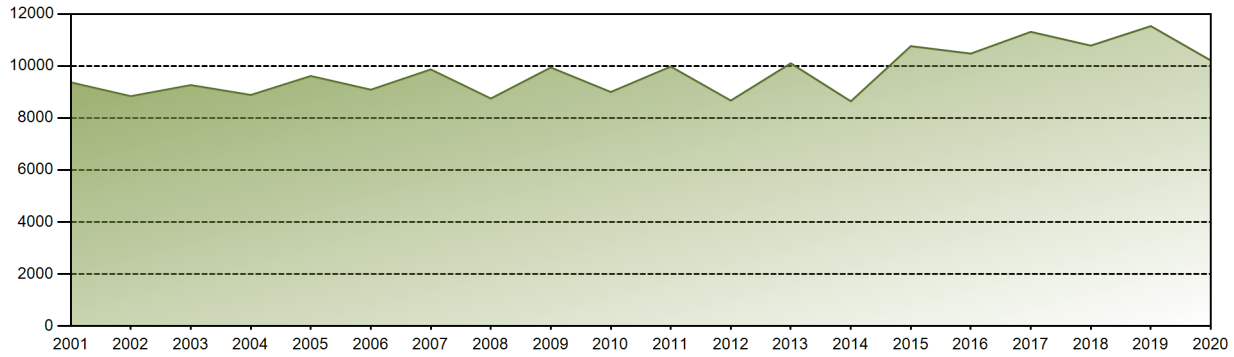
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	1001.34	936.51	995.18	964.53	973.20	925.39	929.81	882.02	771.62	412.70	448.92	970.59	10211.82
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	58.06	49.90	100.00	92.34
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	58.06	49.90	100.00	92.34
LF [%]	103.53	103.50	102.89	103.05	100.62	98.87	96.13	91.19	82.44	42.67	47.96	100.35	89.43
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	58.06	50.00	100.00	92.34
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	41.94	50.10	0.00	7.66
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

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Historical Summary

Lifetime energy generation	:	358577.73 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.45 %
Cumulative Energy Availability Factor (EAF)	:	79.86 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.72 %
Cumulative Unit Capability Factor (UCF)	:	79.87 %	Cumulative Planned Unavailability Factor (PUF)	:	16.41 %
Cumulative Load Factor (LF)	:	77.85 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	80.42 %			

Electricity Production (net) [GWh]

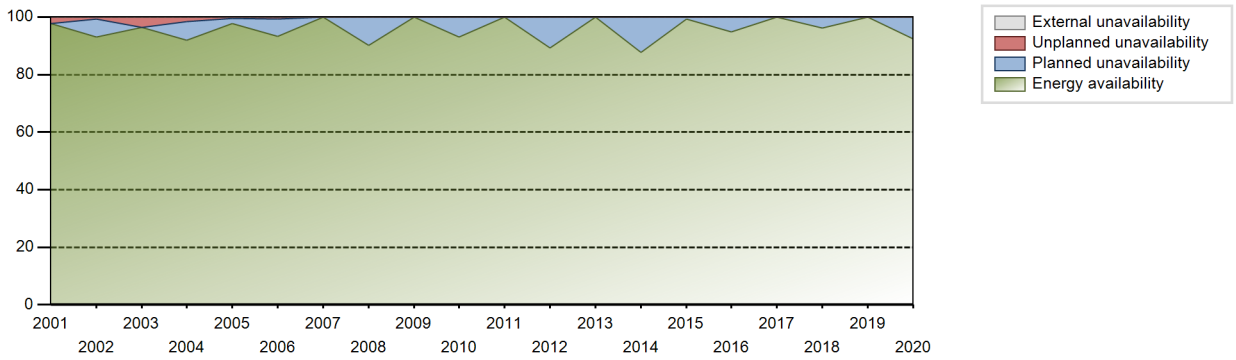


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	4982.70	6162	1053	90.55	90.55	78.92	90.58	7.84	7.70	1.75	0.00
1975	5082.50	6638	1051	55.26	55.26	55.20	75.78	22.93	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

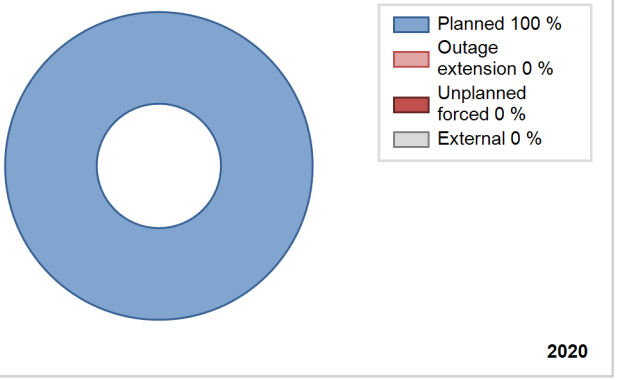
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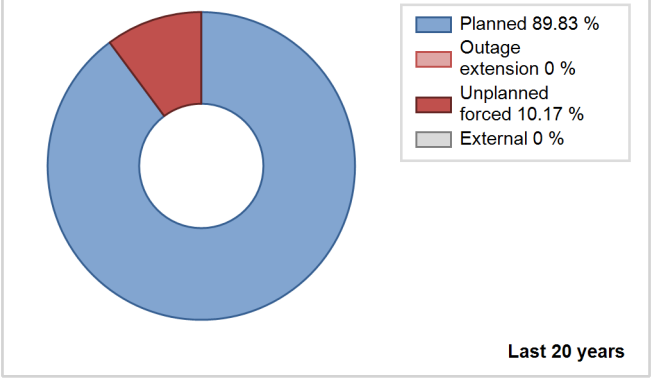
2011	9978.33	8760	1122	100.00	100.00	101.52	100.00	0.00	0.00	0.00	0.00
2012	8671.08	7832	1125	89.18	89.18	87.94	89.16	0.00	0.00	10.82	0.00
2013	10103.52	8760	1125	100.00	100.00	102.51	99.99	0.00	0.00	0.00	0.00
2014	8641.88	7685	1125	87.74	87.74	87.69	87.73	0.00	0.00	12.26	0.00
2015	10762.56	8692	1308	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					309	
B. Refuelling without maintenance	673			22		
C. Inspection, maintenance or repair combined with refuelling				1045		
D. Inspection, maintenance or repair without refuelling				187		
E. Testing of plant systems or components				4	0	
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					116	
J. Grid limitation, failure or grid unavailability						4
L. Human factor related					5	
Z. Other				25	5	1
Subtotal	673			1284	435	5
Total	**673**			**1724**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		0
12. Reactor I&C Systems		19
13. Reactor Auxiliary Systems		12
14. Safety Systems		40
15. Reactor Cooling Systems		79
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		50
31. Turbine and auxiliaries		39
32. Feedwater and Main Steam System		23
34. Miscellaneous Systems		5
35. All other I&C Systems		1
41. Main Generator Systems		5
42. Electrical Power Supply Systems		51
Total		**325**

Highlights (2020)

2R23

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 1)
Thermal power	:	3951 MWth
Gross electrical power	:	1412 MWe
Reference unit power (net)	:	1331 MWe

Key Dates

Construction Date	:	1968-01-31
Grid Date	:	1974-09-01
Commercial Date	:	1974-12-23
Age at end of year	:	46 years

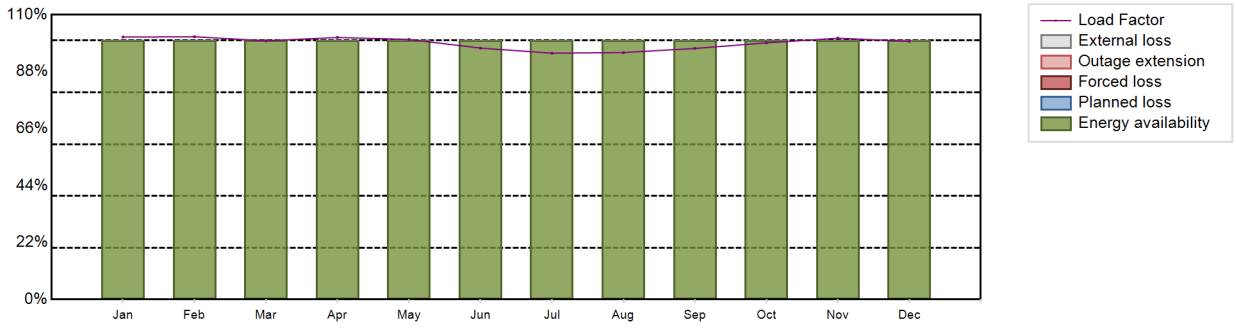
Design Characteristics

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 (2020)

Net Energy Production	:	11580.52 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)	:	99.05 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



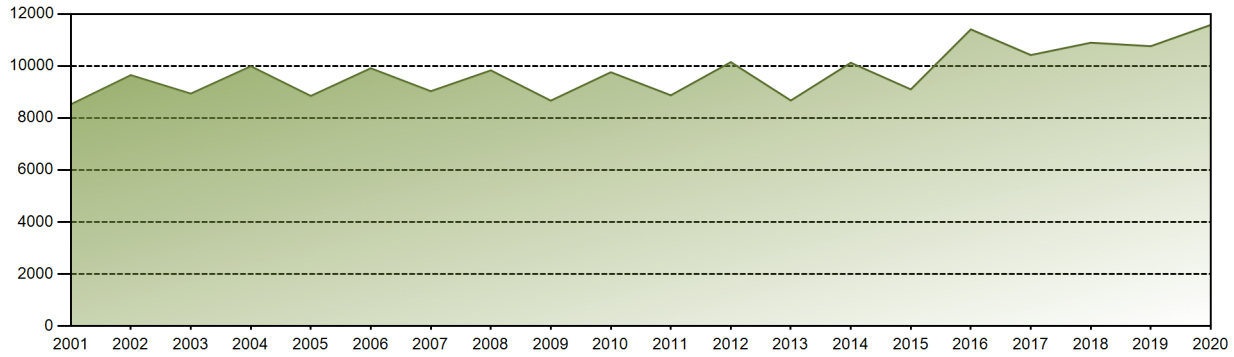
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	1003.65	940.12	989.48	969.87	994.63	930.52	942.15	944.61	929.30	981.57	967.14	987.48	11580.52
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	101.35	101.48	99.92	101.21	100.44	97.10	95.14	95.39	96.97	99.12	100.92	99.72	99.05
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	355997.24 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.96 %
Cumulative Energy Availability Factor (EAF)	:	80.17 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.08 %
Cumulative Unit Capability Factor (UCF)	:	80.24 %	Cumulative Planned Unavailability Factor (PUF)	:	14.68 %
Cumulative Load Factor (LF)	:	78.9 %	Cumulative Externally cause unavailability (XUF)	:	0.08 %
Cumulative Operating Factor (OF)	:	81.13 %			

Electricity Production (net) [GWh]

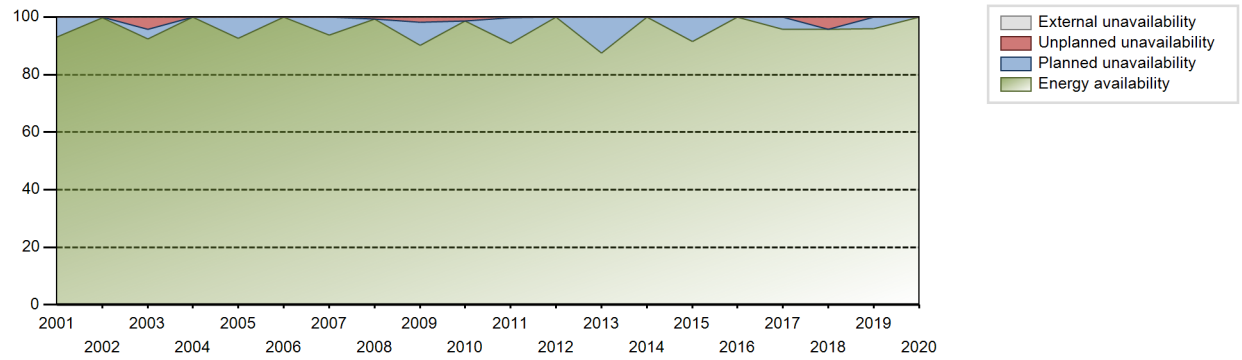


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	1095.30	1902	1073	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	5282.40	7520	1035	58.19	58.19	58.26	85.84	24.55	18.94	22.87	0.00
1976	6056.80	6829	1035	66.68	66.68	66.62	77.74	18.98	15.62	17.70	0.00
1977	4787.80	5450	1035	52.84	52.84	52.81	62.21	14.35	8.85	38.30	0.00
1978	6973.60	7412	1035	76.91	76.91	76.92	84.61	6.53	5.37	17.71	0.00
1979	6110.40	6500	1035	67.21	67.21	67.39	74.20	5.73	4.09	28.71	0.00
1980	7233.40	7089	1035	79.70	80.12	79.56	80.70	11.47	10.38	9.49	0.43
1981	3171.10	3201	1035	33.00	33.00	34.98	36.54	13.97	5.36	61.64	0.00
1982	8532.30	8372	1035	95.35	95.35	94.11	95.57	4.65	4.65	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
1984	7445.52	7545	1035	85.15	86.21	81.90	85.89	13.79	13.79	0.00	1.06
1985	3320.84	3988	1035	45.11	45.11	36.63	45.53	0.83	0.38	54.51	0.00
1986	4858.84	5542	1035	60.94	60.94	53.59	63.26	20.95	16.15	22.91	0.00
1987	1507.72	1658	1035	14.41	14.41	16.63	18.93	85.59	85.59	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
1989	247.31	472	1035	0.10	0.10	2.73	5.39	47.89	0.09	99.81	0.00
1990	7534.10	7684	1035	87.08	87.08	83.10	87.72	5.30	4.87	8.05	0.00
1991	5118.92	5212	1035	57.26	59.14	56.46	59.50	13.61	9.32	31.54	1.88
1992	7180.95	7391	1035	83.65	83.65	78.99	84.14	12.72	12.19	4.16	0.00
1993	6314.03	6594	1035	73.89	73.89	69.64	75.27	7.25	5.77	20.34	0.00
1994	8867.35	8588	1035	97.93	97.93	97.80	98.04	2.07	2.07	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
1996	9424.69	8627	1093	98.21	98.21	98.16	98.21	1.79	1.79	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
1998	8823.63	8172	1093	93.30	93.30	92.16	93.29	1.41	1.34	5.36	0.00
1999	8558.61	8100	1093	92.48	92.48	89.39	92.47	0.00	0.00	7.52	0.00
2000	9556.78	8722	1093	99.30	99.30	99.54	99.29	0.70	0.70	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
2002	9647.38	8740	1093	99.78	99.78	100.76	99.77	0.00	0.00	0.22	0.00
2003	8937.81	8089	1112	92.38	92.38	92.94	92.34	4.49	4.35	3.27	0.00
2004	9989.10	8784	1112	100.00	100.00	102.27	100.00	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
2006	9912.75	8760	1112	100.00	100.00	101.76	100.00	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
2008	9830.48	8729	1112	99.38	99.38	100.64	99.37	0.62	0.62	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
2010	9759.27	8640	1112	98.64	98.64	100.19	98.63	1.36	1.36	0.00	0.00

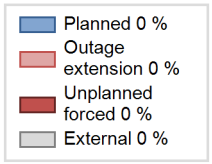
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2011	8873.28	7952	1122	90.81	90.81	90.95	90.78	0.33	0.30	8.89	0.00
2012	10148.35	8784	1138	100.00	100.00	101.52	100.00	0.00	0.00	0.00	0.00
2013	8673.15	7656	1138	87.40	87.40	86.99	87.39	0.00	0.00	12.60	0.00
2014	10124.97	8757	1138	99.96	99.96	101.57	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

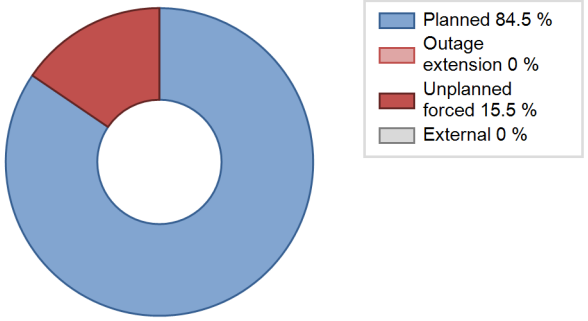
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					292	
C. Inspection, maintenance or repair combined with refuelling				1107		
D. Inspection, maintenance or repair without refuelling				66		
E. Testing of plant systems or components				13	1	
H. Nuclear regulatory requirements					148	
J. Grid limitation, failure or grid unavailability						8
L. Human factor related					14	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						8
Z. Other				18	0	1
Subtotal				1204	455	17
Total	**0**			**1676**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		20
13. Reactor Auxiliary Systems		10
14. Safety Systems		35
15. Reactor Cooling Systems		82
31. Turbine and auxiliaries		38
32. Feedwater and Main Steam System		50
33. Circulating Water System		2
34. Miscellaneous Systems		0
41. Main Generator Systems		15
42. Electrical Power Supply Systems		54
Total		**306**

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2020 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

Reactor type and model	:	BWR / BWR-6 (Mark 3)
Thermal power	:	3758 MWth
Gross electrical power	:	1303 MWe
Reference unit power (net)	:	1240 MWe

Key Dates

Construction Date	:	1974-10-01
Grid Date	:	1986-12-19
Commercial Date	:	1987-11-18
Age at end of year	:	34 years

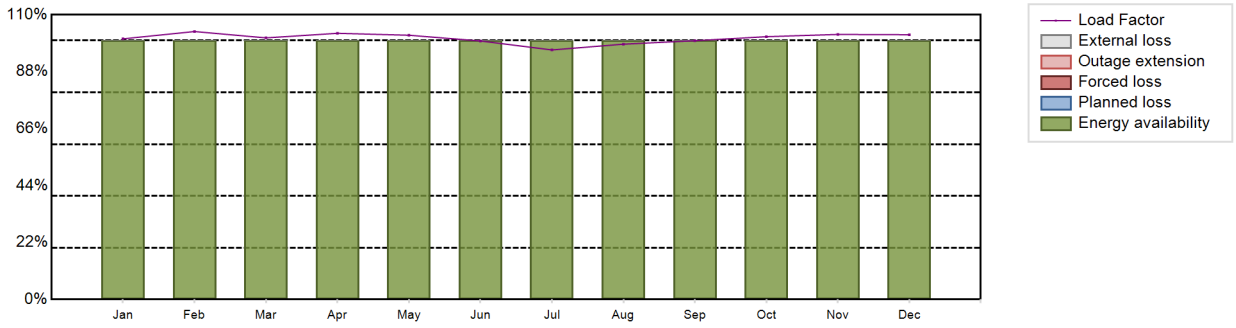
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	7.31
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	285.5
Fuel material	:	UO2	Number of SG	:	NA
Refuelling type	:	OFF-line	Containment type	:	Confinement
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]	:	7614	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	4.65	HP cylinder inlet steam pressure [MPa]	:	6.78
Active core height/length [m]	:	3.81	Output voltage [kV]	:	-
Number of fissile fuel assemblies/bundles	:	748	Primary means of condenser cooling	:	Cooling Towers
Fuel linear heat generation rate [kW/m]	:	19.85	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 (2020)

Net Energy Production	:	10990.96 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)	:	100.91 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



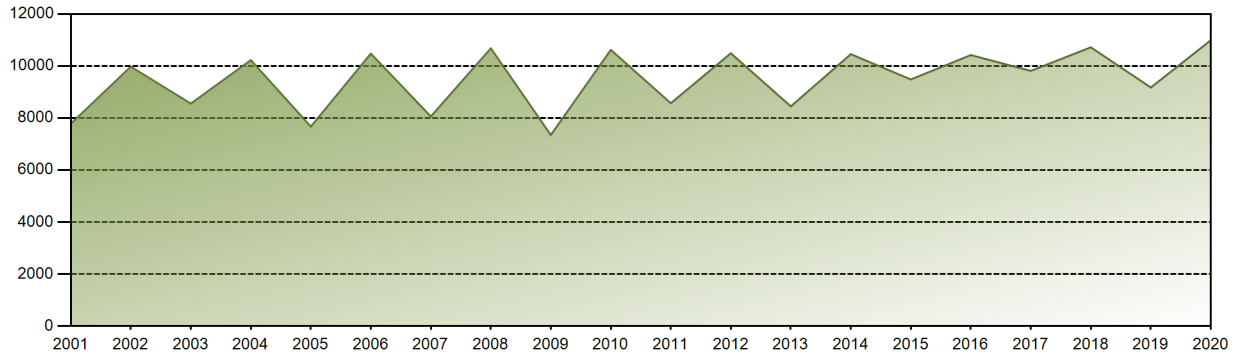
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	928.86	893.21	932.28	917.96	941.61	891.45	889.36	909.73	892.40	936.48	914.07	943.56	10990.96
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	100.68	103.50	101.05	102.82	102.06	99.85	96.40	98.61	99.96	101.51	102.38	102.28	100.91
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	293838.99 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.91 %
Cumulative Energy Availability Factor (EAF)	:	84.17 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.35 %
Cumulative Unit Capability Factor (UCF)	:	84.17 %	Cumulative Planned Unavailability Factor (PUF)	:	11.48 %
Cumulative Load Factor (LF)	:	82.11 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	83.9 %			

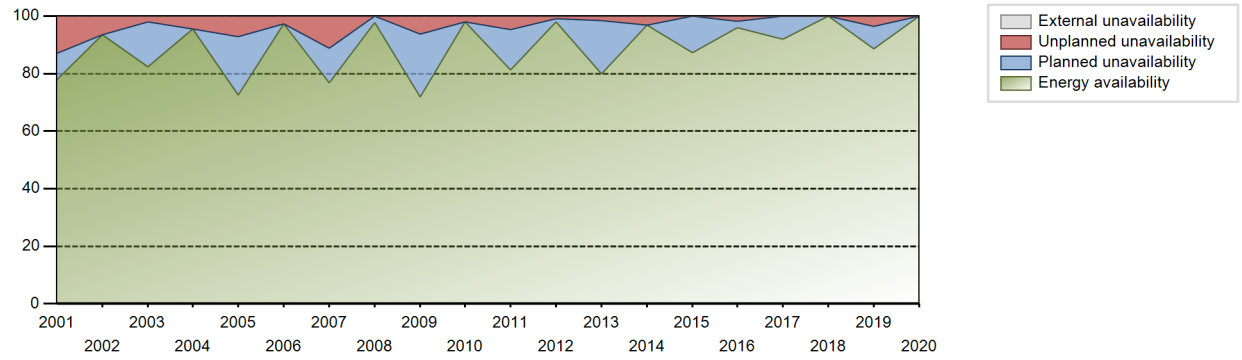
Electricity Production (net) [GWh]



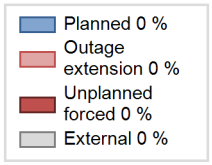
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	Data not provided										
1988	7233.82	6664	1203	76.34	76.34	68.44	75.87	14.72	13.18	10.48	0.00
1989	5357.58	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

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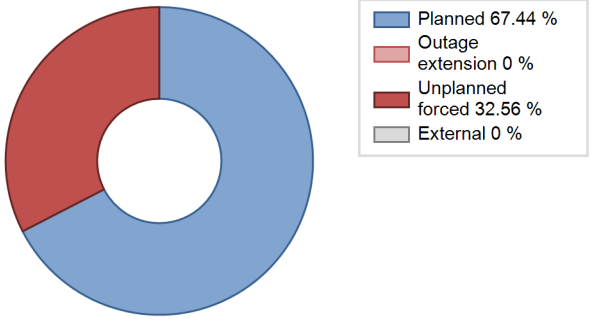
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1987 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					359	
C. Inspection, maintenance or repair combined with refuelling				877		
D. Inspection, maintenance or repair without refuelling				145		
E. Testing of plant systems or components				0		
L. Human factor related					11	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					1	
Z. Other					5	
Subtotal				1022	376	
Total		**0**			**1398**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1987 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		34
13. Reactor Auxiliary Systems		2
14. Safety Systems		0
15. Reactor Cooling Systems		50
17. Safety I&C Systems (excluding reactor I&C)		4
31. Turbine and auxiliaries		50
32. Feedwater and Main Steam System		26
33. Circulating Water System		10
34. Miscellaneous Systems		85
35. All other I&C Systems		18
41. Main Generator Systems		24
42. Electrical Power Supply Systems		62
Total		**368**

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2020 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	:	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 [%]	:	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

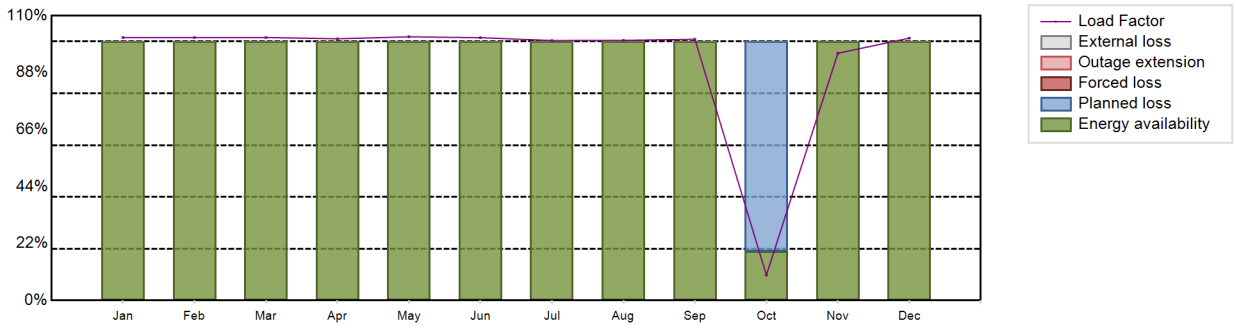
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	316
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.422
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4828.77 GW(e).h
Energy Availability Factor (EAF)	:	93.15 %
Unit Capability Factor (UCF)	:	93.15 %
Load Factor (LF)	:	93.02 %
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	:	603 hours

Annual Summary



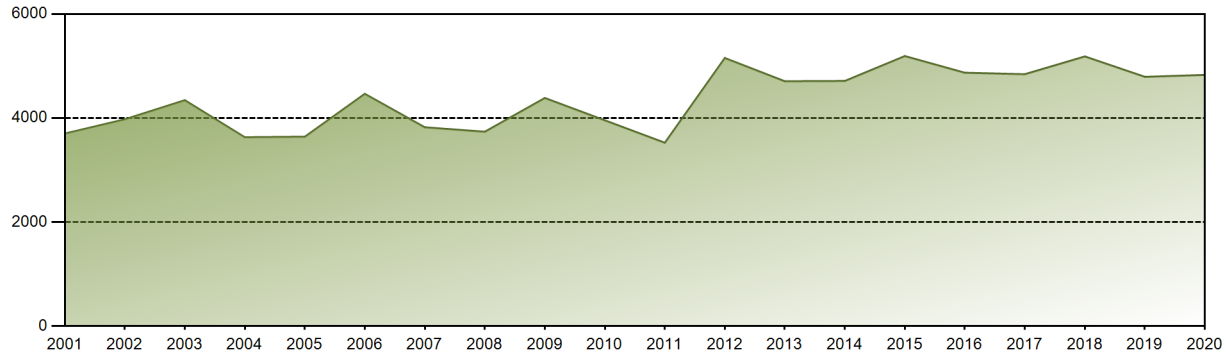
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	446.50	417.80	446.68	430.08	447.86	431.99	441.53	441.77	429.41	43.21	406.35	445.59	4828.76
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	19.07	100.00	100.00	93.15
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	19.07	100.00	100.00	93.15
LF [%]	101.55	101.57	101.59	101.07	101.85	101.52	100.41	100.47	100.91	9.83	95.49	101.34	93.02
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	19.09	100.00	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	80.93	0.00	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

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Historical Summary

Lifetime energy generation	:	188639.27 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.36 %
Cumulative Energy Availability Factor (EAF)	:	85.59 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.99 %
Cumulative Unit Capability Factor (UCF)	:	85.87 %	Cumulative Planned Unavailability Factor (PUF)	:	11.15 %
Cumulative Load Factor (LF)	:	82.31 %	Cumulative Externally cause unavailability (XUF)	:	0.28 %
Cumulative Operating Factor (OF)	:	84.91 %			

Electricity Production (net) [GWh]

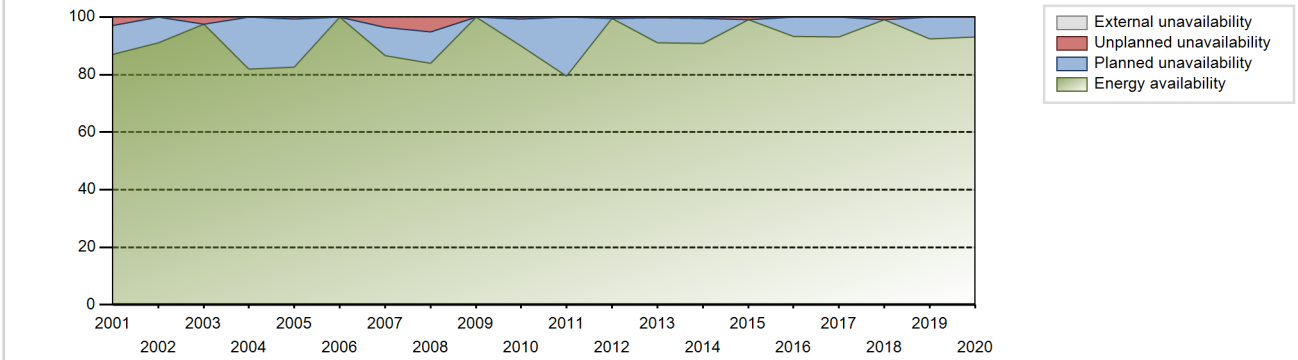


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1970	Data not provided										
1971	3446.20	7699	524	100.00	100.00	75.08	87.89	0.00	0.00	0.00	0.00
1972	3085.50	6349	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

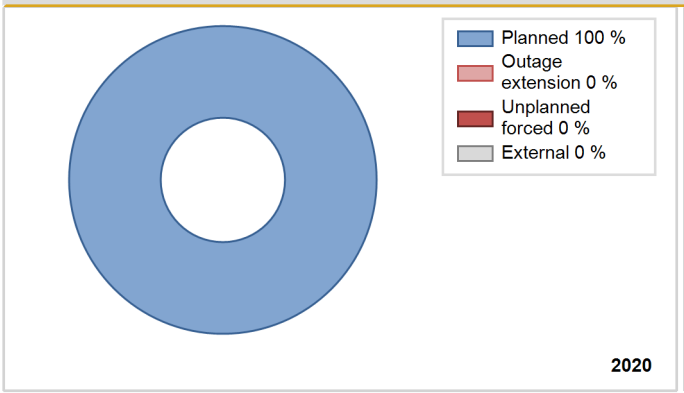
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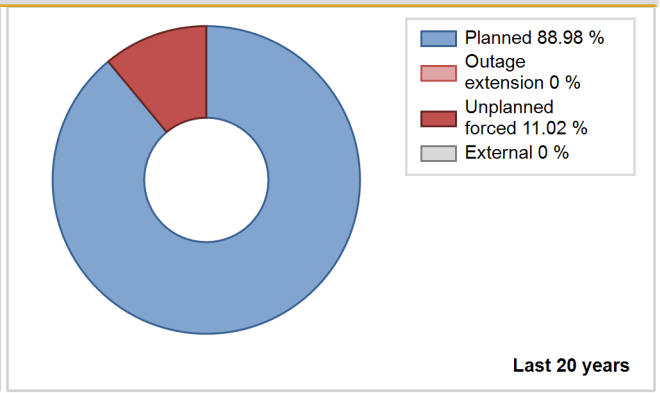
2007	3822.30	7582	512	86.57	86.57	85.22	86.55	3.89	3.51	9.92	0.00
2008	3737.01	7365	512	83.87	83.87	83.09	83.85	5.89	5.24	10.89	0.00
2009	4385.38	8760	512	100.00	100.00	97.78	100.00	0.00	0.00	0.00	0.00
2010	3956.14	7870	512	89.89	89.89	88.21	89.84	0.83	0.75	9.36	0.00
2011	3525.04	6954	512	79.39	79.39	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1970 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					123	
B. Refuelling without maintenance	602			12		
C. Inspection, maintenance or repair combined with refuelling				963		
D. Inspection, maintenance or repair without refuelling				45		
E. Testing of plant systems or components				2		
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					25	
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.)						138
Z. Other				1	3	
Subtotal	602			1024	152	139
Total	**602**			**1315**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1970 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		1
15. Reactor Cooling Systems		8
16. Steam generation systems		73
31. Turbine and auxiliaries		15
32. Feedwater and Main Steam System		21
33. Circulating Water System		1
34. Miscellaneous Systems		146
41. Main Generator Systems		8
42. Electrical Power Supply Systems		13
Total		**289**

Highlights (2020)

Refueling Outage 39

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2020 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

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	:	1968-07-25
Grid Date	:	1972-08-02
Commercial Date	:	1972-10-01
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]	:	-
Refuelling frequency [month]	:	18
Part of the core refuelled [%]	:	74
Average discharge burnup [MWd/t]	:	45000
Active core diameter [m]	:	2.44
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

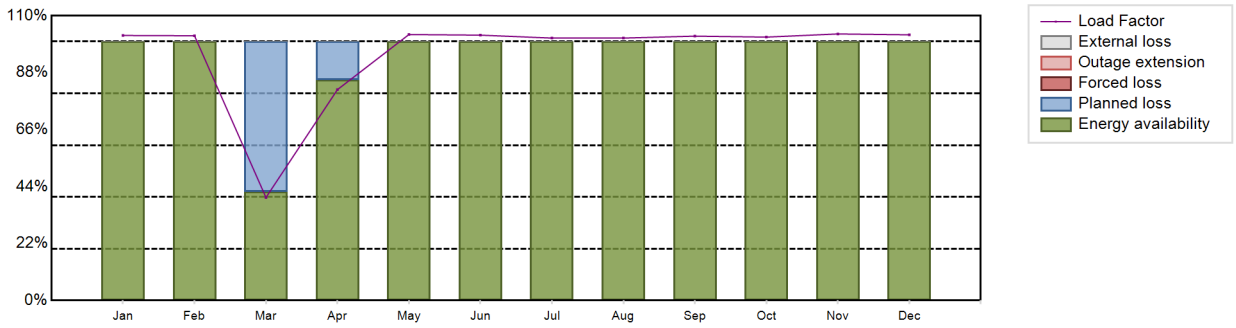
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	316
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.422
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	4942.57 GW(e).h
Energy Availability Factor (EAF)	:	93.87 %
Unit Capability Factor (UCF)	:	93.87 %
Load Factor (LF)	:	95.21 %
Operating Factor (OF)	:	93.85 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	6.13 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	540 hours

Annual Summary



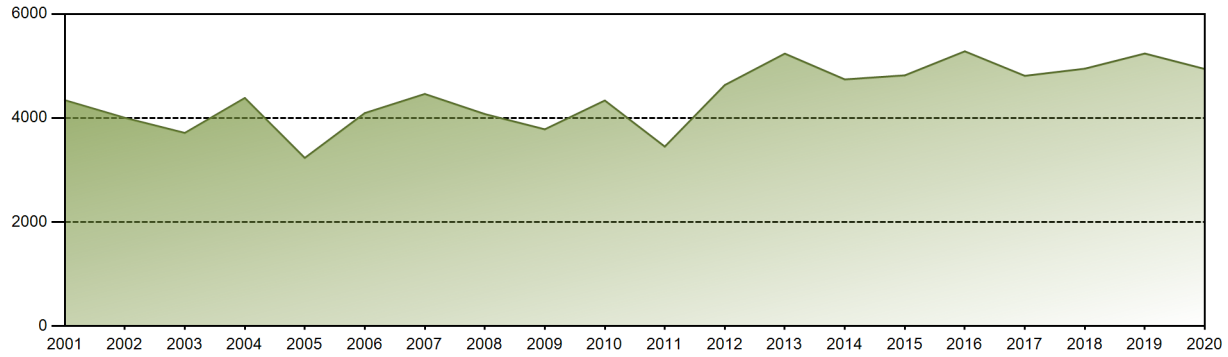
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	450.08	420.65	174.97	346.62	451.70	436.13	445.69	445.70	434.48	447.30	438.07	451.17	4942.57
EAF [%]	100.00	100.00	41.94	85.17	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.87
UCF [%]	100.00	100.00	41.94	85.17	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.87
LF [%]	102.36	102.27	39.79	81.46	102.73	102.49	101.36	101.36	102.11	101.73	102.95	102.61	95.21
OF [%]	100.00	100.00	41.80	85.14	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.85
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	58.06	14.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.13
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

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Historical Summary

Lifetime energy generation	:	137102 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.71 %
Cumulative Energy Availability Factor (EAF)	:	86.74 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.51 %
Cumulative Unit Capability Factor (UCF)	:	86.75 %	Cumulative Planned Unavailability Factor (PUF)	:	11.74 %
Cumulative Load Factor (LF)	:	85.17 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	86.43 %			

Electricity Production (net) [GWh]

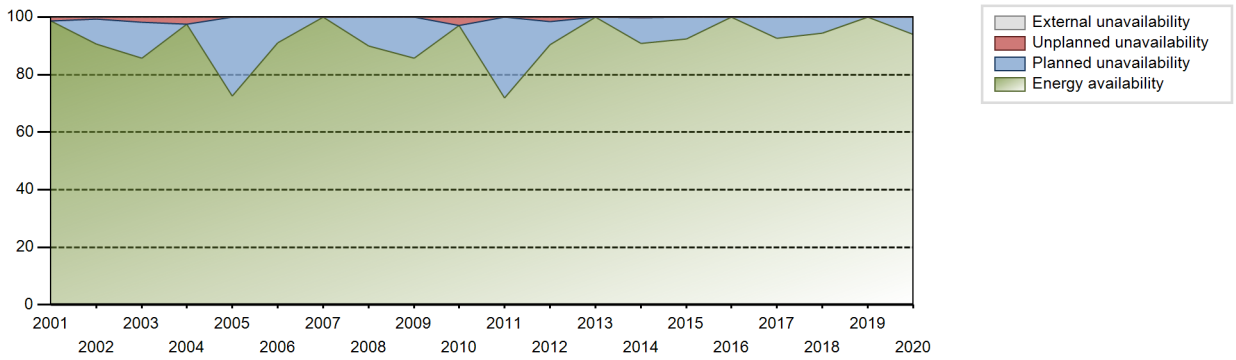


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1972	225.70	2987	288	100.00	100.00	84.78	81.48	0.00	0.00	0.00	0.00
1973	2991.00	8192	497	80.16	80.16	68.70	93.52	16.63	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

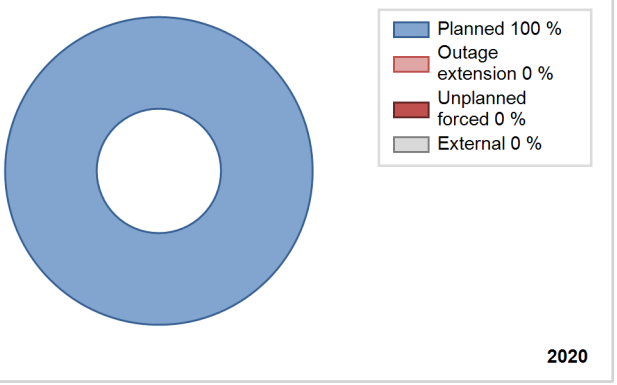
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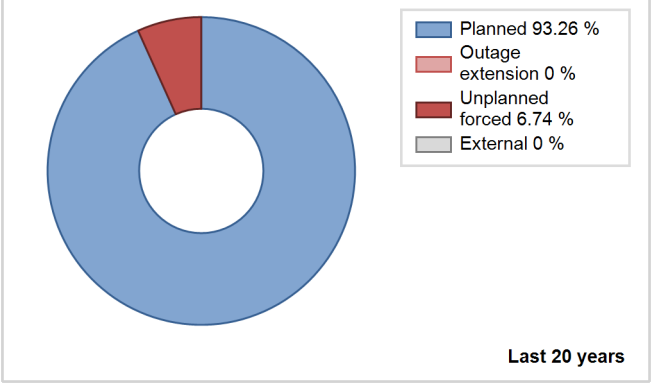
2009	3782.45	7501	516	85.69	85.69	83.68	85.63	0.00	0.00	14.31	0.00
2010	4336.29	8495	515	96.99	96.99	96.12	96.97	3.01	3.01	0.00	0.00
2011	3450.08	6098	586	71.91	71.91	70.75	69.61	0.00	0.00	28.09	0.00
2012	4633.79	7935	591	90.36	90.36	89.26	90.33	1.68	1.55	8.09	0.00
2013	5237.69	8760	591	100.00	100.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1972 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					89	
B. Refuelling without maintenance	539			21		
C. Inspection, maintenance or repair combined with refuelling				997		
D. Inspection, maintenance or repair without refuelling				35		
E. Testing of plant systems or components				1	19	
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					14	
Subtotal	539			1056	130	1
Total	**539**			**1187**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1972 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		4
12. Reactor I&C Systems		43
13. Reactor Auxiliary Systems		1
14. Safety Systems		0
15. Reactor Cooling Systems		27
16. Steam generation systems		13
31. Turbine and auxiliaries		9
32. Feedwater and Main Steam System		6
41. Main Generator Systems		1
42. Electrical Power Supply Systems		15
Total		**119**

Highlights (2020)

Refueling Outage 37 (U2R37)

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2020 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

Reactor type and model	:	PWR / WH 2LP (DRYAMB)
Thermal power	:	1677 MWth
Gross electrical power	:	566 MWe
Reference unit power (net)	:	522 MWe

Key Dates

Construction Date	:	1968-06-25
Grid Date	:	1973-12-04
Commercial Date	:	1973-12-16
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 [%]	:	40
Average discharge burnup [MWd/t]	:	51000
Active core diameter [m]	:	2.45
Active core height/length [m]	:	3.66
Number of fissile fuel assemblies/bundles	:	121
Fuel linear heat generation rate [kW/m]	:	20.3
Number of control rod assemblies	:	21
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

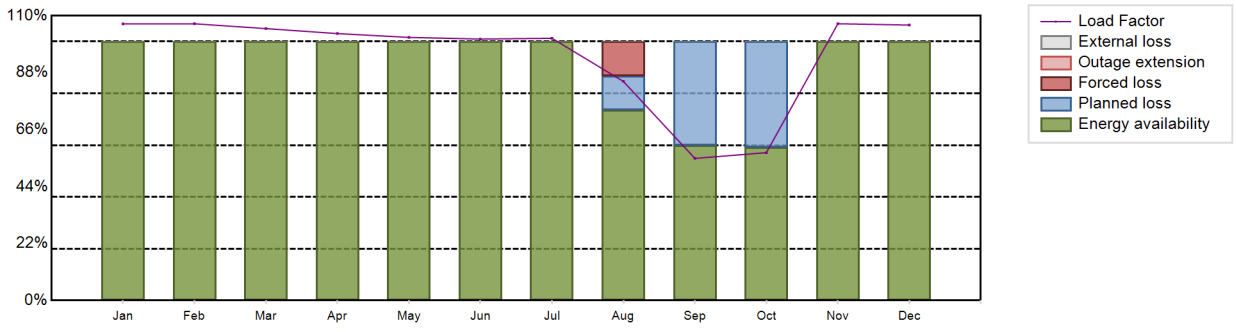
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	315
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.291
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	5.06
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 (2020)

Net Energy Production	:	4337.58 GW(e).h
Energy Availability Factor (EAF)	:	91.02 %
Unit Capability Factor (UCF)	:	91.02 %
Load Factor (LF)	:	94.6 %
Operating Factor (OF)	:	92.12 %

Forced Loss Rate (FLR)	:	1.21 %
Unplanned Capability Loss Factor (UCL)	:	1.12 %
Planned Unavailability Factor (PUF)	:	7.86 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	692 hours

Annual Summary



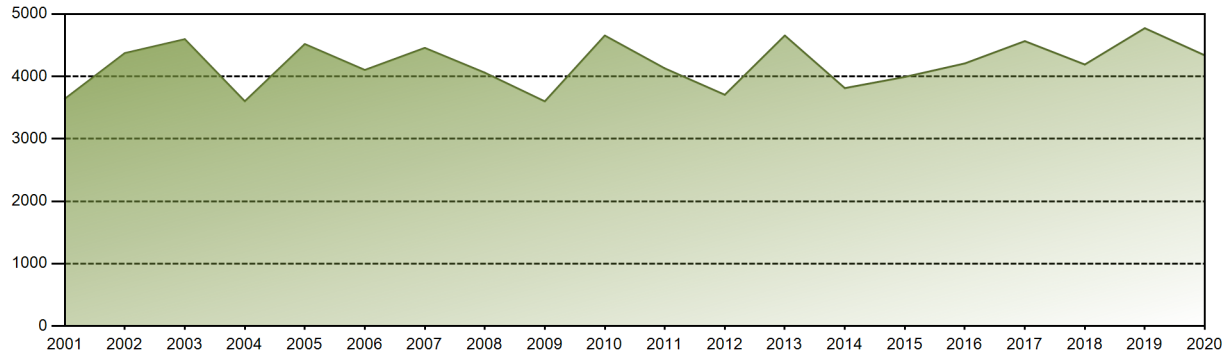
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	414.86	388.29	407.86	387.48	394.66	379.48	393.34	328.61	206.32	221.78	401.77	413.14	4337.58
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	73.62	59.86	59.18	100.00	100.00	91.02
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	73.62	59.86	59.18	100.00	100.00	91.02
LF [%]	106.82	106.88	105.02	103.10	101.62	100.97	101.28	84.61	54.90	57.11	106.90	106.38	94.60
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	86.83	59.86	59.14	100.00	100.00	92.12
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.20	0.00	0.00	0.00	0.00	1.21
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.19	0.00	0.00	0.00	0.00	1.12
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.19	40.14	40.82	0.00	0.00	7.86
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

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Historical Summary

Lifetime energy generation	:	188189.77 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4 %
Cumulative Energy Availability Factor (EAF)	:	87.22 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.63 %
Cumulative Unit Capability Factor (UCF)	:	87.23 %	Cumulative Planned Unavailability Factor (PUF)	:	9.14 %
Cumulative Load Factor (LF)	:	86.82 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	87.75 %			

Electricity Production (net) [GWh]

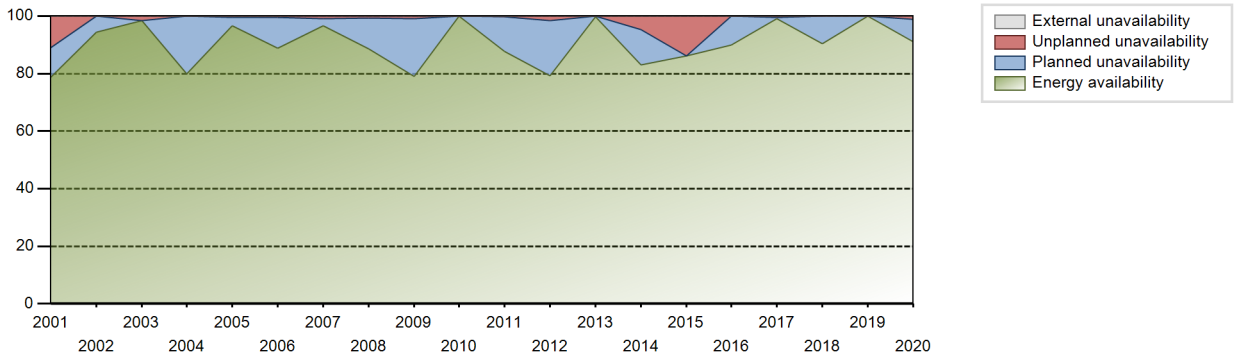


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	7.20	312	514	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	1452.20	3848	520	43.95	43.95	31.88	43.93	51.66	46.97	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

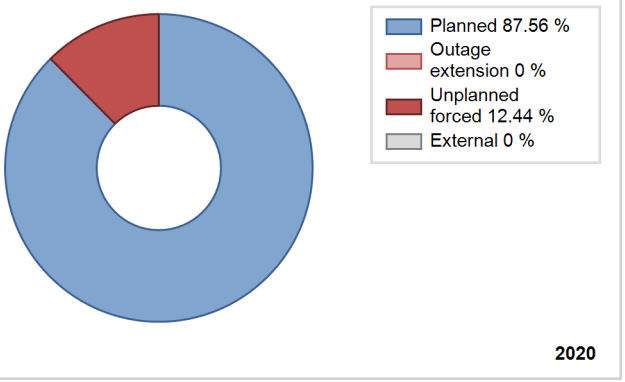
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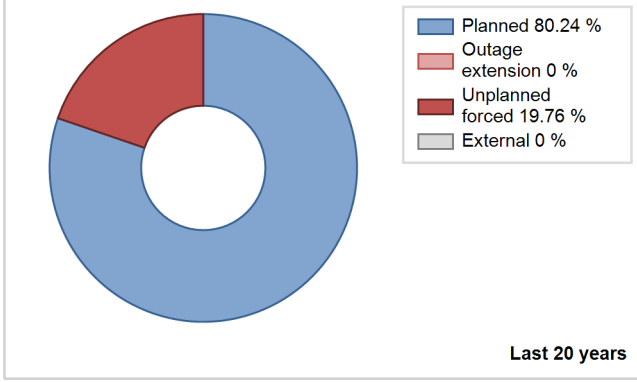
2010	4654.86	8760	560	100.00	100.00	96.04	100.00	0.00	0.00	0.00	0.00
2011	4128.39	7717	521	87.69	87.69	87.22	88.09	0.39	0.34	11.96	0.00
2012	3705.98	6961	522	79.26	79.26	80.82	79.25	1.99	1.61	19.13	0.00
2013	4654.69	8732	522	99.68	99.68	101.78	99.67	0.00	0.00	0.32	0.00
2014	3812.46	7264	522	82.92	82.92	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					267	
B. Refuelling without maintenance	593			13		
C. Inspection, maintenance or repair combined with refuelling				683		
D. Inspection, maintenance or repair without refuelling				68		
E. Testing of plant systems or components				5	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					3	
L. Human factor related					1	
P. Fire					20	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					0	
Z. Other		98			2	1
Subtotal	593	98		770	294	1
Total		**691**			**1065**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		12
12. Reactor I&C Systems		42
14. Safety Systems		8
15. Reactor Cooling Systems		31
16. Steam generation systems		30
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		97
32. Feedwater and Main Steam System		29
33. Circulating Water System		2
34. Miscellaneous Systems		3
35. All other I&C Systems		7
41. Main Generator Systems		16
42. Electrical Power Supply Systems		12
Total		**290**

Highlights (2020)

Automatic reactor scram on a spurious Power Range Negative Rate trip signal during surveillance testing of PRNIs.

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2020 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

Reactor type and model	:	PWR / WH 2LP (DRYAMB)
Thermal power	:	1677 MWth
Gross electrical power	:	560 MWe
Reference unit power (net)	:	519 MWe

Key Dates

Construction Date	:	1969-06-25
Grid Date	:	1974-12-21
Commercial Date	:	1974-12-21
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]	:	-
Refuelling frequency [month]	:	18
Part of the core refuelled [%]	:	40
Average discharge burnup [MWd/t]	:	51000
Active core diameter [m]	:	2.45
Active core height/length [m]	:	3.66
Number of fissile fuel assemblies/bundles	:	121
Fuel linear heat generation rate [kW/m]	:	20.3
Number of control rod assemblies	:	21
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

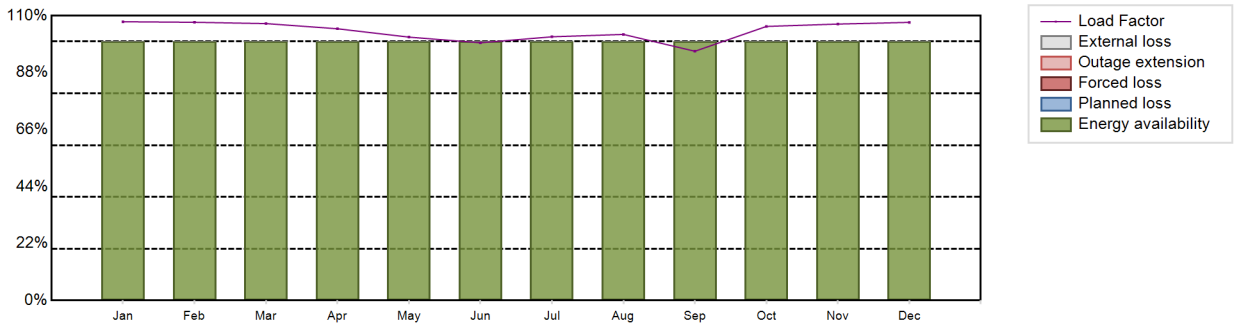
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	315
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.291
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	5.06
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 (2020)

Net Energy Production	:	4746.4 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	104.11 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



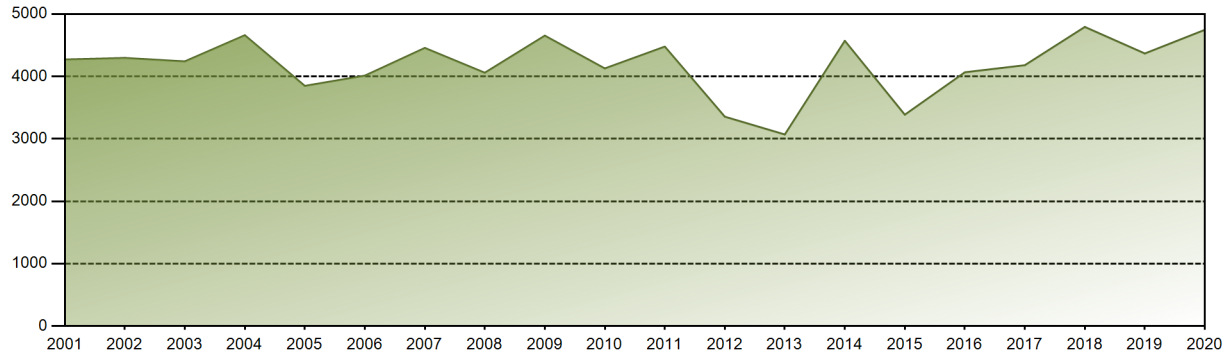
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	415.77	388.16	412.98	392.20	392.84	372.00	393.31	396.86	359.77	408.72	398.96	414.82	4746.40
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	107.68	107.46	106.95	104.96	101.74	99.55	101.86	102.78	96.28	105.85	106.77	107.43	104.11
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	185005.28 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.31 %
Cumulative Energy Availability Factor (EAF)	:	88.23 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.02 %
Cumulative Unit Capability Factor (UCF)	:	88.25 %	Cumulative Planned Unavailability Factor (PUF)	:	8.74 %
Cumulative Load Factor (LF)	:	88.32 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	88.8 %			

Electricity Production (net) [GWh]

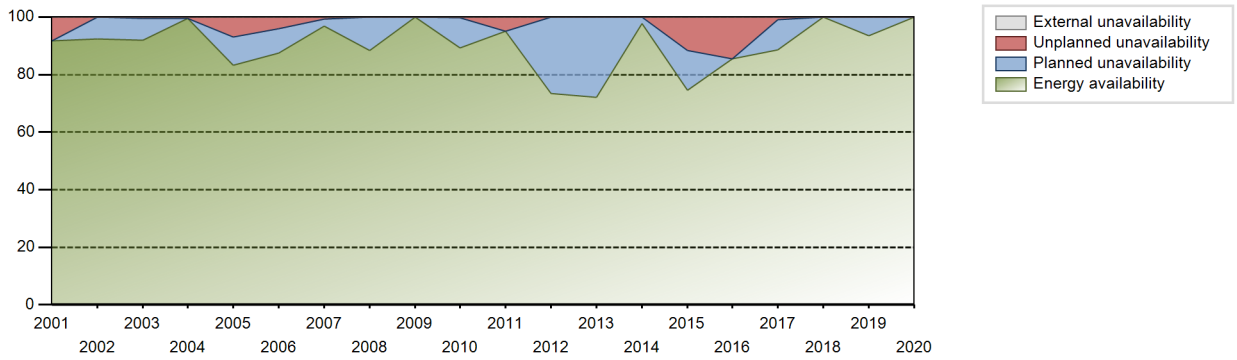


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1974	7.40	104	513	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	3176.20	7035	520	69.91	69.91	69.92	80.53	22.79	20.63	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

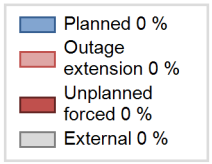
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2011	4477.65	8354	519	95.07	95.07	98.49	95.37	4.93	4.93	0.00	0.00
2012	3354.75	6453	518	73.49	73.49	73.73	73.46	0.00	0.00	26.51	0.00
2013	3069.71	6311	519	72.11	72.11	67.51	72.04	0.00	0.00	27.89	0.00
2014	4570.74	8556	518	97.67	97.67	100.73	97.67	0.00	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

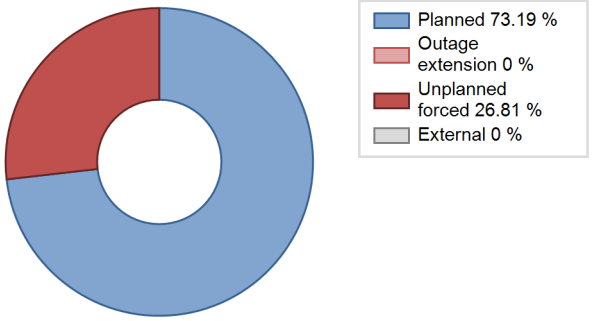
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1974 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					216	
C. Inspection, maintenance or repair combined with refuelling				650		
D. Inspection, maintenance or repair without refuelling				70		
E. Testing of plant systems or components				4		
H. Nuclear regulatory requirements					11	
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				724	230	12
Total	**0**			**966**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1974 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		0
12. Reactor I&C Systems		33
13. Reactor Auxiliary Systems		3
14. Safety Systems		2
15. Reactor Cooling Systems		37
16. Steam generation systems		5
17. Safety I&C Systems (excluding reactor I&C)		11
31. Turbine and auxiliaries		64
32. Feedwater and Main Steam System		4
33. Circulating Water System		13
34. Miscellaneous Systems		4
35. All other I&C Systems		1
41. Main Generator Systems		41
42. Electrical Power Supply Systems		23
Total		**241**

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2020 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

Reactor type and model	:	BWR / BWR-3 (Mark 1)
Thermal power	:	2957 MWth
Gross electrical power	:	940 MWe
Reference unit power (net)	:	908 MWe

Key Dates

Construction Date	:	1967-02-15
Grid Date	:	1972-04-12
Commercial Date	:	1973-02-18
Age at end of year	:	48 years

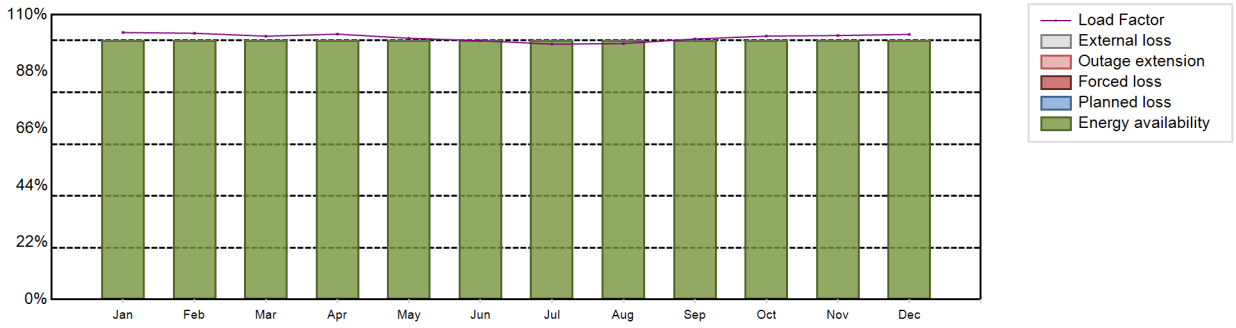
Design Characteristics

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 (2020)

Net Energy Production	:	8075.97 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)	:	101.25 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



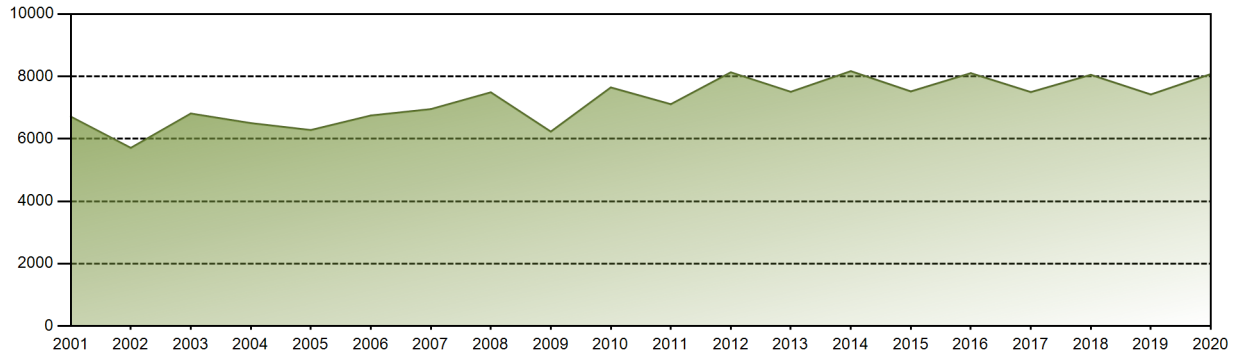
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	696.58	649.83	687.06	670.04	681.68	653.42	666.31	667.81	657.82	687.21	666.48	691.74	8075.97
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	103.11	102.83	101.70	102.49	100.91	99.95	98.63	98.85	100.62	101.72	101.94	102.40	101.25
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	277926.16 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.77 %
Cumulative Energy Availability Factor (EAF)	:	82.29 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.08 %
Cumulative Unit Capability Factor (UCF)	:	82.32 %	Cumulative Planned Unavailability Factor (PUF)	:	12.6 %
Cumulative Load Factor (LF)	:	78.68 %	Cumulative Externally cause unavailability (XUF)	:	0.03 %
Cumulative Operating Factor (OF)	:	83.28 %			

Electricity Production (net) [GWh]

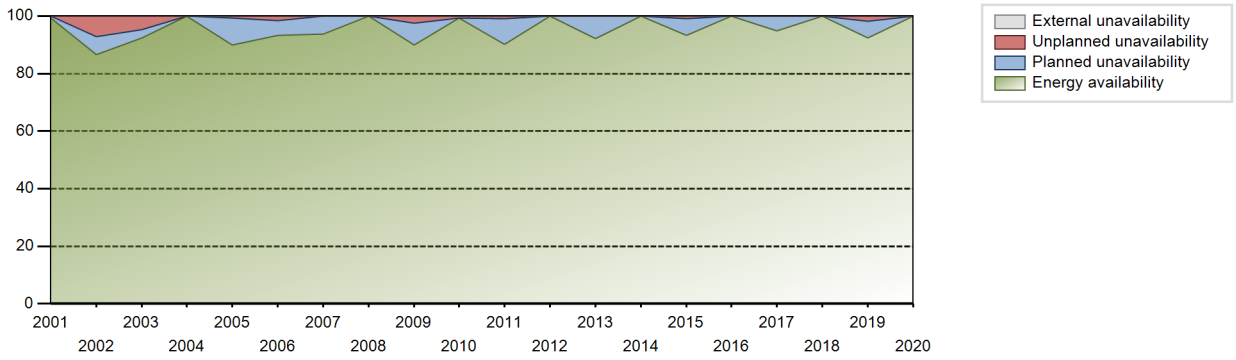


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	4908.50	7382	800	86.81	86.81	69.05	82.79	4.33	3.93	9.26	0.00
1974	3464.10	5365	800	61.37	61.37	49.43	61.24	17.84	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

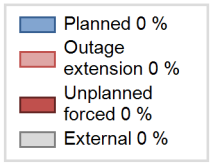
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2010	7646.11	8698	882	99.31	99.31	98.96	99.29	0.69	0.69	0.00	0.00
2011	7109.23	7898	882	90.18	90.18	92.01	90.16	1.13	1.03	8.79	0.00
2012	8130.41	8784	908	100.00	100.00	101.94	100.00	0.00	0.00	0.00	0.00
2013	7505.99	8073	908	92.16	92.16	94.36	92.15	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

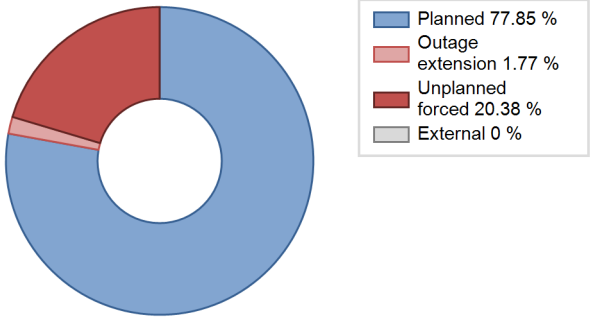
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					264	
C. Inspection, maintenance or repair combined with refuelling				917		
D. Inspection, maintenance or repair without refuelling				124	61	
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)						11
L. Human factor related					54	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						2
P. Fire					7	
Z. Other				3	7	2
Subtotal				1051	405	15
Total	**0**			**1471**		

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Equipment Related Unplanned Full Outages, Analysis by System		
System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		6
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		2
14. Safety Systems		6
15. Reactor Cooling Systems		78
31. Turbine and auxiliaries		72
32. Feedwater and Main Steam System		19
34. Miscellaneous Systems		23
41. Main Generator Systems		16
42. Electrical Power Supply Systems		32
Total		**272**

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2020 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
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Commercial Date	:	1973-03-10
Age at end of year	:	48 years

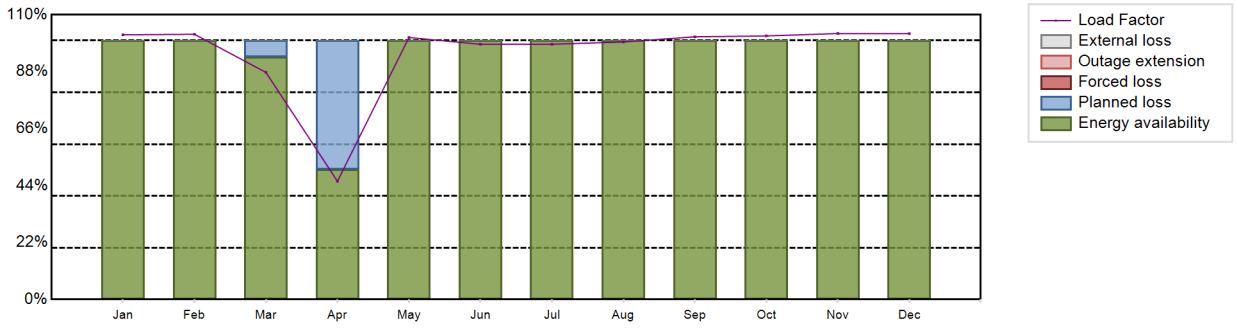
Design Characteristics

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 (2020)

Net Energy Production	:	7636.48 GW(e).h	Forced Loss Rate (FLR)	:	0 %
Energy Availability Factor (EAF)	:	95.37 %	Unplanned Capability Loss Factor (UCL)	:	0 %
Unit Capability Factor (UCF)	:	95.37 %	Planned Unavailability Factor (PUF)	:	4.63 %
Load Factor (LF)	:	95.43 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	95.36 %	Total off-line time	:	408 hours

Annual Summary



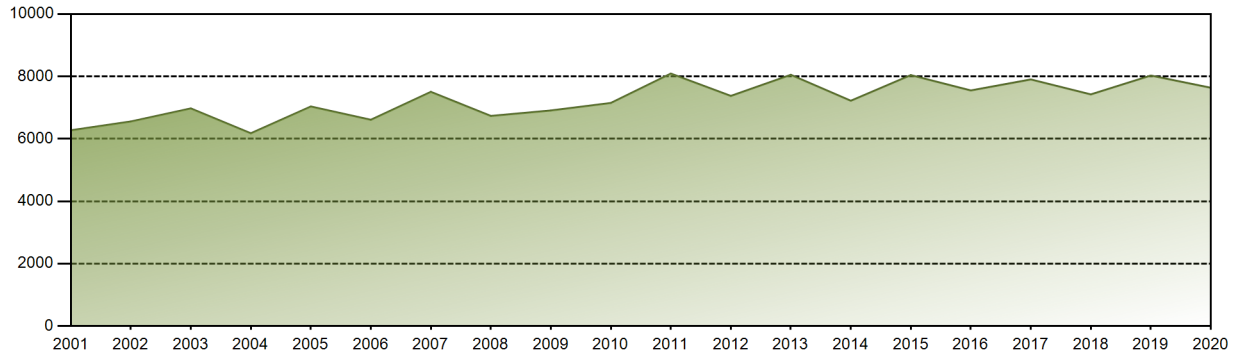
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	692.91	649.52	594.47	299.58	685.80	646.57	668.26	674.15	665.51	690.07	673.79	695.84	7636.48
EAF [%]	100.00	100.00	93.55	50.13	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.37
UCF [%]	100.00	100.00	93.55	50.13	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.37
LF [%]	102.23	102.44	87.71	45.67	101.18	98.58	98.59	99.46	101.46	101.81	102.72	102.66	95.43
OF [%]	100.00	100.00	93.41	50.14	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	95.36
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	6.45	49.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63
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

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Historical Summary

Lifetime energy generation	:	274008.32 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.39 %
Cumulative Energy Availability Factor (EAF)	:	81.06 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.6 %
Cumulative Unit Capability Factor (UCF)	:	81.61 %	Cumulative Planned Unavailability Factor (PUF)	:	12.8 %
Cumulative Load Factor (LF)	:	77.38 %	Cumulative Externally cause unavailability (XUF)	:	0.54 %
Cumulative Operating Factor (OF)	:	82.07 %			

Electricity Production (net) [GWh]

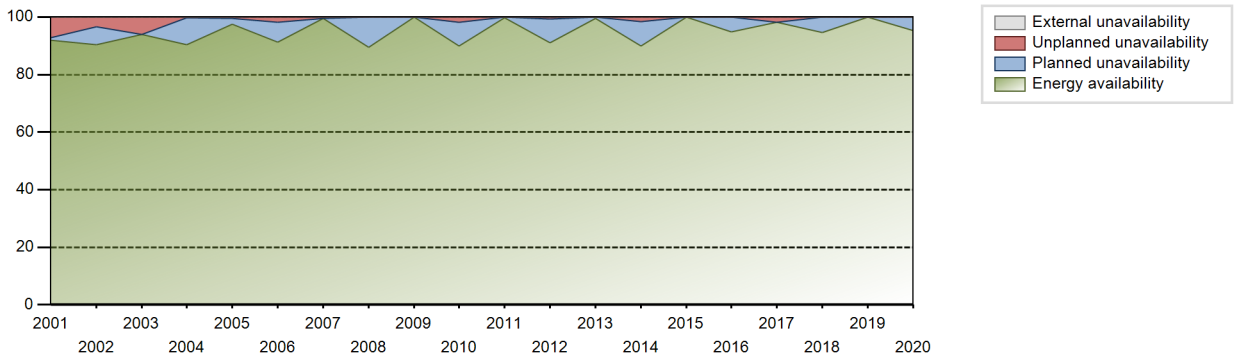


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	5208.90	7405	800	86.42	86.42	74.76	84.94	4.05	3.64	9.94	0.00
1974	4643.80	7232	800	82.56	82.56	66.26	82.56	11.84	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

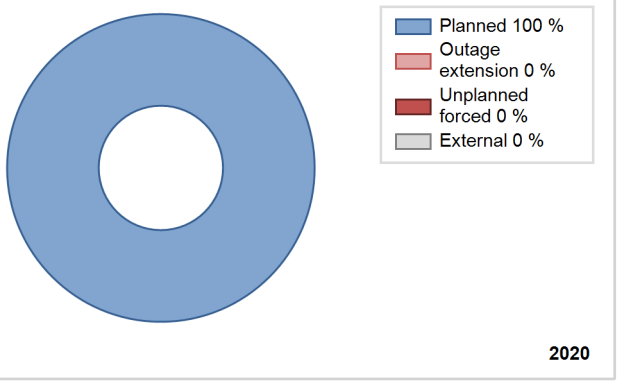
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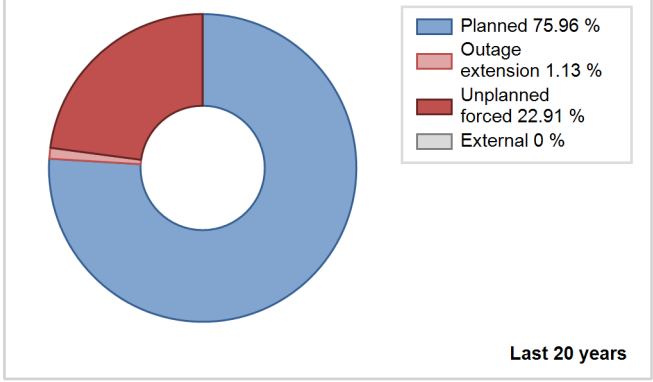
2010	7150.14	7849	892	89.90	89.90	91.51	89.60	0.88	1.93	8.17	0.00
2011	8092.34	8743	892	99.81	99.81	103.56	99.81	0.00	0.00	0.19	0.00
2012	7375.56	8004	911	91.14	91.14	92.17	91.12	0.67	0.61	8.25	0.00
2013	8051.85	8723	911	99.58	99.58	100.88	99.57	0.00	0.00	0.42	0.00
2014	7220.77	7886	911	90.03	90.03	90.48	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					400	
B. Refuelling without maintenance	407			19		
C. Inspection, maintenance or repair combined with refuelling				868		
D. Inspection, maintenance or repair without refuelling				111		
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)						12
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				74	35	49
Subtotal	407			1075	461	62
Total	**407**			**1598**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		21
12. Reactor I&C Systems		12
13. Reactor Auxiliary Systems		3
14. Safety Systems		14
15. Reactor Cooling Systems		57
16. Steam generation systems		9
17. Safety I&C Systems (excluding reactor I&C)		6
31. Turbine and auxiliaries		72
32. Feedwater and Main Steam System		40
33. Circulating Water System		6
34. Miscellaneous Systems		72
35. All other I&C Systems		1
41. Main Generator Systems		27
42. Electrical Power Supply Systems		65
Total		**405**

Highlights (2020)

Refueling Outage 30.

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2020 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

Reactor type and model	:	BWR / BWR-6 (Mark 3)
Thermal power	:	3091 MWth
Gross electrical power	:	1016 MWe
Reference unit power (net)	:	967 MWe

Key Dates

Construction Date	:	1977-03-25
Grid Date	:	1985-12-03
Commercial Date	:	1986-06-16
Age at end of year	:	35 years

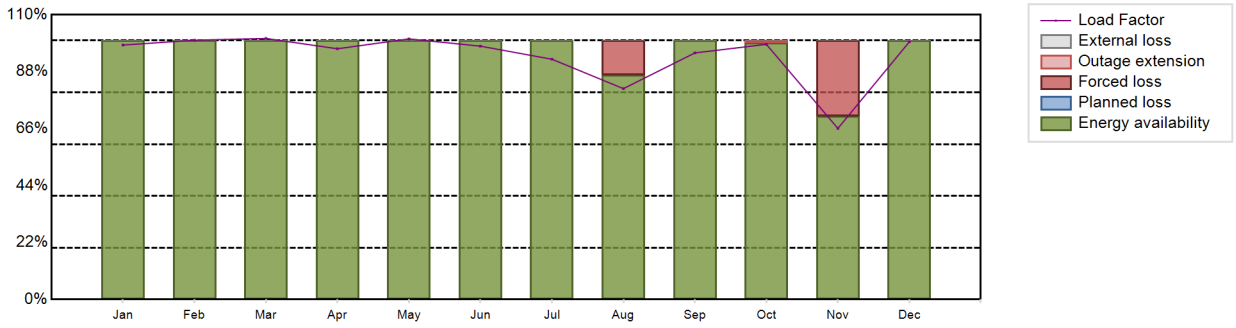
Design Characteristics

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 (2020)

Net Energy Production	:	7988.37 GW(e).h	Forced Loss Rate (FLR)	:	3.54 %
Energy Availability Factor (EAF)	:	96.4 %	Unplanned Capability Loss Factor (UCL)	:	3.6 %
Unit Capability Factor (UCF)	:	96.4 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	94.05 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	96.39 %	Total off-line time	:	317 hours

Annual Summary



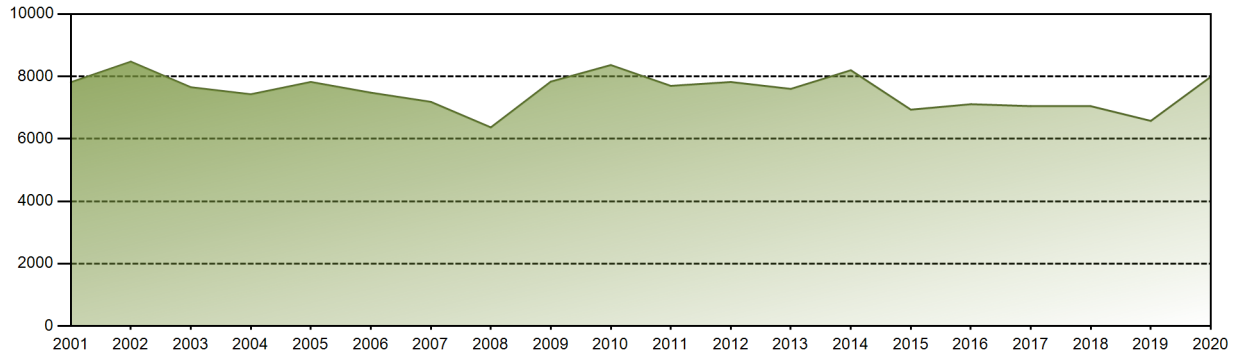
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	707.06	674.07	725.43	674.27	724.23	681.32	667.70	586.01	663.11	709.06	460.14	715.96	7988.37
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.59	100.00	99.23	70.72	100.00	96.40
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	86.59	100.00	99.23	70.72	100.00	96.40
LF [%]	98.28	100.15	100.83	96.84	100.66	97.86	92.81	81.45	95.24	98.56	66.09	99.51	94.05
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	86.56	100.00	99.19	70.83	100.00	96.39
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.41	0.00	0.00	29.27	0.00	3.54
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.41	0.00	0.77	29.27	0.00	3.60
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

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Historical Summary

Lifetime energy generation	:	195107.14 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	5.77 %
Cumulative Energy Availability Factor (EAF)	:	84.76 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.21 %
Cumulative Unit Capability Factor (UCF)	:	84.93 %	Cumulative Planned Unavailability Factor (PUF)	:	9.86 %
Cumulative Load Factor (LF)	:	82.16 %	Cumulative Externally cause unavailability (XUF)	:	0.17 %
Cumulative Operating Factor (OF)	:	84.64 %			

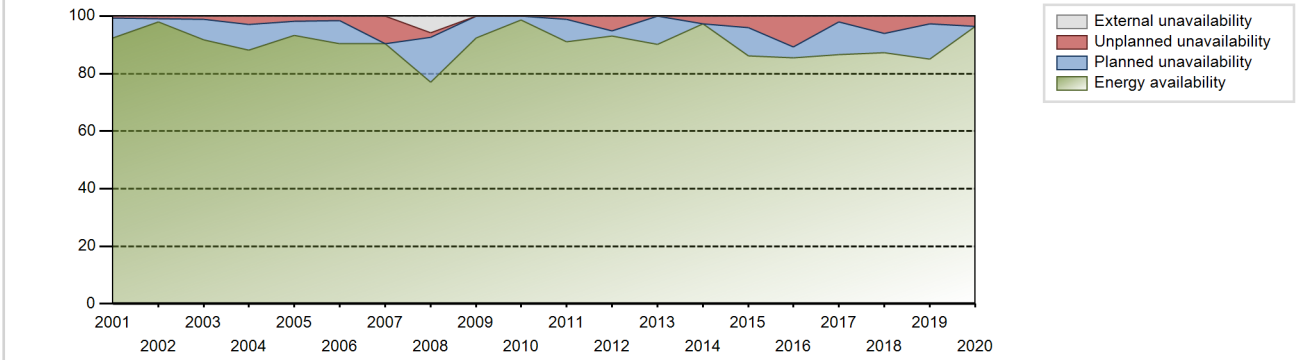
Electricity Production (net) [GWh]



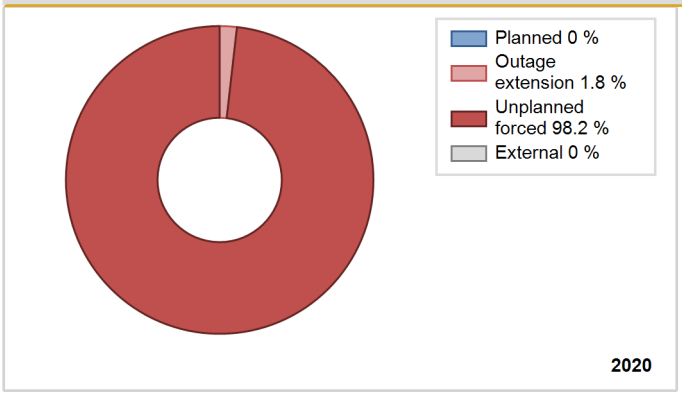
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1986	2995.44	4221	936	51.92	51.92	47.08	51.73	18.86	12.07	36.01	0.00
1987	4964.44	5836	936	66.65	66.65	60.55	66.62	5.69	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

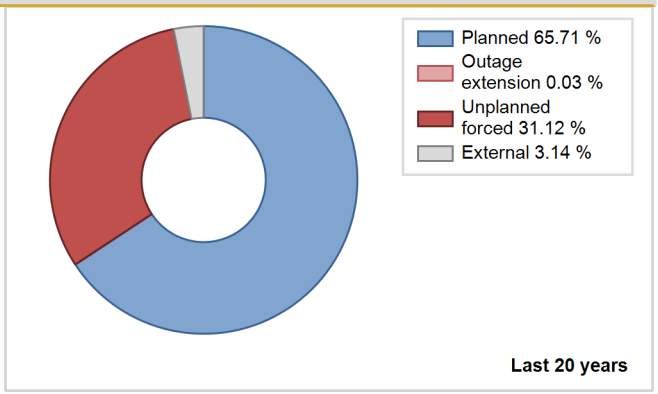
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1986 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					359	
C. Inspection, maintenance or repair combined with refuelling				712		
D. Inspection, maintenance or repair without refuelling				152		
E. Testing of plant systems or components				9	15	
L. Human factor related					17	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						15
P. Fire					0	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)				10		
Z. Other		311	6	8	95	0
Subtotal		311	6	891	486	15
Total		**317**			**1392**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1986 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		35
12. Reactor I&C Systems		59
13. Reactor Auxiliary Systems		2
14. Safety Systems		8
15. Reactor Cooling Systems		71
17. Safety I&C Systems (excluding reactor I&C)		14
31. Turbine and auxiliaries		67
32. Feedwater and Main Steam System		67
33. Circulating Water System		2
34. Miscellaneous Systems		15
35. All other I&C Systems		7
41. Main Generator Systems		43
42. Electrical Power Supply Systems		33
Total		**423**

Highlights (2020)

Shutdown due to loss of Make-Up Water flow.

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2020 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

Reactor type and model	:	PWR / WH 3LP (DRYAMB)
Thermal power	:	2339 MWth
Gross electrical power	:	780 MWe
Reference unit power (net)	:	741 MWe

Key Dates

Construction Date	:	1967-04-13
Grid Date	:	1970-09-26
Commercial Date	:	1971-03-07
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]	:	30000
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]	:	43.96
Number of control rod assemblies	:	45
Number of external reactor coolant loops	:	3
Coolant type	:	H2O

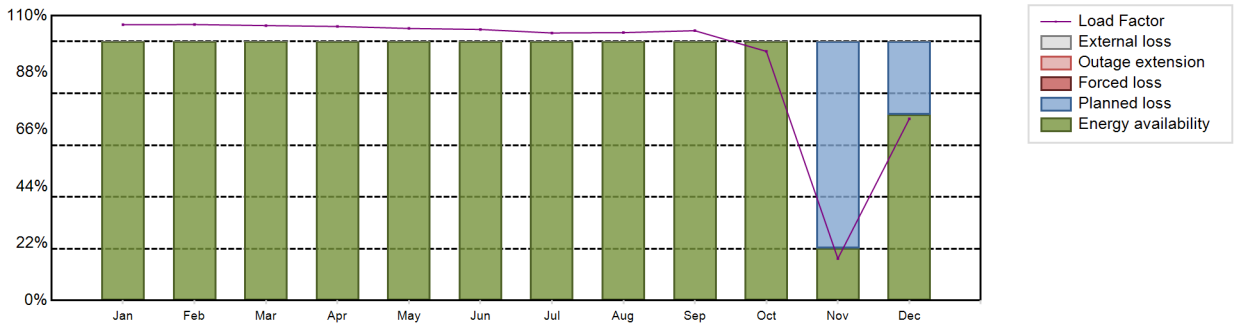
Operating coolant pressure [MPa]	:	15.71
Reactor outlet temperature [°C]	:	318
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.295
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder inlet steam pressure [MPa]	:	5.4
Output voltage [kV]	:	-
Primary means of condenser cooling	:	Lake (once-through)
Number of main condensate pumps	:	-
Number of FW pumps for full power operation	:	-
Number of on-site safety related diesel generators	:	-
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	6124.63 GW(e).h
Energy Availability Factor (EAF)	:	91.08 %
Unit Capability Factor (UCF)	:	91.08 %
Load Factor (LF)	:	94.1 %
Operating Factor (OF)	:	91.09 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.92 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	783 hours

Annual Summary



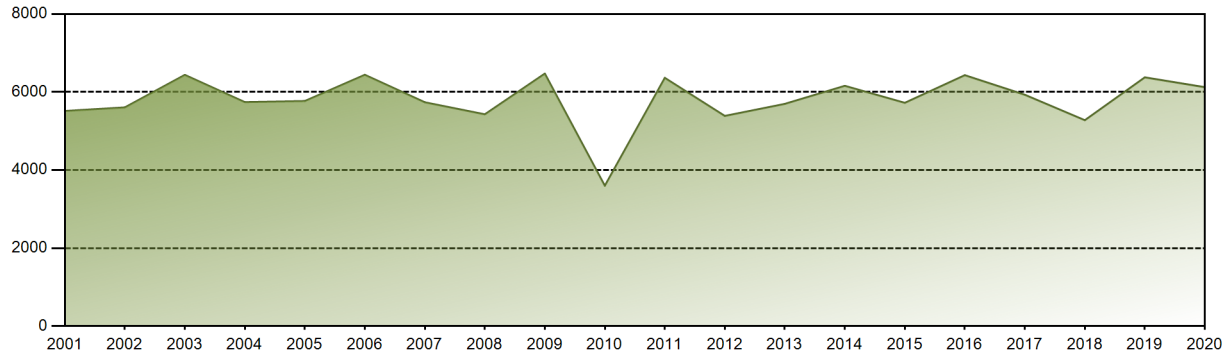
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	587.24	549.66	585.38	564.64	579.28	558.50	569.63	570.45	555.98	530.42	86.39	387.05	6124.63
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	20.25	71.87	91.08
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	20.25	71.87	91.08
LF [%]	106.52	106.58	106.18	105.83	105.07	104.68	103.32	103.47	104.21	96.21	16.19	70.21	94.10
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	20.42	71.91	91.09
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	0.00	0.00	79.75	28.13	8.92
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

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Historical Summary

Lifetime energy generation	:	245151.54 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.73 %
Cumulative Energy Availability Factor (EAF)	:	80.72 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.83 %
Cumulative Unit Capability Factor (UCF)	:	80.88 %	Cumulative Planned Unavailability Factor (PUF)	:	13.29 %
Cumulative Load Factor (LF)	:	79.37 %	Cumulative Externally cause unavailability (XUF)	:	0.16 %
Cumulative Operating Factor (OF)	:	79.72 %			

Electricity Production (net) [GWh]

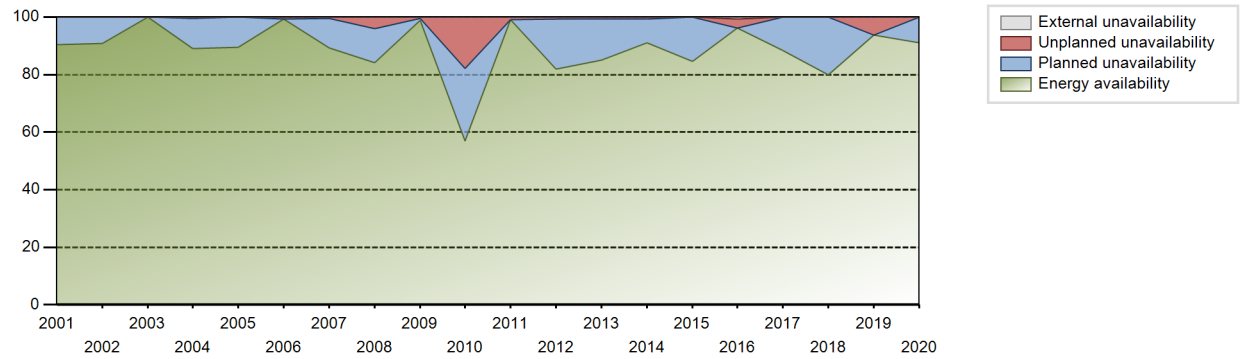


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1971	2538.60	4078	739	100.00	100.00	43.07	48.12	0.00	0.00	0.00	0.00
1972	5082.40	7487	739	100.00	100.00	78.29	85.23	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

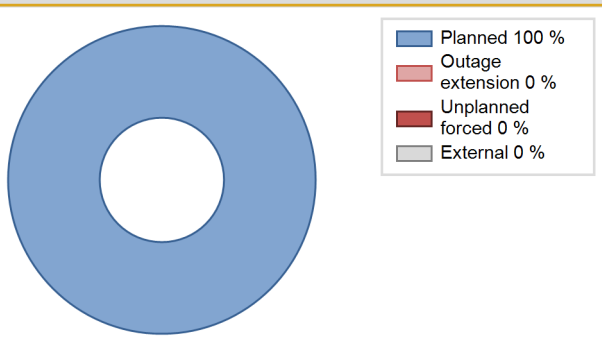
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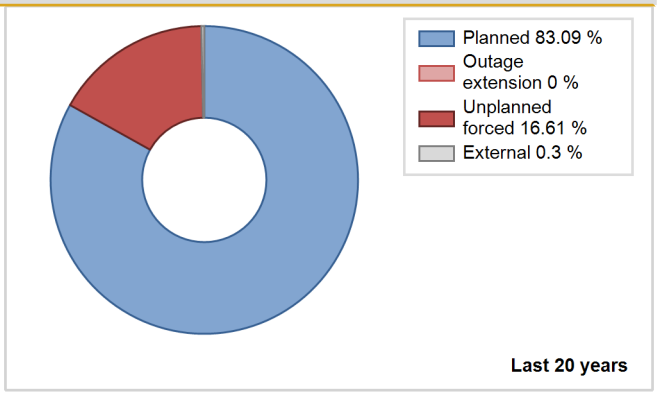
2008	5429.26	7380	710	84.03	84.03	87.05	84.02	4.50	3.96	12.01	0.00
2009	6473.19	8667	710	98.95	98.95	104.08	98.94	0.52	0.52	0.54	0.00
2010	3598.36	4902	724	56.85	56.85	56.74	55.96	23.96	17.91	25.24	0.00
2011	6363.80	8677	724	99.06	99.06	100.34	99.05	0.94	0.94	0.00	0.00
2012	5388.11	7165	741	81.90	81.90	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1971 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					445	
B. Refuelling without maintenance	784			16		
C. Inspection, maintenance or repair combined with refuelling				1076		
D. Inspection, maintenance or repair without refuelling				56		
E. Testing of plant systems or components				0	0	
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					95	
J. Grid limitation, failure or grid unavailability						1
L. Human factor related					49	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
Z. Other					28	
Subtotal	784			1149	617	2
Total	**784**			**1768**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1971 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		0
12. Reactor I&C Systems		50
13. Reactor Auxiliary Systems		2
14. Safety Systems		45
15. Reactor Cooling Systems		70
16. Steam generation systems		104
31. Turbine and auxiliaries		85
32. Feedwater and Main Steam System		34
34. Miscellaneous Systems		73
35. All other I&C Systems		0
41. Main Generator Systems		12
42. Electrical Power Supply Systems		88
Total		**563**

Highlights (2020)

Refueling Outage 32

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2020 Operating Experience

US-272 SALEM-1 UNITED STATES OF AMERICA



Status at end of year	:	**Operational**
Operator	:	PSEG (PSEG Nuclear, LLC)
Owner	:	PSEGPOWR (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	:	1254 MWe
Reference unit power (net)	:	1169 MWe

Key Dates

Construction Date	:	1968-09-25
Grid Date	:	1976-12-25
Commercial Date	:	1977-06-30
Age at end of year	:	44 years

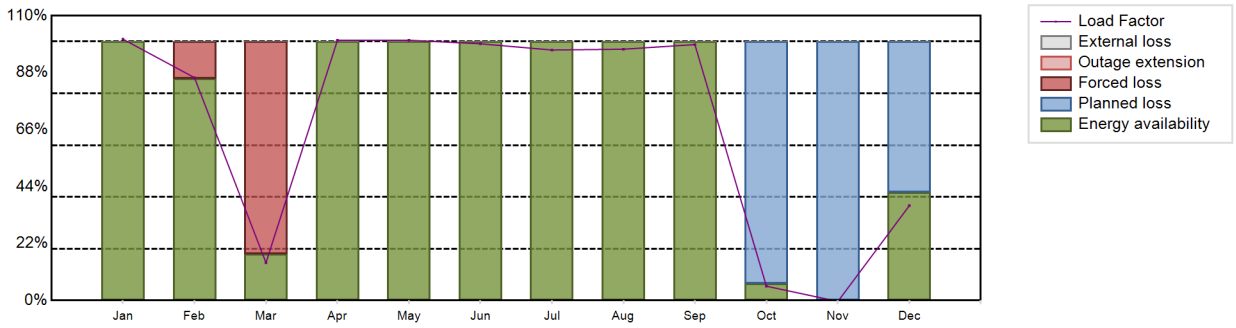
Design Characteristics

Primary Systems			Operating coolant pressure [MPa]	:	15.8
Reactor vessel centreline orientation	:	Vertical	Reactor outlet temperature [°C]	:	322
Fuel material	:	UO2	Number of SG	:	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 [%]	:	33	Turbine speed [rpm]	:	1800
Average discharge burnup [MWd/t]	:	40000	Number of LP cylinders per turbine	:	-
Active core diameter [m]	:	3.4	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	:	River (once-through)
Fuel linear heat generation rate [kW/m]	:	17.85	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	:	4	Number of on-site safety related diesel generators	:	-
Coolant type	:	H2O	**Non-electrical applications**	:	none

Annual Production Results (2020)

Net Energy Production	:	7142.17 GW(e).h	Forced Loss Rate (FLR)	:	10.22 %
Energy Availability Factor (EAF)	:	70.87 %	Unplanned Capability Loss Factor (UCL)	:	8.07 %
Unit Capability Factor (UCF)	:	70.87 %	Planned Unavailability Factor (PUF)	:	21.05 %
Load Factor (LF)	:	69.55 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	70.87 %	Total off-line time	:	2559 hours

Annual Summary



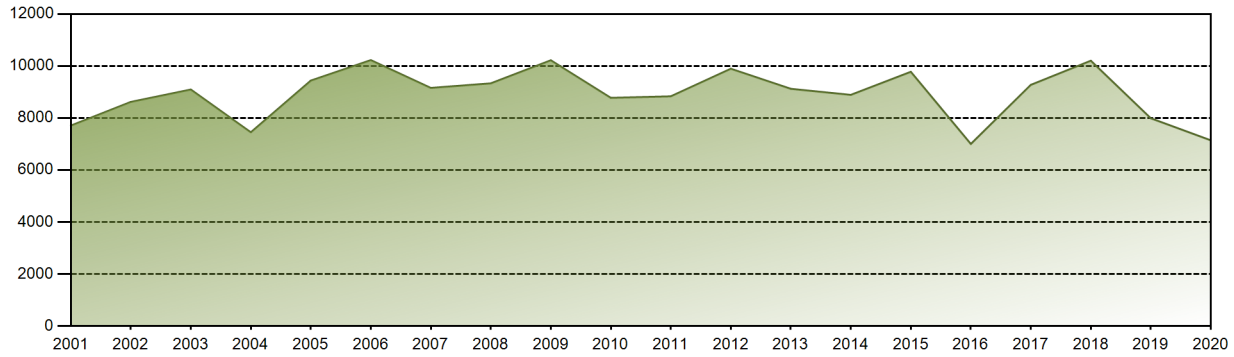
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	877.80	700.41	127.05	846.23	874.32	834.52	841.53	844.24	831.95	48.27	-2.89	318.73	7142.17
EAF [%]	100.00	85.72	18.06	100.00	100.00	100.00	100.00	100.00	100.00	6.45	0.00	41.74	70.87
UCF [%]	100.00	85.72	18.06	100.00	100.00	100.00	100.00	100.00	100.00	6.45	0.00	41.74	70.87
LF [%]	100.93	86.09	14.61	100.54	100.53	99.15	96.76	97.07	98.84	5.55	-0.34	36.65	69.55
OF [%]	100.00	85.78	17.88	100.00	100.00	100.00	100.00	100.00	100.00	6.45	0.00	41.80	70.87
FLR [%]	0.00	14.28	81.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.22
UCL [%]	0.00	14.28	81.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.07
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.55	100.00	58.26	21.05
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

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Historical Summary

Lifetime energy generation	:	307296.94 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	16.54 %
Cumulative Energy Availability Factor (EAF)	:	73.03 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	14.51 %
Cumulative Unit Capability Factor (UCF)	:	73.19 %	Cumulative Planned Unavailability Factor (PUF)	:	12.3 %
Cumulative Load Factor (LF)	:	70.58 %	Cumulative Externally cause unavailability (XUF)	:	0.16 %
Cumulative Operating Factor (OF)	:	73.03 %			

Electricity Production (net) [GWh]

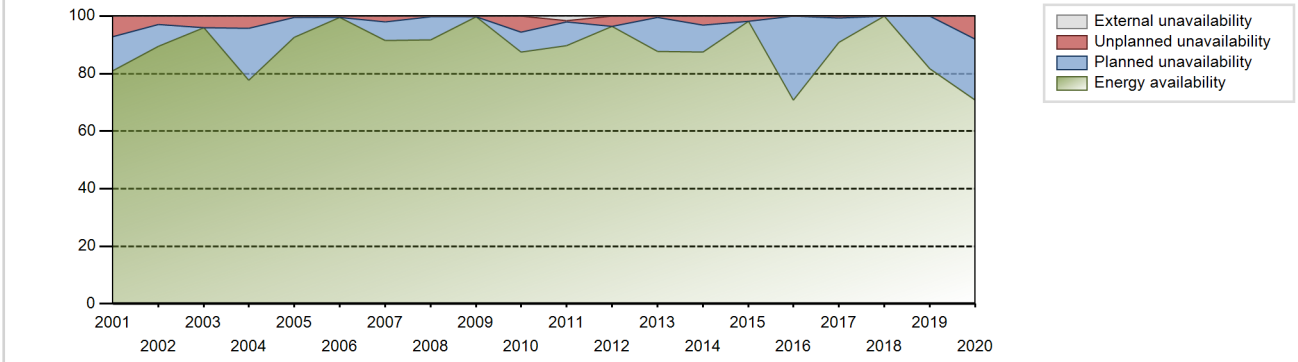


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1977	3398.20	2432	1079	42.77	42.77	42.79	54.53	56.99	56.66	0.57	0.00
1978	4537.00	4862	1079	48.00	48.00	48.00	55.50	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

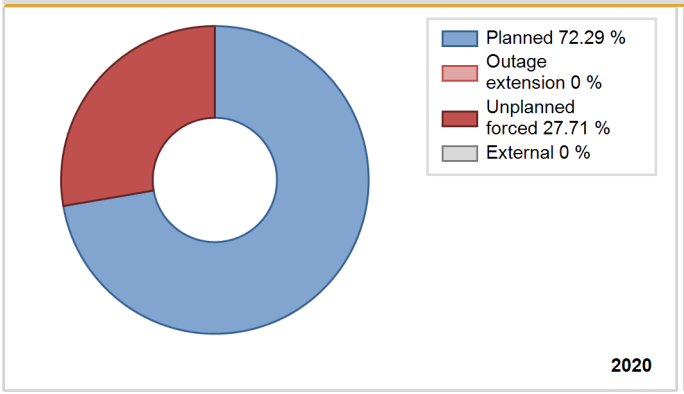
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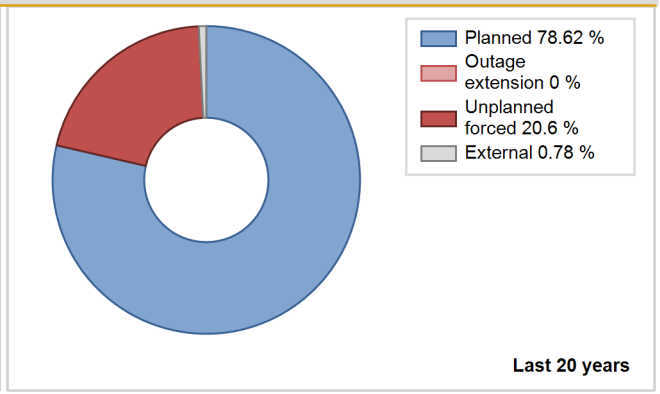
2014	8891.48	7657	1168	87.40	87.40	86.90	87.41	3.51	3.17	9.42	0.00
2015	9778.02	8593	1169	98.09	98.09	95.48	98.09	1.91	1.91	0.00	0.00
2016	7002.31	6214	1169	70.74	70.74	68.19	70.74	0.00	0.00	29.26	0.00
2017	9275.70	7964	1169	90.92	90.92	90.58	90.91	0.67	0.62	8.47	0.00
2018	10204.37	8760	1169	100.00	100.00	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1977 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					1048	
B. Refuelling without maintenance	1849			43		
C. Inspection, maintenance or repair combined with refuelling				953		
D. Inspection, maintenance or repair without refuelling				75		
E. Testing of plant systems or components				1	1	
H. Nuclear regulatory requirements					113	
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		709		10	97	
Subtotal	1849	709		1082	1266	8
Total	**2558**			**2356**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1977 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories	709	17
12. Reactor I&C Systems		69
13. Reactor Auxiliary Systems		9
14. Safety Systems		88
15. Reactor Cooling Systems		68
16. Steam generation systems		432
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		183
32. Feedwater and Main Steam System		89
33. Circulating Water System		46
34. Miscellaneous Systems		67
35. All other I&C Systems		5
41. Main Generator Systems		85
42. Electrical Power Supply Systems		49
Total	**709**	**1210**

Highlights (2020)

1R27 Refueling Outage

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2020 Operating Experience

US-311 SALEM-2 UNITED STATES OF AMERICA



Status at end of year	:	**Operational**
Operator	:	PSEG (PSEG Nuclear, LLC)
Owner	:	PSEGPOWR (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	:	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]	:	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

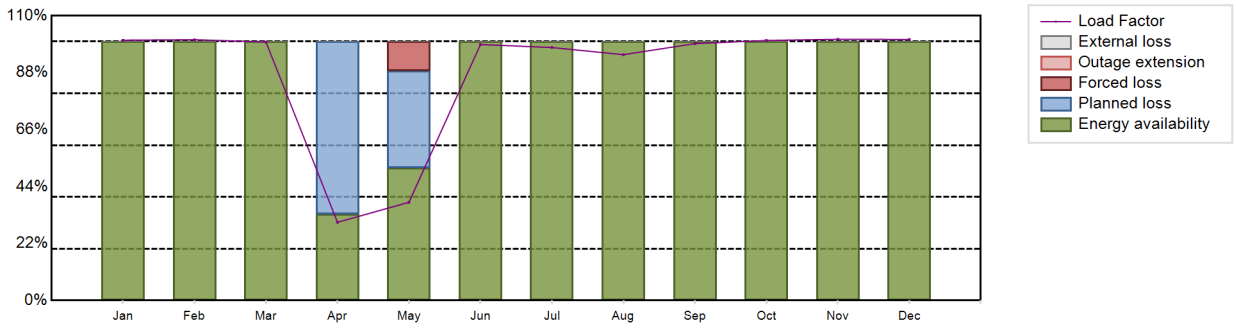
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	322
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.42
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	9003.39 GW(e).h
Energy Availability Factor (EAF)	:	90.41 %
Unit Capability Factor (UCF)	:	90.41 %
Load Factor (LF)	:	88.51 %
Operating Factor (OF)	:	90.4 %

Forced Loss Rate (FLR)	:	1.05 %
Unplanned Capability Loss Factor (UCL)	:	0.96 %
Planned Unavailability Factor (PUF)	:	8.63 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	843 hours

Annual Summary



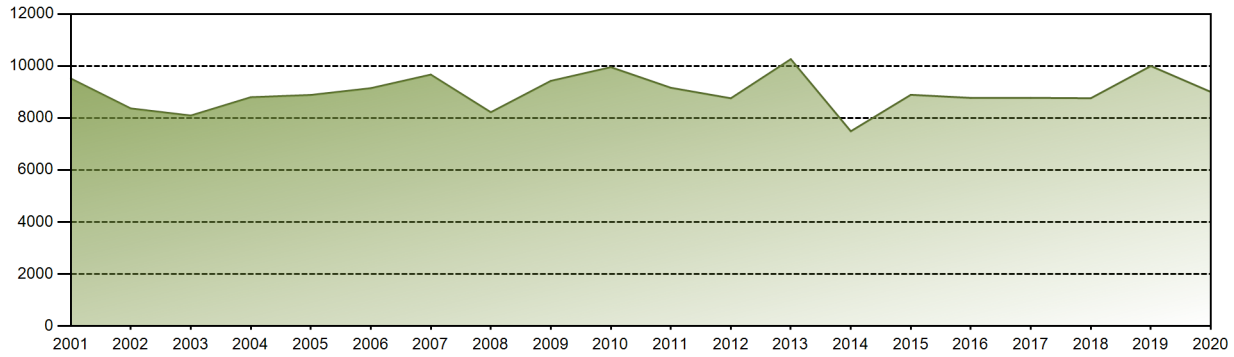
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	866.14	811.75	860.25	251.85	326.74	824.23	841.90	818.08	827.18	865.22	841.21	868.85	9003.39
EAF [%]	100.00	100.00	100.00	33.34	51.30	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.41
UCF [%]	100.00	100.00	100.00	33.34	51.30	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.41
LF [%]	100.53	100.72	99.85	30.21	37.92	98.86	97.72	94.95	99.21	100.43	100.89	100.85	88.51
OF [%]	100.00	100.00	99.87	33.33	51.34	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.40
FLR [%]	0.00	0.00	0.00	0.00	18.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
UCL [%]	0.00	0.00	0.00	0.00	11.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96
PUF [%]	0.00	0.00	0.00	66.66	37.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.63
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

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Historical Summary

Lifetime energy generation	:	378149.53 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.37 %
Cumulative Energy Availability Factor (EAF)	:	75.98 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.22 %
Cumulative Unit Capability Factor (UCF)	:	75.99 %	Cumulative Planned Unavailability Factor (PUF)	:	10.79 %
Cumulative Load Factor (LF)	:	72.9 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	75.38 %			

Electricity Production (net) [GWh]

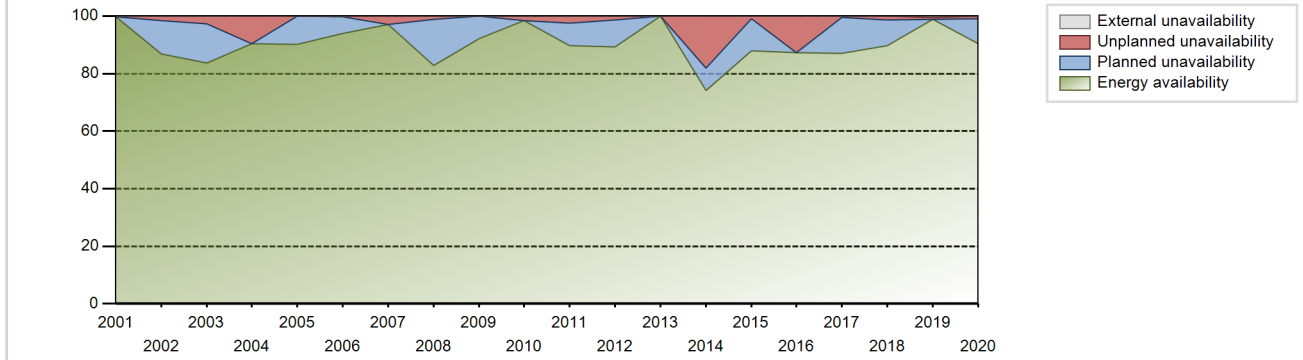


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	3009.57	3253	1105	96.27	96.27	76.89	94.59	3.73	3.73	0.00	0.00
1982	7941.70	8517	1106	97.54	97.54	81.97	97.23	2.46	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

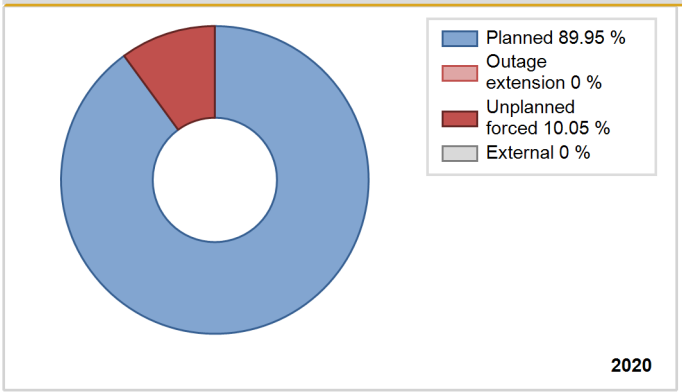
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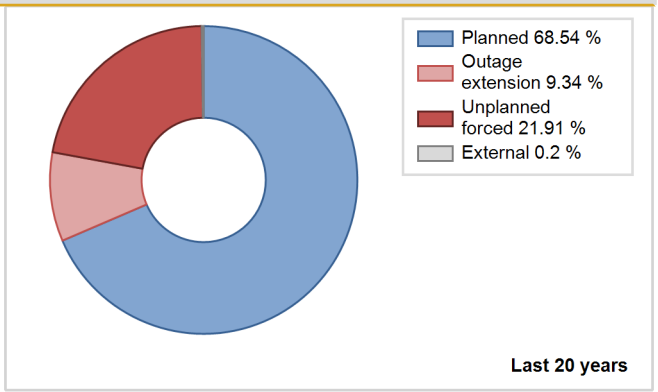
2018	8761.52	7844	1158	89.75	89.75	86.37	89.54	1.54	1.40	8.85	0.00
2019	9999.01	8649	1158	98.75	99.13	98.57	98.73	0.87	0.87	0.00	0.38
2020	9003.39	7941	1158	90.41	90.41	88.51	90.40	1.05	0.96	8.63	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					902	
B. Refuelling without maintenance	758			19		
C. Inspection, maintenance or repair combined with refuelling				848		
D. Inspection, maintenance or repair without refuelling				80		
E. Testing of plant systems or components				0	0	
H. Nuclear regulatory requirements					219	
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		85		3	22	
Subtotal	758	85		950	1149	5
Total		**843**			**2104**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		203
12. Reactor I&C Systems		47
13. Reactor Auxiliary Systems		4
14. Safety Systems		40
15. Reactor Cooling Systems		104
16. Steam generation systems		150
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		79
32. Feedwater and Main Steam System		99
33. Circulating Water System		15
34. Miscellaneous Systems		9
35. All other I&C Systems		3
41. Main Generator Systems		208
42. Electrical Power Supply Systems		164
Total		**1127**

Highlights (2020)

Refueling Outage 24 (2R24)

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2020 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	:	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 [%]	:	33.3
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

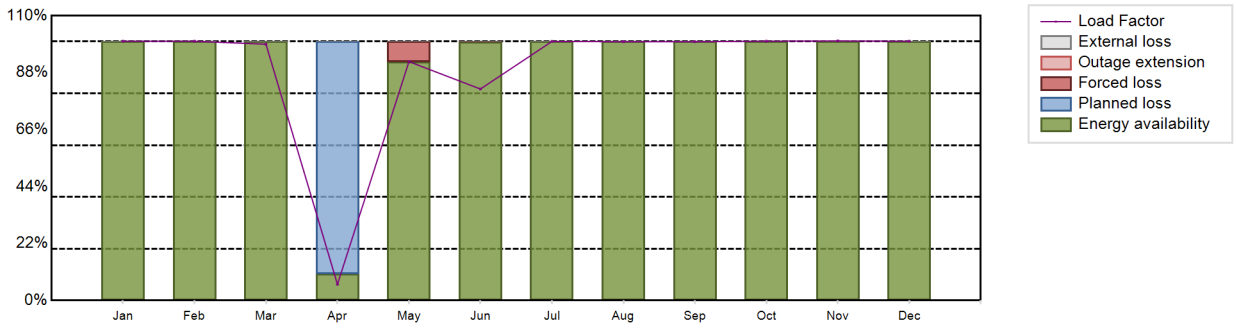
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	326
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.37
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	9865.2 GW(e).h
Energy Availability Factor (EAF)	:	91.96 %
Unit Capability Factor (UCF)	:	91.96 %
Load Factor (LF)	:	90.14 %
Operating Factor (OF)	:	90.63 %

Forced Loss Rate (FLR)	:	0.72 %
Unplanned Capability Loss Factor (UCL)	:	0.67 %
Planned Unavailability Factor (PUF)	:	7.36 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	823 hours

Annual Summary



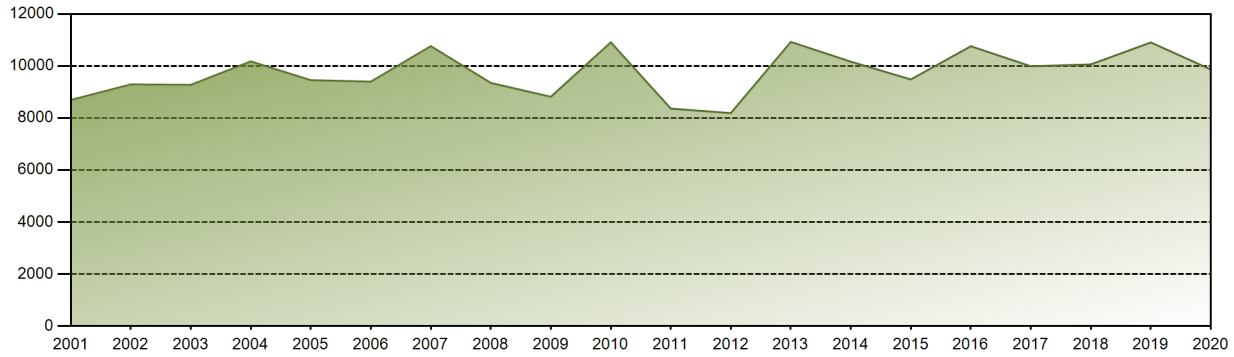
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	928.05	868.31	917.65	56.21	855.39	732.89	927.49	926.70	896.51	928.34	899.42	928.23	9865.20
EAF [%]	100.00	100.00	100.00	10.16	92.21	99.86	100.00	100.00	100.00	100.00	100.00	100.00	91.96
UCF [%]	100.00	100.00	100.00	10.16	92.21	99.86	100.00	100.00	100.00	100.00	100.00	100.00	91.96
LF [%]	100.11	100.13	98.99	6.27	92.27	81.69	100.05	99.97	99.93	100.14	100.26	100.13	90.14
OF [%]	100.00	100.00	99.87	10.14	92.20	83.75	100.00	100.00	100.00	100.00	100.00	100.00	90.63
FLR [%]	0.00	0.00	0.00	0.00	7.79	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.72
UCL [%]	0.00	0.00	0.00	0.00	7.79	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.67
PUF [%]	0.00	0.00	0.00	89.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.36
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

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Historical Summary

Lifetime energy generation	:	280516.3 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.56 %
Cumulative Energy Availability Factor (EAF)	:	88.86 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.33 %
Cumulative Unit Capability Factor (UCF)	:	88.95 %	Cumulative Planned Unavailability Factor (PUF)	:	8.72 %
Cumulative Load Factor (LF)	:	87.42 %	Cumulative Externally cause unavailability (XUF)	:	0.09 %
Cumulative Operating Factor (OF)	:	88.69 %			

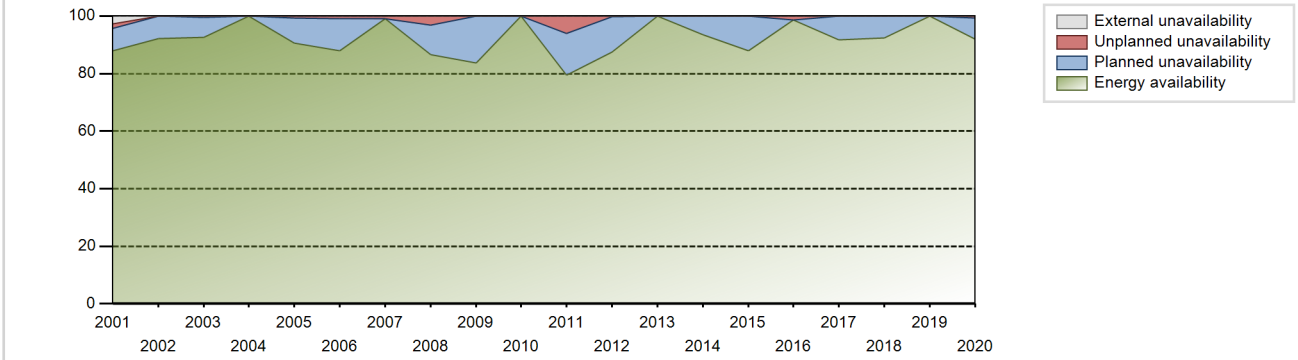
Electricity Production (net) [GWh]



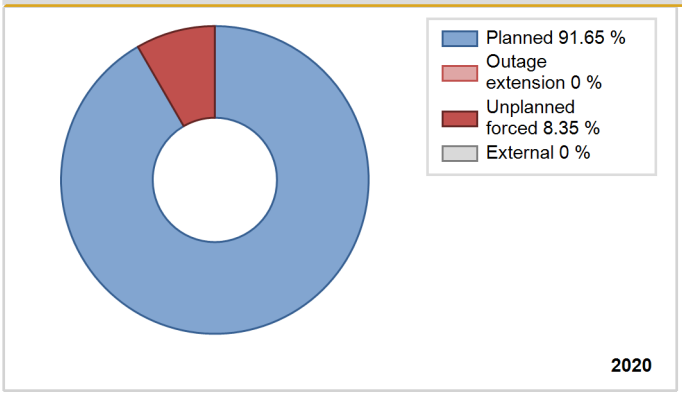
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1990	4094.00	4125	1151	84.94	84.94	82.11	84.94	15.06	15.06	0.00	0.00
1991	6814.38	6394	1150	73.00	73.00	67.64	72.99	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

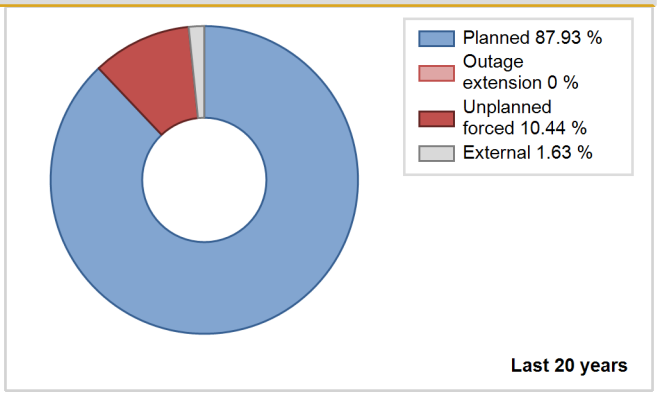
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1990 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					215	
B. Refuelling without maintenance	647			21		
C. Inspection, maintenance or repair combined with refuelling				731		
D. Inspection, maintenance or repair without refuelling				22		
E. Testing of plant systems or components				1	4	
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.)						8
Z. Other		175		0	8	
Subtotal	647	175		775	227	8
Total		**822**			**1010**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1990 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		57
15. Reactor Cooling Systems		28
16. Steam generation systems		0
17. Safety I&C Systems (excluding reactor I&C)		3
31. Turbine and auxiliaries		26
32. Feedwater and Main Steam System		30
35. All other I&C Systems		13
41. Main Generator Systems		30
42. Electrical Power Supply Systems		26
Total		**218**

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Highlights (2020)

Refueling Outage 20.

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2020 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	:	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 [%]	:	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

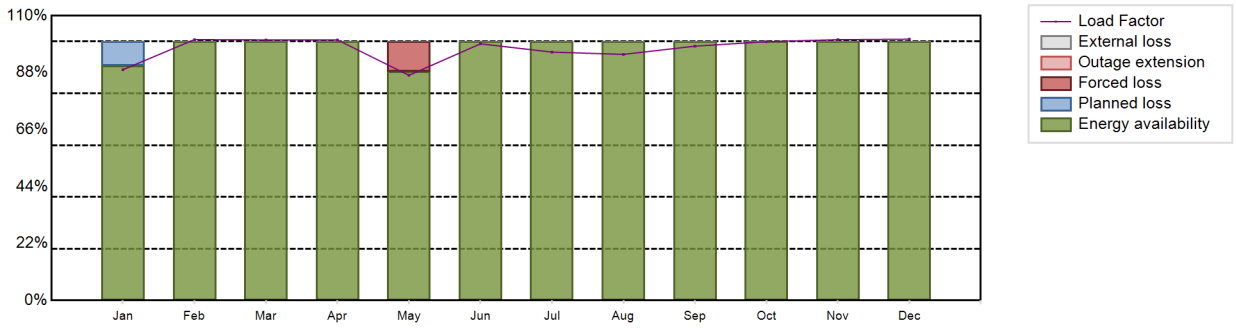
Operating coolant pressure [MPa]	:	15.82
Reactor outlet temperature [°C]	:	322.4
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	0.84
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
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	:	none

Annual Production Results (2020)

Net Energy Production	:	9846.77 GW(e).h
Energy Availability Factor (EAF)	:	98.22 %
Unit Capability Factor (UCF)	:	98.22 %
Load Factor (LF)	:	97.31 %
Operating Factor (OF)	:	98.21 %

Forced Loss Rate (FLR)	:	0.99 %
Unplanned Capability Loss Factor (UCL)	:	0.98 %
Planned Unavailability Factor (PUF)	:	0.79 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	157 hours

Annual Summary



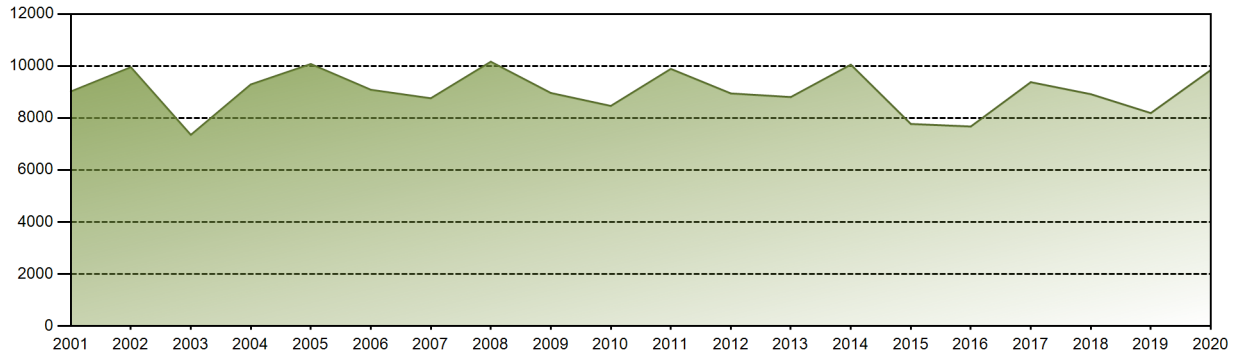
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	764.14	807.95	862.76	834.78	745.49	822.29	822.34	814.81	814.78	856.71	835.53	865.19	9846.77
EAF [%]	90.63	100.00	100.00	100.00	88.38	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.22
UCF [%]	90.63	100.00	100.00	100.00	88.38	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.22
LF [%]	89.16	100.77	100.66	100.64	86.98	99.14	95.95	95.07	98.23	99.96	100.73	100.94	97.31
OF [%]	90.59	100.00	99.87	100.00	88.44	100.00	100.00	100.00	100.00	100.00	100.00	100.00	98.21
FLR [%]	0.00	0.00	0.00	0.00	11.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99
UCL [%]	0.00	0.00	0.00	0.00	11.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98
PUF [%]	9.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79
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

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Historical Summary

Lifetime energy generation	:	343361.7 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	14.69 %
Cumulative Energy Availability Factor (EAF)	:	77.06 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	13.27 %
Cumulative Unit Capability Factor (UCF)	:	77.1 %	Cumulative Planned Unavailability Factor (PUF)	:	9.63 %
Cumulative Load Factor (LF)	:	75.11 %	Cumulative Externally cause unavailability (XUF)	:	0.04 %
Cumulative Operating Factor (OF)	:	76.79 %			

Electricity Production (net) [GWh]

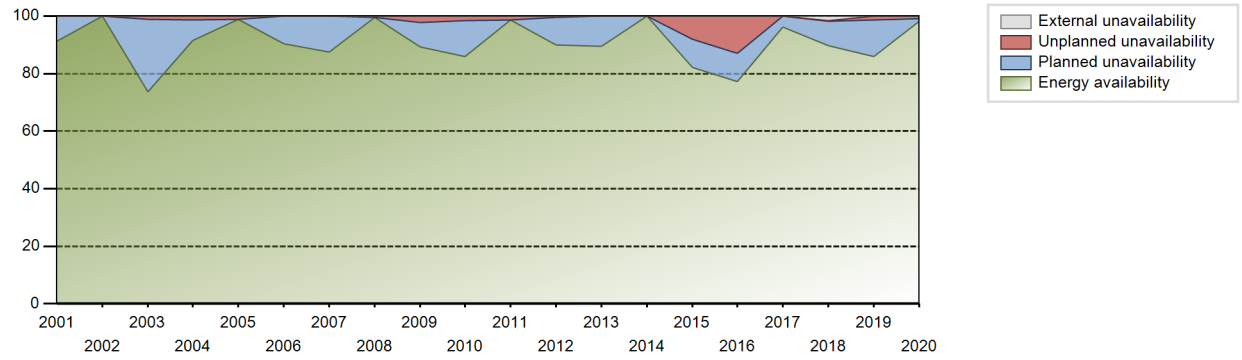


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1981	4806.21	4984	1128	62.10	62.10	50.72	60.86	17.60	13.26	24.64	0.00
1982	4909.70	4626	1128	53.36	53.36	49.69	52.81	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

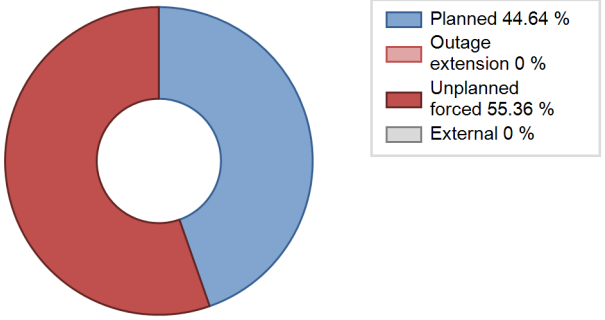
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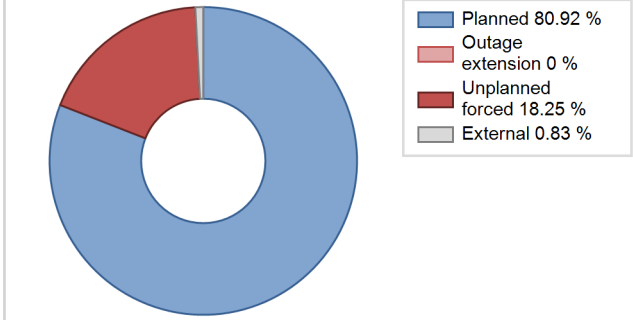
2018	8916.87	7858	1152	89.70	91.23	88.36	89.70	0.33	0.30	8.46	1.53
2019	8189.64	7523	1152	85.90	85.90	81.15	85.88	1.58	1.38	12.72	0.00
2020	9846.77	8627	1152	98.22	98.22	97.31	98.21	0.99	0.98	0.79	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1981 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					507	
C. Inspection, maintenance or repair combined with refuelling				773		
D. Inspection, maintenance or repair without refuelling	70			46		
E. Testing of plant systems or components				1		
H. Nuclear regulatory requirements					231	
J. Grid limitation, failure or grid unavailability						3
L. Human factor related					18	
P. Fire					3	
Z. Other		86		35	415	
Subtotal	70	86		855	1174	3
Total	**156**			**2032**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1981 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		18
13. Reactor Auxiliary Systems		11
14. Safety Systems		28
15. Reactor Cooling Systems		42
16. Steam generation systems		5
31. Turbine and auxiliaries		35
32. Feedwater and Main Steam System		222
34. Miscellaneous Systems		1
35. All other I&C Systems		4
41. Main Generator Systems		112
42. Electrical Power Supply Systems		30
Total		**508**

Highlights (2020)

EHC Turbine Control Maintenance

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2020 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	:	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 [%]	:	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

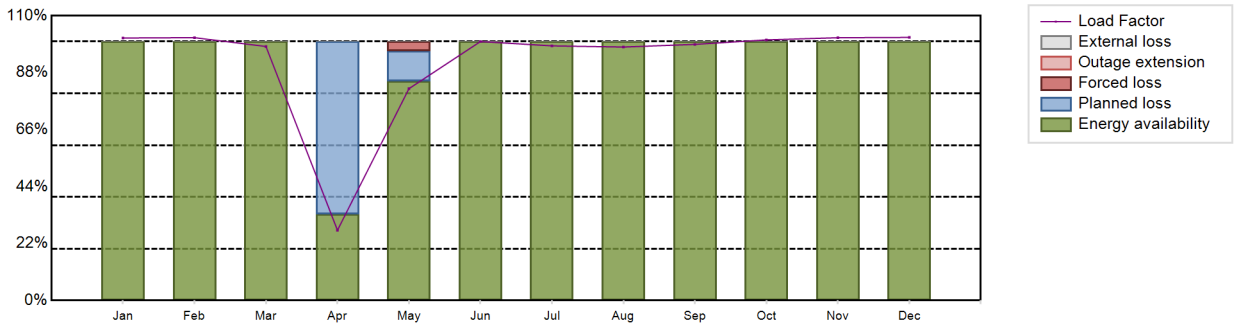
Operating coolant pressure [MPa]	:	15.82
Reactor outlet temperature [°C]	:	322.4
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	0.84
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
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	:	none

Annual Production Results (2020)

Net Energy Production	:	9252.42 GW(e).h
Energy Availability Factor (EAF)	:	93.24 %
Unit Capability Factor (UCF)	:	93.24 %
Load Factor (LF)	:	92.48 %
Operating Factor (OF)	:	93.24 %

Forced Loss Rate (FLR)	:	0.33 %
Unplanned Capability Loss Factor (UCL)	:	0.31 %
Planned Unavailability Factor (PUF)	:	6.45 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	594 hours

Annual Summary



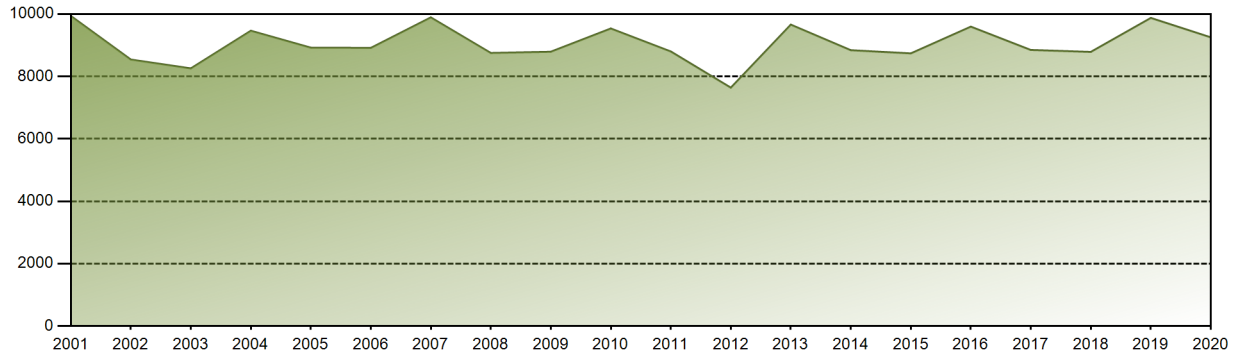
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	859.17	804.82	831.40	222.56	693.35	820.23	833.45	829.67	811.25	853.02	832.31	861.20	9252.42
EAF [%]	100.00	100.00	100.00	33.30	84.76	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.24
UCF [%]	100.00	100.00	100.00	33.30	84.76	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.24
LF [%]	101.39	101.52	98.11	27.14	81.82	100.02	98.35	97.91	98.92	100.66	101.49	101.63	92.48
OF [%]	100.00	100.00	99.87	33.33	84.81	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.24
FLR [%]	0.00	0.00	0.00	0.00	4.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
UCL [%]	0.00	0.00	0.00	0.00	3.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
PUF [%]	0.00	0.00	0.00	66.70	11.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.45
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

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Historical Summary

Lifetime energy generation	:	306250.64 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	12.32 %
Cumulative Energy Availability Factor (EAF)	:	80.4 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	11.29 %
Cumulative Unit Capability Factor (UCF)	:	80.4 %	Cumulative Planned Unavailability Factor (PUF)	:	8.31 %
Cumulative Load Factor (LF)	:	78.23 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	80.34 %			

Electricity Production (net) [GWh]

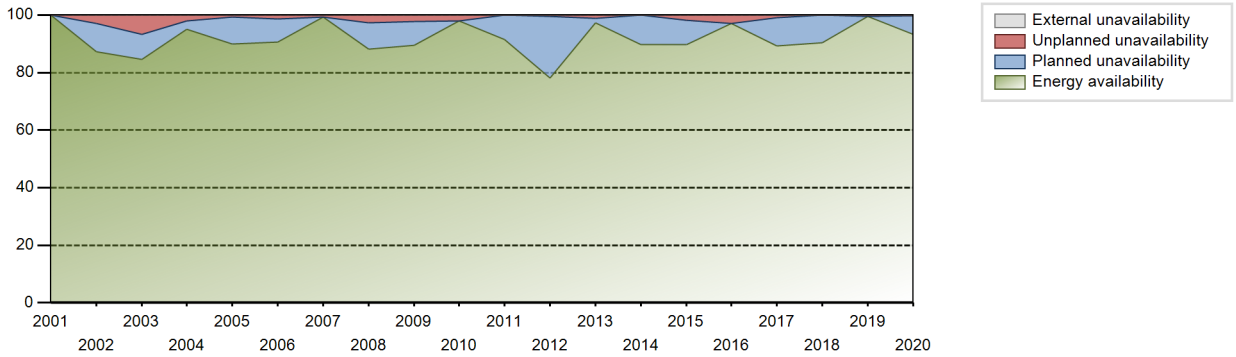


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1982	5207.56	5881	1145	75.00	75.00	66.75	74.05	17.32	15.71	9.29	0.00
1983	6691.40	6346	1133	72.76	72.76	67.42	72.44	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

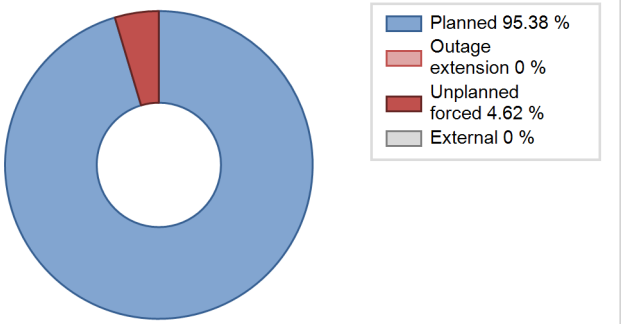
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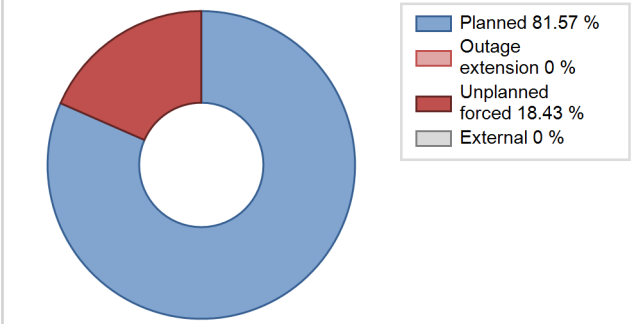
2019	9874.98	8711	1139	99.45	99.45	98.97	99.44	0.55	0.55	0.00	0.00
2020	9252.42	8190	1139	93.24	93.24	92.48	93.24	0.33	0.31	6.45	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1982 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					367	
B. Refuelling without maintenance	566			15		
C. Inspection, maintenance or repair combined with refuelling				690		
D. Inspection, maintenance or repair without refuelling				28		
E. Testing of plant systems or components				1		
H. Nuclear regulatory requirements					309	
L. Human factor related					20	
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					0	
Z. Other		27			291	
Subtotal	566	27		734	987	
Total	**593**			**1721**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1982 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		1
12. Reactor I&C Systems		6
13. Reactor Auxiliary Systems		6
14. Safety Systems		1
15. Reactor Cooling Systems		37
16. Steam generation systems		19
17. Safety I&C Systems (excluding reactor I&C)		1
31. Turbine and auxiliaries		28
32. Feedwater and Main Steam System		46
34. Miscellaneous Systems		2
35. All other I&C Systems		2
41. Main Generator Systems		198
42. Electrical Power Supply Systems		19
Total		**366**

Highlights (2020)

Refueling Outage 23

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2020 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	:	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]	:	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

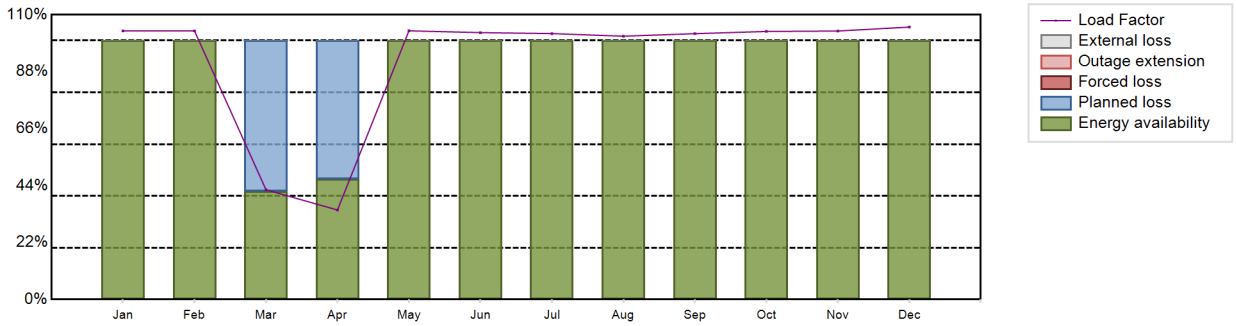
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	330
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.397
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	10409.82 GW(e).h
Energy Availability Factor (EAF)	:	90.69 %
Unit Capability Factor (UCF)	:	90.69 %
Load Factor (LF)	:	92.59 %
Operating Factor (OF)	:	90.68 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	9.31 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	819 hours

Annual Summary



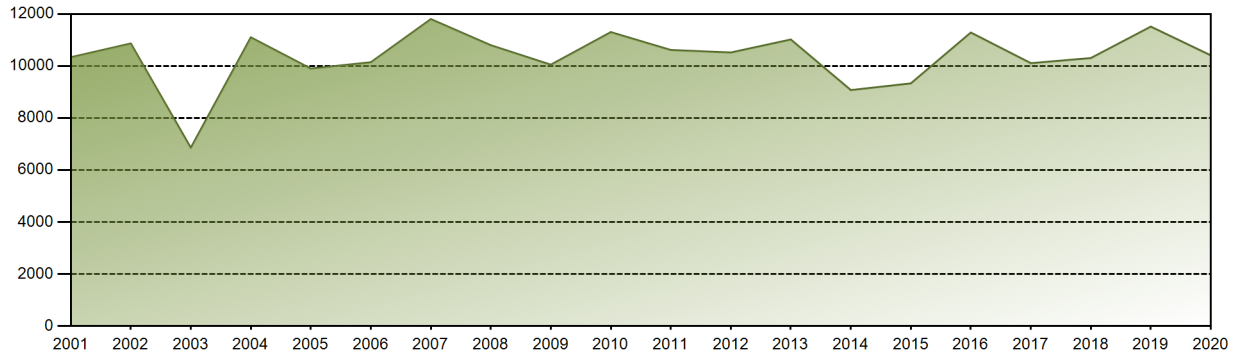
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	988.11	924.40	403.84	318.64	988.26	950.01	978.11	968.47	946.23	985.99	955.75	1002.02	10409.82
EAF [%]	100.00	100.00	41.80	46.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.69
UCF [%]	100.00	100.00	41.80	46.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.69
LF [%]	103.76	103.76	42.41	34.57	103.77	103.08	102.71	101.70	102.67	103.54	103.71	105.22	92.59
OF [%]	100.00	100.00	41.67	46.53	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	90.68
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	58.20	53.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.31
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

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Historical Summary

Lifetime energy generation	:	293660.92 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.96 %
Cumulative Energy Availability Factor (EAF)	:	84.36 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.31 %
Cumulative Unit Capability Factor (UCF)	:	84.36 %	Cumulative Planned Unavailability Factor (PUF)	:	9.33 %
Cumulative Load Factor (LF)	:	84.89 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	84.24 %			

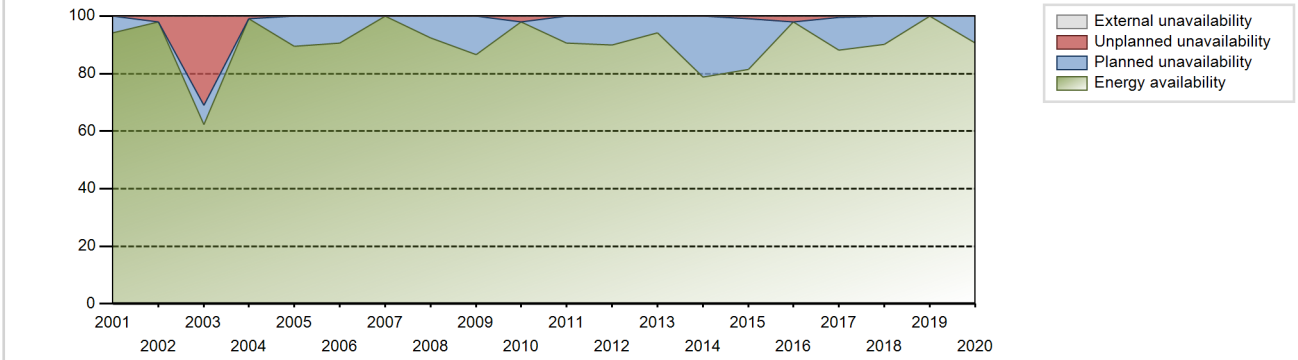
Electricity Production (net) [GWh]



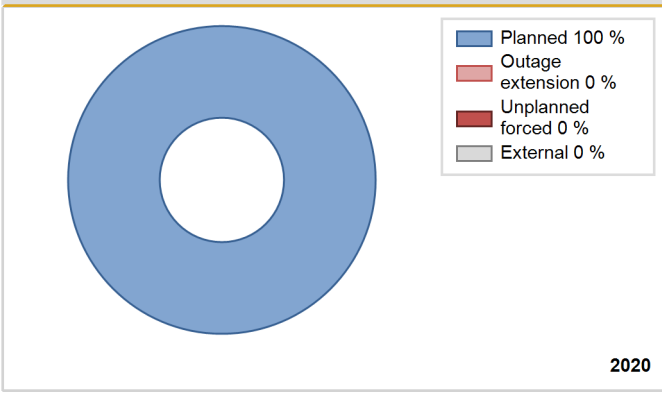
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1988	2791.49	2404	1250	80.04	80.04	74.87	79.55	7.84	6.81	13.15	0.00
1989	6307.67	5524	1250	63.09	63.09	57.60	63.06	8.17	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

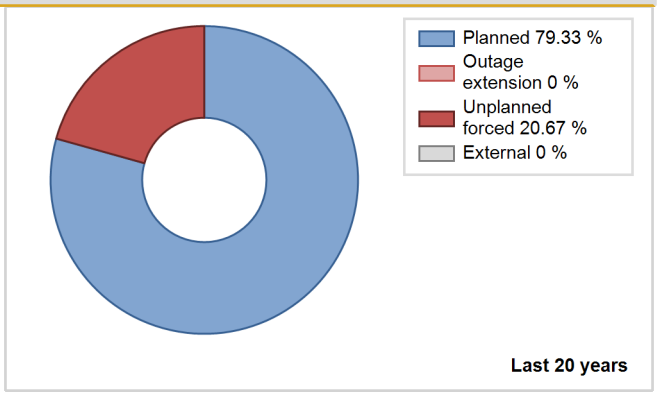
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1988 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					508	
B. Refuelling without maintenance	818			25		
C. Inspection, maintenance or repair combined with refuelling				726		
D. Inspection, maintenance or repair without refuelling				65	30	
E. Testing of plant systems or components				4		
H. Nuclear regulatory requirements					12	
L. Human factor related					12	
Z. Other				0		
Subtotal	818			820	562	
Total	**818**			**1382**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1988 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		3
12. Reactor I&C Systems		5
13. Reactor Auxiliary Systems		6
14. Safety Systems		291
15. Reactor Cooling Systems		8
17. Safety I&C Systems (excluding reactor I&C)		99
31. Turbine and auxiliaries		15
32. Feedwater and Main Steam System		17
34. Miscellaneous Systems		1
35. All other I&C Systems		5
41. Main Generator Systems		54
42. Electrical Power Supply Systems		4
Total		**508**

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Highlights (2020)

Refueling Outage 22 (1RE22)

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2020 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	:	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]	:	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

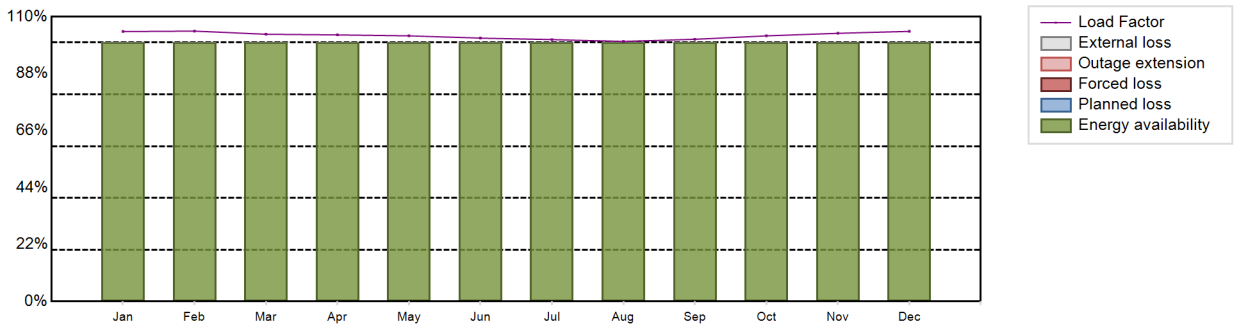
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	330
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.397
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	11548.94 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	102.72 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



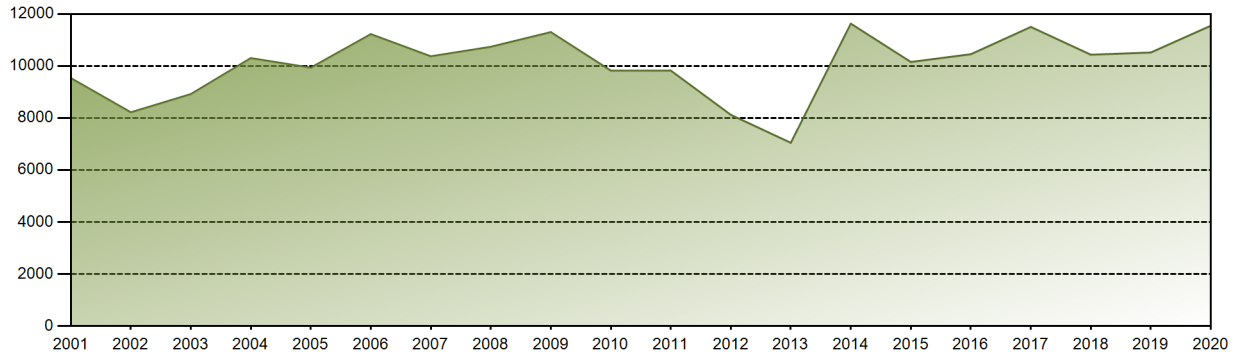
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	993.02	930.50	983.01	948.97	977.15	937.51	963.39	956.56	933.39	977.05	954.76	993.63	11548.94
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	104.27	104.45	103.22	102.97	102.61	101.73	101.16	100.45	101.28	102.60	103.60	104.34	102.72
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	297025.52 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	7.06 %
Cumulative Energy Availability Factor (EAF)	:	84.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	6.4 %
Cumulative Unit Capability Factor (UCF)	:	84.28 %	Cumulative Planned Unavailability Factor (PUF)	:	9.32 %
Cumulative Load Factor (LF)	:	84.61 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	84.22 %			

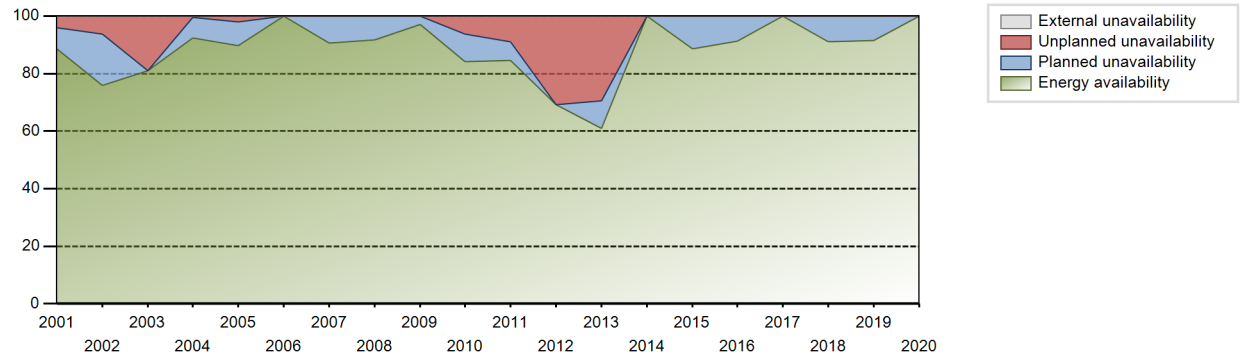
Electricity Production (net) [GWh]



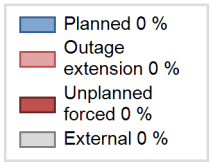
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	3026.67	2845	1250	57.92	57.92	48.32	57.89	22.68	16.99	25.09	0.00
1990	6452.17	5494	1251	62.76	62.76	58.88	62.72	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

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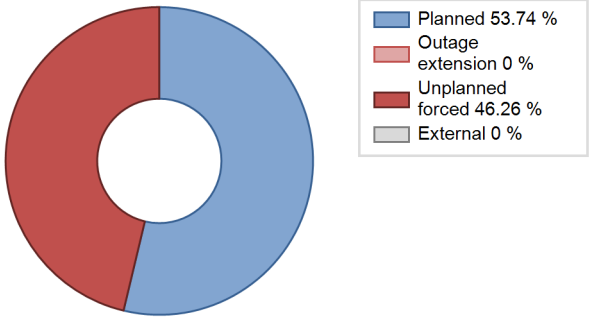
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					550	
C. Inspection, maintenance or repair combined with refuelling				759		
D. Inspection, maintenance or repair without refuelling				60		
E. Testing of plant systems or components				2		
H. Nuclear regulatory requirements					2	
L. Human factor related					6	
Z. Other					5	
Subtotal				821	563	
Total		**0**			**1384**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		4
13. Reactor Auxiliary Systems		7
14. Safety Systems		130
15. Reactor Cooling Systems		6
16. Steam generation systems		10
17. Safety I&C Systems (excluding reactor I&C)		5
31. Turbine and auxiliaries		73
32. Feedwater and Main Steam System		34
33. Circulating Water System		1
34. Miscellaneous Systems		10
35. All other I&C Systems		6
41. Main Generator Systems		138
42. Electrical Power Supply Systems		124
Total		**548**

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2020 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

Reactor type and model	:	PWR / CE 2LP (DRYAMB)
Thermal power	:	3020 MWth
Gross electrical power	:	1045 MWe
Reference unit power (net)	:	981 MWe

Key Dates

Construction Date	:	1970-07-01
Grid Date	:	1976-05-07
Commercial Date	:	1976-12-21
Age at end of year	:	44 years

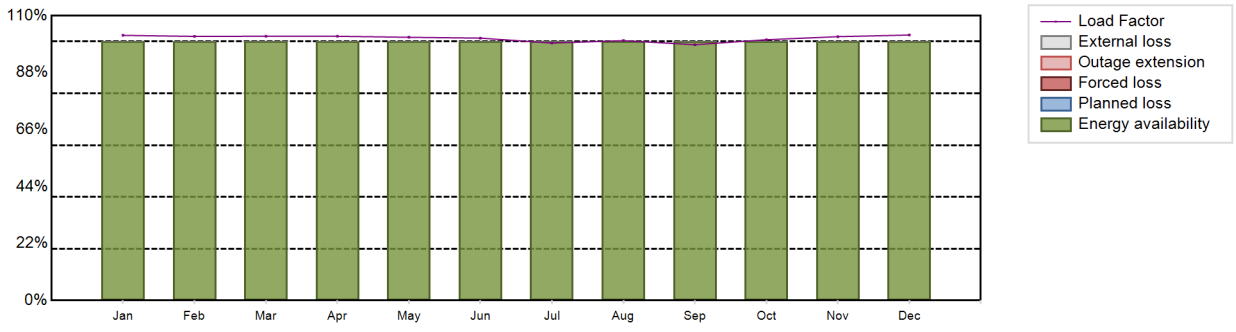
Design Characteristics

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 (2020)

Net Energy Production	:	8726.84 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)	:	101.27 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	99.99 %	Total off-line time	:	1 hours

Annual Summary



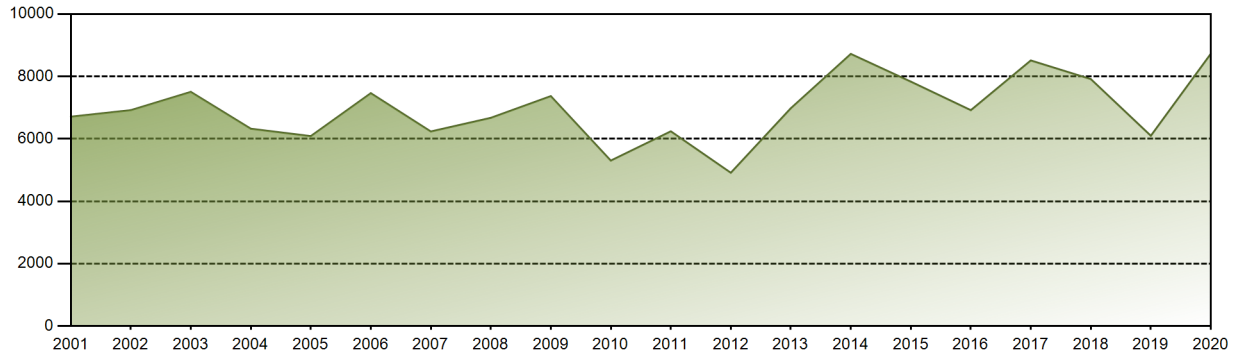
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	747.53	696.47	744.82	720.77	742.08	715.81	725.79	732.52	697.79	735.15	719.76	748.35	8726.84
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	102.42	102.01	102.05	102.05	101.67	101.34	99.44	100.36	98.79	100.72	101.90	102.53	101.27
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	308662.38 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.02 %
Cumulative Energy Availability Factor (EAF)	:	83.45 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.5 %
Cumulative Unit Capability Factor (UCF)	:	83.65 %	Cumulative Planned Unavailability Factor (PUF)	:	12.85 %
Cumulative Load Factor (LF)	:	83.21 %	Cumulative Externally cause unavailability (XUF)	:	0.2 %
Cumulative Operating Factor (OF)	:	83.39 %			

Electricity Production (net) [GWh]

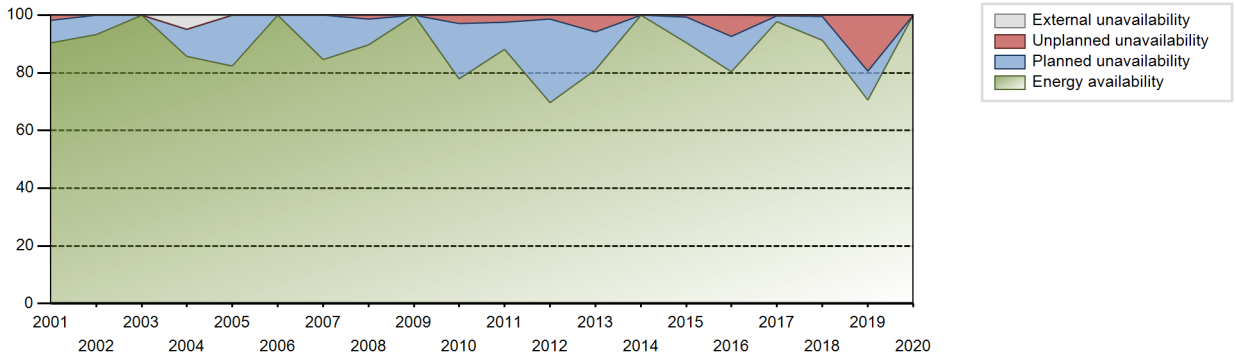


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1976	317.20	919	814	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1977	5343.70	7414	779	78.39	78.39	78.31	84.63	16.10	15.04	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

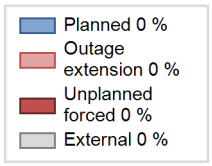
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2013	6980.44	7104	982	81.09	81.09	81.14	81.09	6.68	5.80	13.11	0.00
2014	8721.17	8760	982	100.00	100.00	101.38	100.00	0.00	0.00	0.00	0.00
2015	7833.25	7927	982	90.48	90.48	91.06	90.49	0.65	0.59	8.92	0.00
2016	6918.93	7059	982	80.36	80.36	80.21	80.36	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

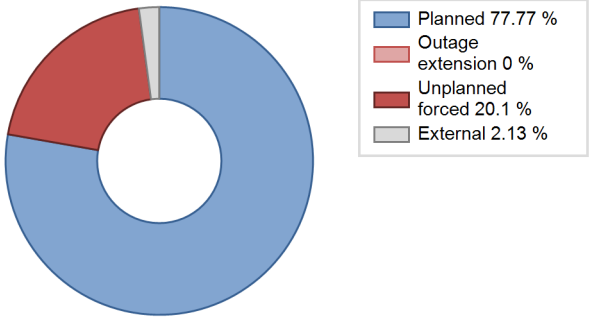
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1976 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					356	
C. Inspection, maintenance or repair combined with refuelling				1052		
D. Inspection, maintenance or repair without refuelling				77		
E. Testing of plant systems or components				3		
L. Human factor related					19	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						23
Z. Other				0	3	
Subtotal				1132	378	23
Total		**0**			**1533**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1976 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		109
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		11
14. Safety Systems		12
15. Reactor Cooling Systems		107
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		22
33. Circulating Water System		6
34. Miscellaneous Systems		13
41. Main Generator Systems		47
42. Electrical Power Supply Systems		20
Total		**376**

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2020 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

Reactor type and model	:	PWR / CE 2LP (DRYAMB)
Thermal power	:	3020 MWth
Gross electrical power	:	1050 MWe
Reference unit power (net)	:	987 MWe

Key Dates

Construction Date	:	1977-06-02
Grid Date	:	1983-06-13
Commercial Date	:	1983-08-08
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 [%]	:	35
Average discharge burnup [MWd/t]	:	36000
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]	:	14.5
Number of control rod assemblies	:	91
Number of external reactor coolant loops	:	2
Coolant type	:	H2O

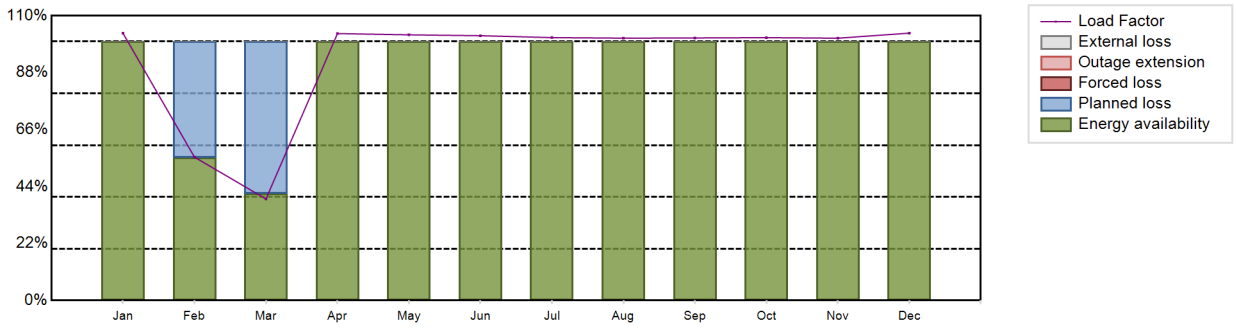
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	314
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.31
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	8073.53 GW(e).h
Energy Availability Factor (EAF)	:	91.48 %
Unit Capability Factor (UCF)	:	91.48 %
Load Factor (LF)	:	93.12 %
Operating Factor (OF)	:	91.47 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.52 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	749 hours

Annual Summary



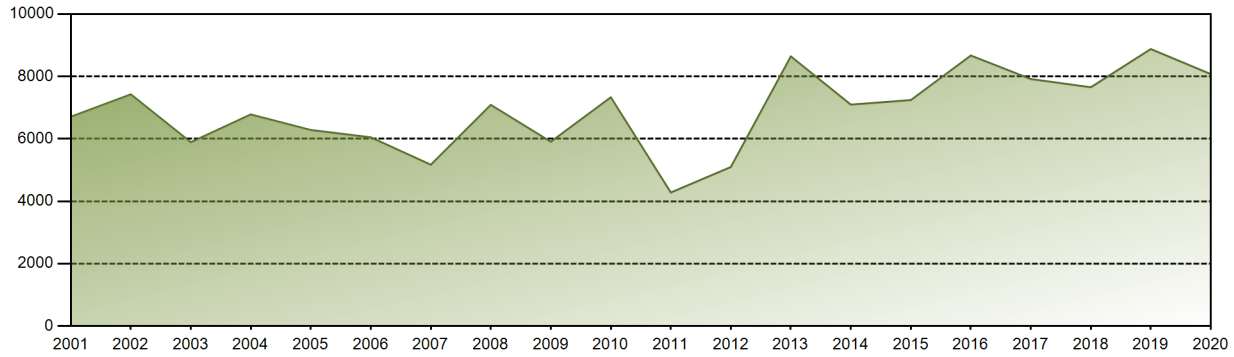
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	757.93	380.45	288.00	732.59	753.54	726.80	745.67	744.04	720.60	745.59	719.96	758.36	8073.53
EAF [%]	100.00	55.17	41.36	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.48
UCF [%]	100.00	55.17	41.36	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.48
LF [%]	103.21	55.38	39.22	103.09	102.62	102.27	101.54	101.32	101.40	101.53	101.31	103.27	93.12
OF [%]	100.00	55.17	41.26	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	91.47
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	44.83	58.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.52
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

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Historical Summary

Lifetime energy generation	:	188540.34 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.47 %
Cumulative Energy Availability Factor (EAF)	:	86.46 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.27 %
Cumulative Unit Capability Factor (UCF)	:	86.82 %	Cumulative Planned Unavailability Factor (PUF)	:	9.91 %
Cumulative Load Factor (LF)	:	86.16 %	Cumulative Externally cause unavailability (XUF)	:	0.36 %
Cumulative Operating Factor (OF)	:	86.27 %			

Electricity Production (net) [GWh]

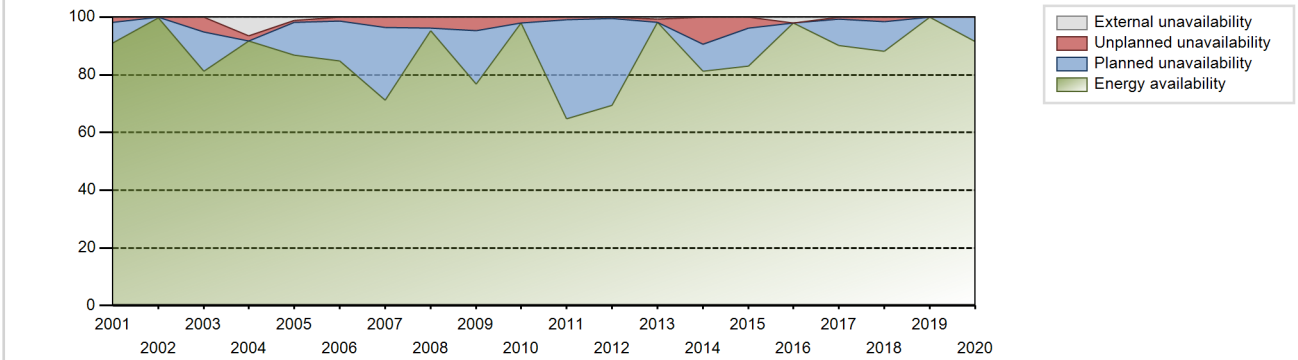


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	2575.80	3598	808	89.40	89.40	87.03	89.27	10.60	10.60	0.00	0.00
1984	5564.83	7067	786	79.49	82.85	80.60	80.45	6.88	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

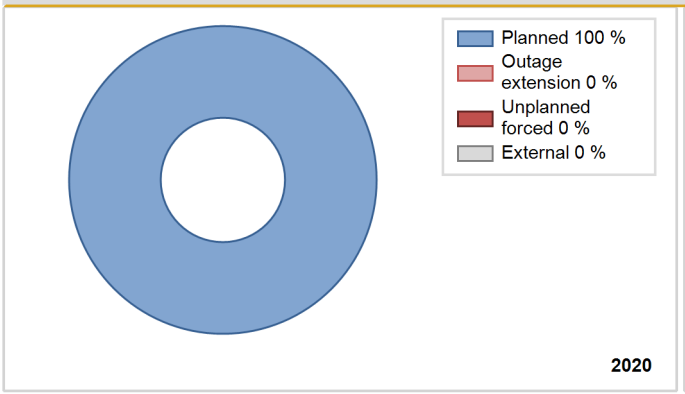
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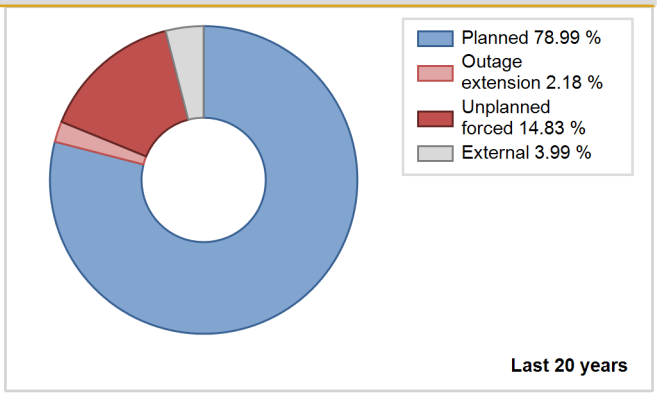
2020	8073.53	8035	987	91.48	91.48	93.12	91.47	0.00	0.00	8.52	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1983 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					260	
B.	Refuelling without maintenance	748			20		
C.	Inspection, maintenance or repair combined with refuelling				841		
D.	Inspection, maintenance or repair without refuelling				35		
E.	Testing of plant systems or components				1	0	
H.	Nuclear regulatory requirements					7	
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.)						33
P.	Fire					2	
Z.	Other				0	11	
Subtotal		748			897	288	33
Total			**748**			**1218**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		0
12. Reactor I&C Systems		29
14. Safety Systems		22
15. Reactor Cooling Systems		105
16. Steam generation systems		19
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		37
32. Feedwater and Main Steam System		47
33. Circulating Water System		8
34. Miscellaneous Systems		4
41. Main Generator Systems		11
42. Electrical Power Supply Systems		5
Total		**289**

Highlights (2020)

Refueling Outage 25

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2020 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	:	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 [%]	:	43.3
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

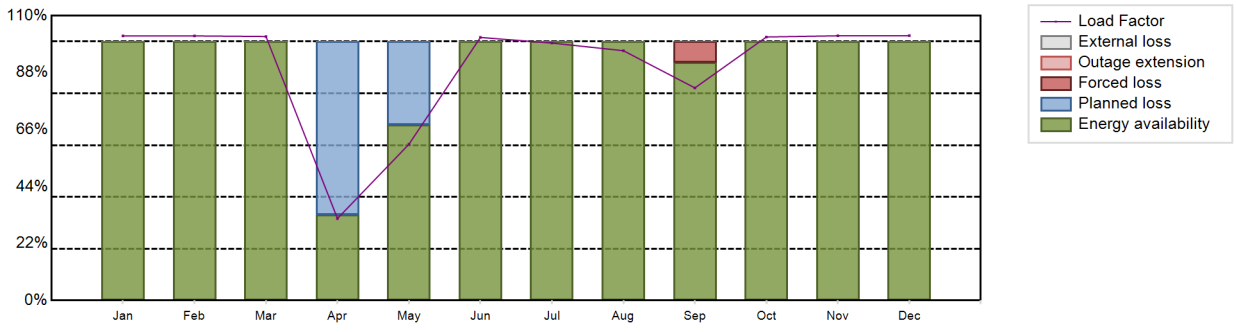
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	327
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.4
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7727.52 GW(e).h
Energy Availability Factor (EAF)	:	91.11 %
Unit Capability Factor (UCF)	:	91.11 %
Load Factor (LF)	:	90.41 %
Operating Factor (OF)	:	91.1 %

Forced Loss Rate (FLR)	:	0.73 %
Unplanned Capability Loss Factor (UCL)	:	0.67 %
Planned Unavailability Factor (PUF)	:	8.22 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	782 hours

Annual Summary



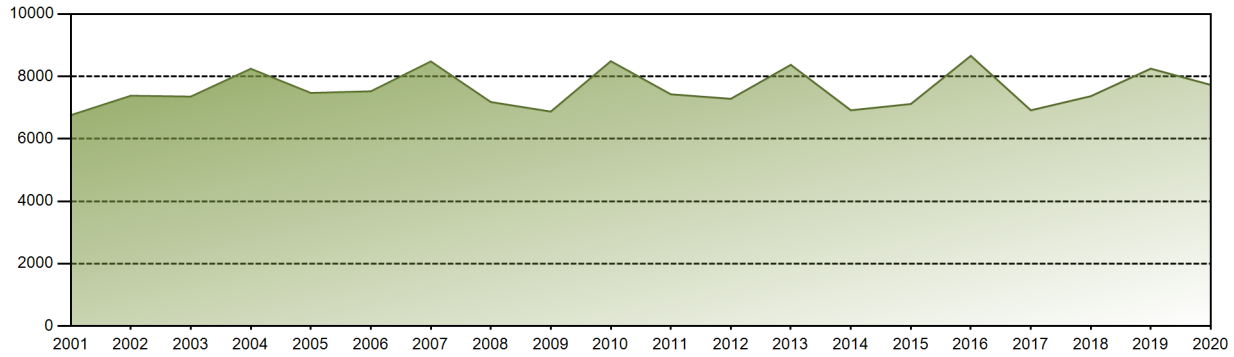
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	739.62	692.04	738.14	221.85	436.99	711.80	719.80	698.50	575.28	736.73	716.32	740.45	7727.52
EAF [%]	100.00	100.00	100.00	33.05	67.80	100.00	100.00	100.00	91.80	100.00	100.00	100.00	91.11
UCF [%]	100.00	100.00	100.00	33.05	67.80	100.00	100.00	100.00	91.80	100.00	100.00	100.00	91.11
LF [%]	102.17	102.19	101.97	31.67	60.37	101.60	99.43	96.49	82.12	101.77	102.25	102.28	90.41
OF [%]	100.00	100.00	99.87	33.06	67.74	100.00	100.00	100.00	91.81	100.00	100.00	100.00	91.10
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.20	0.00	0.00	0.00	0.73
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.20	0.00	0.00	0.00	0.67
PUF [%]	0.00	0.00	0.00	66.95	32.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.22
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

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Historical Summary

Lifetime energy generation	:	489464.19 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.28 %
Cumulative Energy Availability Factor (EAF)	:	86.07 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.01 %
Cumulative Unit Capability Factor (UCF)	:	86.07 %	Cumulative Planned Unavailability Factor (PUF)	:	11.92 %
Cumulative Load Factor (LF)	:	84.51 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	85.85 %			

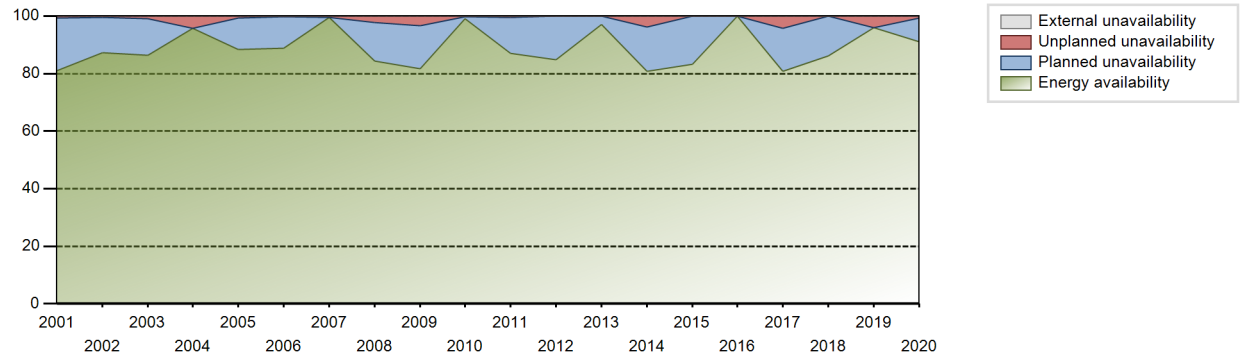
Electricity Production (net) [GWh]



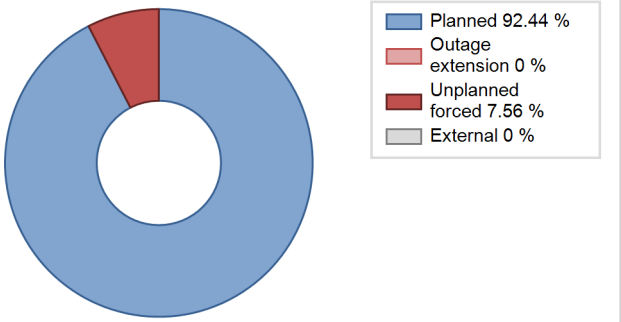
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1984	4208.59	5362	900	61.26	61.26	53.24	61.04	10.76	7.38	31.36	0.00
1985	5235.09	6272	885	71.64	71.64	67.53	71.60	6.13	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

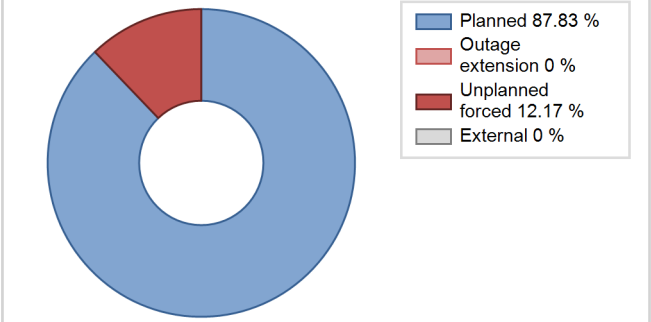
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1984 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					136	
B. Refuelling without maintenance	722			20		
C. Inspection, maintenance or repair combined with refuelling				964		
D. Inspection, maintenance or repair without refuelling				131		
E. Testing of plant systems or components				2	0	
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.)						1
S. Fuel management limitation (including high flux tilt, stretch out or coast-down operation)					1	
Z. Other		59			27	
Subtotal	722	59		1117	172	1
Total		**781**			**1290**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1984 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		5
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems		8
14. Safety Systems		4
15. Reactor Cooling Systems		27
16. Steam generation systems		18
31. Turbine and auxiliaries		9
32. Feedwater and Main Steam System		14
34. Miscellaneous Systems		1
35. All other I&C Systems		1
41. Main Generator Systems		19
42. Electrical Power Supply Systems		16
Total		**138**

Highlights (2020)

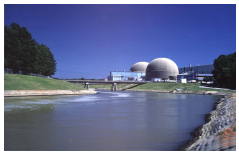
Refueling Outage 25.

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2020 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	:	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 [%]	:	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

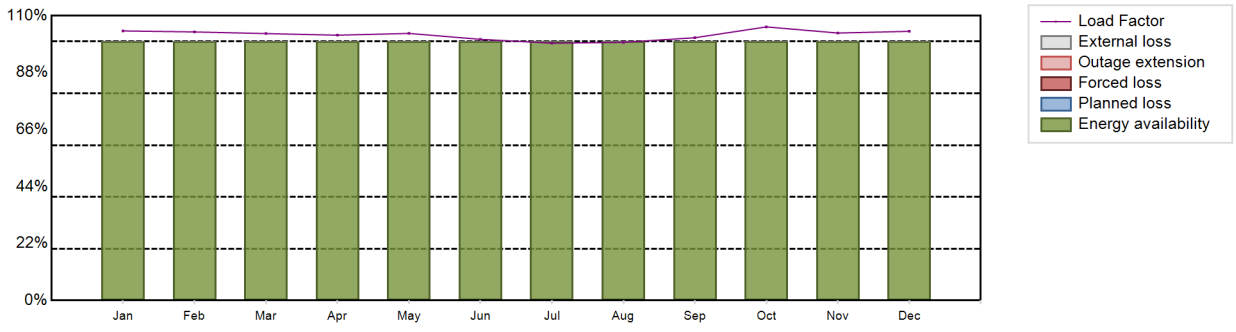
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	318
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.422
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	7551.07 GW(e).h
Energy Availability Factor (EAF)	:	100 %
Unit Capability Factor (UCF)	:	100 %
Load Factor (LF)	:	102.58 %
Operating Factor (OF)	:	99.99 %

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	:	1 hours

Annual Summary



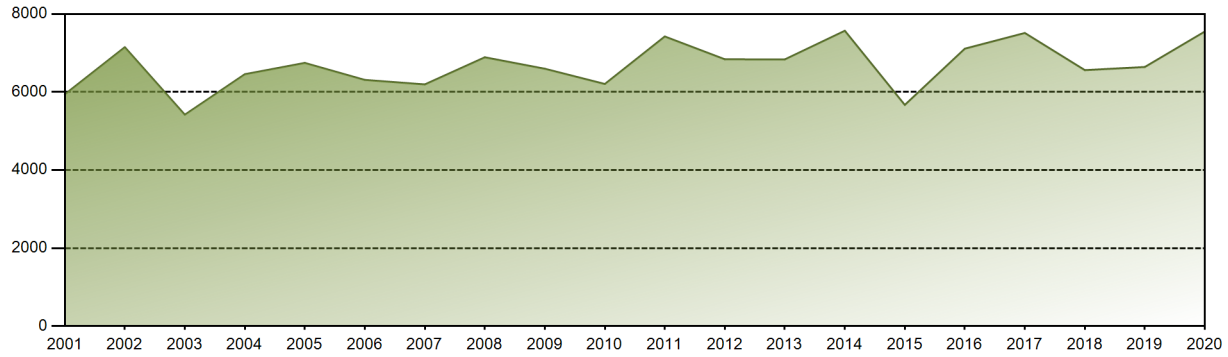
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	649.12	604.98	642.76	618.34	643.12	608.69	619.65	621.71	612.40	658.80	623.33	648.17	7551.07
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
LF [%]	104.11	103.73	103.09	102.48	103.15	100.88	99.39	99.72	101.50	105.67	103.31	103.96	102.58
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99
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	0.00	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

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Historical Summary

Lifetime energy generation	:	268417.91 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	8.71 %
Cumulative Energy Availability Factor (EAF)	:	79.27 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	7.56 %
Cumulative Unit Capability Factor (UCF)	:	79.31 %	Cumulative Planned Unavailability Factor (PUF)	:	13.13 %
Cumulative Load Factor (LF)	:	78.5 %	Cumulative Externally cause unavailability (XUF)	:	0.04 %
Cumulative Operating Factor (OF)	:	79.84 %			

Electricity Production (net) [GWh]

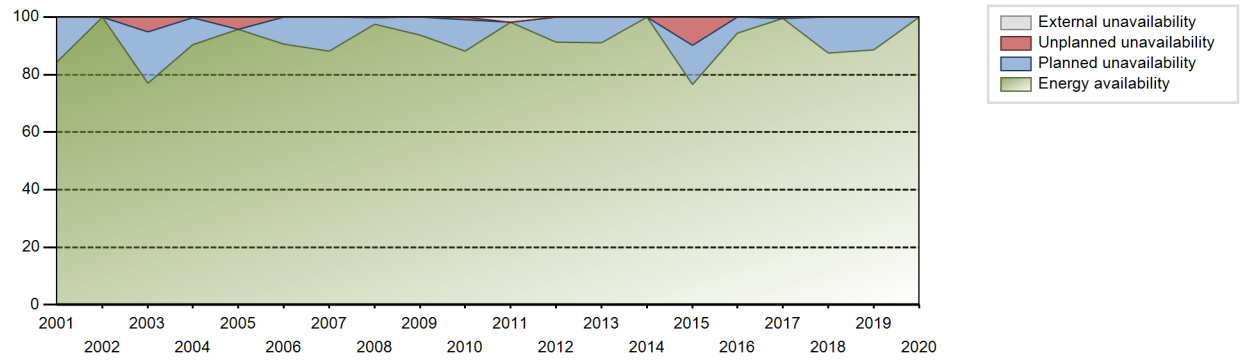


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1972	407.60	1048	794	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	3479.70	5377	788	61.88	61.88	50.41	61.38	27.15	23.06	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

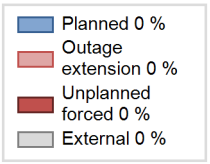
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2009	6597.35	8214	799	93.78	93.78	94.26	93.77	0.00	0.00	6.22	0.00
2010	6206.40	7724	839	88.25	88.25	88.30	88.17	1.06	0.95	10.80	0.00
2011	7423.81	8590	839	98.07	100.00	101.01	98.06	0.00	0.00	0.00	1.93
2012	6839.54	8019	838	91.30	91.30	92.92	91.29	0.00	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

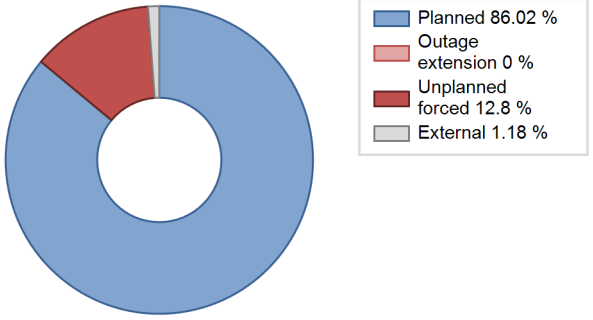
Key Factors in Last 20 Years [%]



Energy Losses by Type



2020



Last 20 years

Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1972 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					463	
C. Inspection, maintenance or repair combined with refuelling				794		
D. Inspection, maintenance or repair without refuelling				334		
E. Testing of plant systems or components				1	1	
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					154	
L. Human factor related					15	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						5
Z. Other					95	
Subtotal				1130	728	5
Total	**0**			**1863**		

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Equipment Related Unplanned Full Outages, Analysis by System

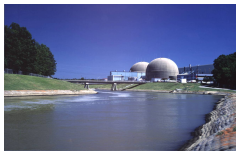
System	2020	1972 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		0
12. Reactor I&C Systems		26
13. Reactor Auxiliary Systems		5
14. Safety Systems		4
15. Reactor Cooling Systems		164
16. Steam generation systems		45
17. Safety I&C Systems (excluding reactor I&C)		2
31. Turbine and auxiliaries		18
32. Feedwater and Main Steam System		71
34. Miscellaneous Systems		39
41. Main Generator Systems		24
42. Electrical Power Supply Systems		71
Total		**469**

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2020 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	:	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 [%]	:	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

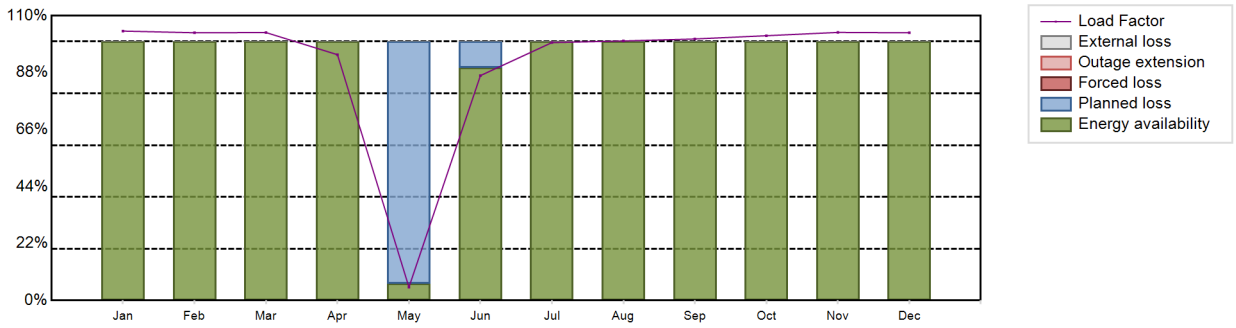
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	318
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.422
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6789.08 GW(e).h
Energy Availability Factor (EAF)	:	91.25 %
Unit Capability Factor (UCF)	:	91.25 %
Load Factor (LF)	:	92.23 %
Operating Factor (OF)	:	91.23 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	8.75 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	770 hours

Annual Summary



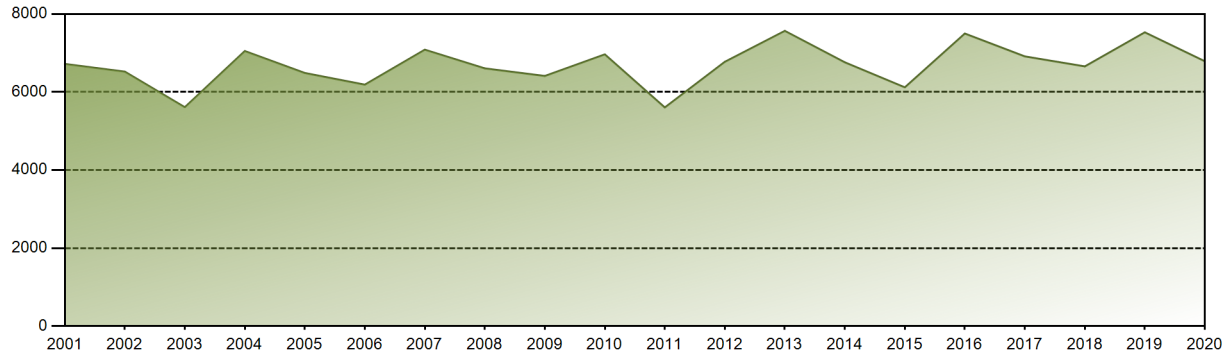
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	648.76	603.18	645.30	572.85	32.06	524.15	621.11	625.02	609.53	637.65	624.75	644.71	6789.08
EAF [%]	100.00	100.00	100.00	100.00	6.50	89.82	100.00	100.00	100.00	100.00	100.00	100.00	91.25
UCF [%]	100.00	100.00	100.00	100.00	6.50	89.82	100.00	100.00	100.00	100.00	100.00	100.00	91.25
LF [%]	104.06	103.42	103.50	94.94	5.14	86.87	99.62	100.25	101.02	102.27	103.54	103.41	92.23
OF [%]	100.00	100.00	99.87	100.00	6.45	89.86	100.00	100.00	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	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	93.50	10.18	0.00	0.00	0.00	0.00	0.00	0.00	8.75
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

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Historical Summary

Lifetime energy generation	:	268157.65 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	6.19 %
Cumulative Energy Availability Factor (EAF)	:	79.75 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	5.27 %
Cumulative Unit Capability Factor (UCF)	:	79.81 %	Cumulative Planned Unavailability Factor (PUF)	:	14.93 %
Cumulative Load Factor (LF)	:	78.74 %	Cumulative Externally cause unavailability (XUF)	:	0.06 %
Cumulative Operating Factor (OF)	:	80.01 %			

Electricity Production (net) [GWh]

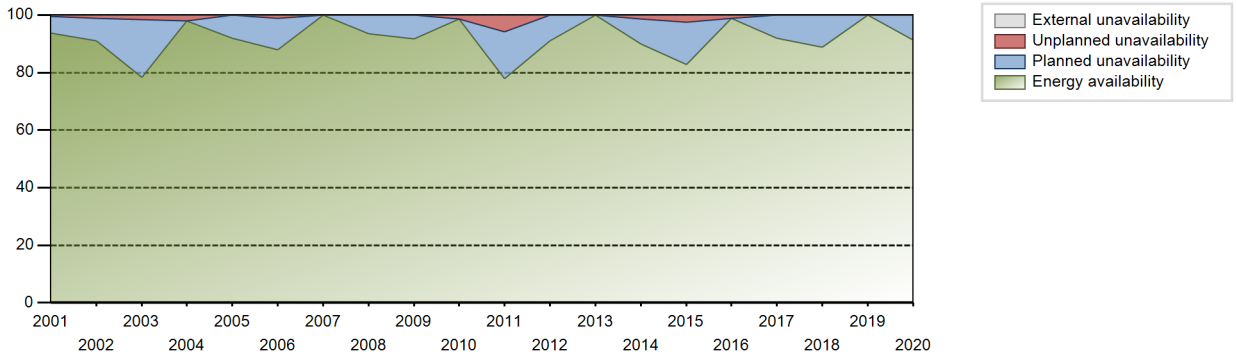


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	3377.50	5392	790	77.93	77.93	66.14	77.09	5.82	4.82	17.25	0.00
1974	2660.50	3854	788	44.00	44.00	38.54	44.00	36.59	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

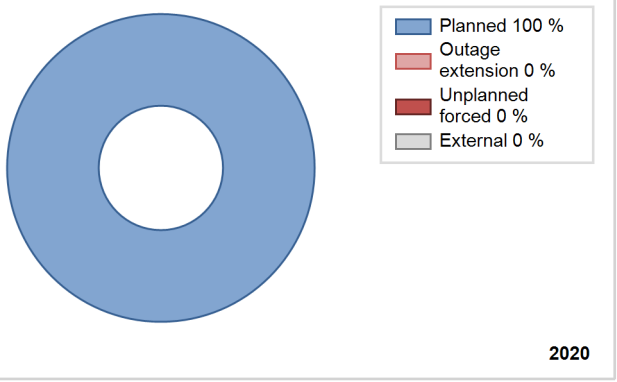
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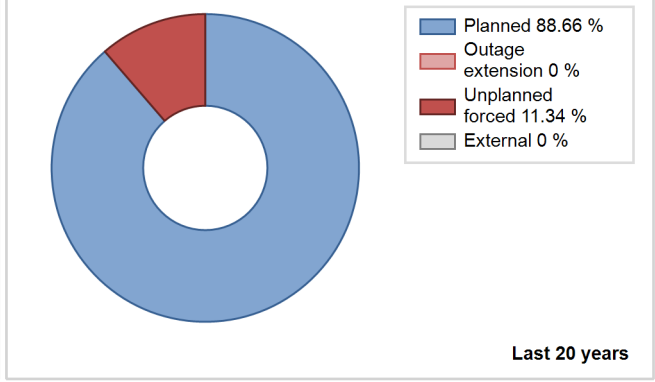
2010	6966.03	8646	799	98.70	98.70	99.53	98.70	1.30	1.30	0.00	0.00
2011	5605.67	6771	839	77.88	77.88	78.12	77.29	6.89	5.76	16.36	0.00
2012	6775.06	8001	838	91.10	91.10	92.04	91.09	0.00	0.00	8.90	0.00
2013	7568.22	8760	838	100.00	100.00	103.09	99.99	0.00	0.00	0.00	0.00
2014	6761.76	7882	838	89.96	89.96	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					438	
B. Refuelling without maintenance	769			16		
C. Inspection, maintenance or repair combined with refuelling				1088		
D. Inspection, maintenance or repair without refuelling				179		
E. Testing of plant systems or components				1		
F. Major backfitting, refurbishment or upgrading activities with refuelling				1		
H. Nuclear regulatory requirements					19	
L. Human factor related					14	
Z. Other				4	0	
Subtotal	769			1289	471	
Total	**769**			**1760**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		31
13. Reactor Auxiliary Systems		3
14. Safety Systems		52
15. Reactor Cooling Systems		25
16. Steam generation systems		104
31. Turbine and auxiliaries		90
32. Feedwater and Main Steam System		94
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		22
Total		**445**

Highlights (2020)

Refueling Outage 29. 5/3/20, Breaker open 5/3/20 0022, Breaker closed 6/4/20 0119

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 2)
Thermal power	:	3952 MWth
Gross electrical power	:	1330 MWe
Reference unit power (net)	:	1257 MWe

Key Dates

Construction Date	:	1973-11-02
Grid Date	:	1982-11-16
Commercial Date	:	1983-06-08
Age at end of year	:	38 years

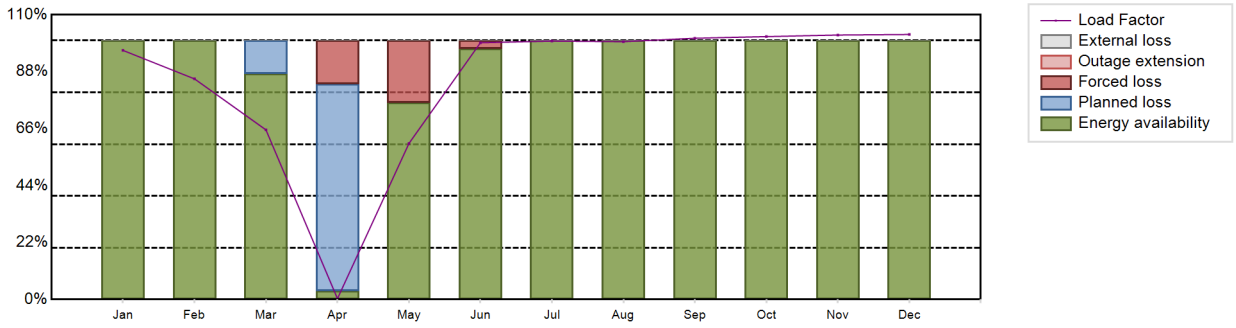
Design Characteristics

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 (2020)

Net Energy Production	:	9332.24 GW(e).h	Forced Loss Rate (FLR)	:	3.97 %
Energy Availability Factor (EAF)	:	88.69 %	Unplanned Capability Loss Factor (UCL)	:	3.67 %
Unit Capability Factor (UCF)	:	88.69 %	Planned Unavailability Factor (PUF)	:	7.64 %
Load Factor (LF)	:	84.52 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	88.68 %	Total off-line time	:	994 hours

Annual Summary



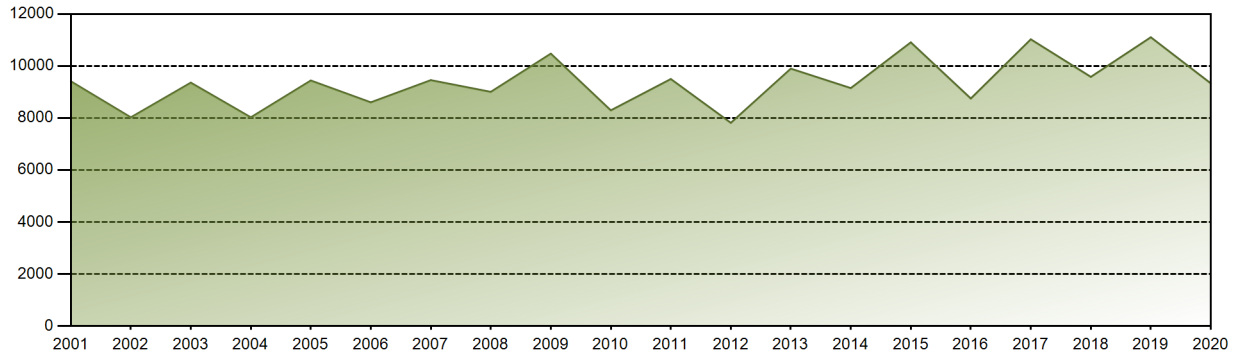
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	899.82	745.58	612.76	3.06	563.72	897.54	933.62	931.45	913.26	949.66	924.48	957.28	9332.24
EAF [%]	100.00	100.00	87.21	3.29	75.98	96.78	100.00	100.00	100.00	100.00	100.00	100.00	88.69
UCF [%]	100.00	100.00	87.21	3.29	75.98	96.78	100.00	100.00	100.00	100.00	100.00	100.00	88.69
LF [%]	96.22	85.22	65.52	0.34	60.28	99.17	99.83	99.60	100.91	101.55	102.15	102.36	84.52
OF [%]	100.00	100.00	87.10	3.33	72.85	100.00	100.00	100.00	100.00	100.00	100.00	100.00	88.68
FLR [%]	0.00	0.00	0.00	83.56	24.02	3.22	0.00	0.00	0.00	0.00	0.00	0.00	3.97
UCL [%]	0.00	0.00	0.00	16.73	24.02	3.22	0.00	0.00	0.00	0.00	0.00	0.00	3.67
PUF [%]	0.00	0.00	12.79	79.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.64
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

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Historical Summary

Lifetime energy generation	:	333133.09 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.63 %
Cumulative Energy Availability Factor (EAF)	:	85.46 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.36 %
Cumulative Unit Capability Factor (UCF)	:	85.52 %	Cumulative Planned Unavailability Factor (PUF)	:	11.13 %
Cumulative Load Factor (LF)	:	84.18 %	Cumulative Externally cause unavailability (XUF)	:	0.06 %
Cumulative Operating Factor (OF)	:	85.32 %			

Electricity Production (net) [GWh]

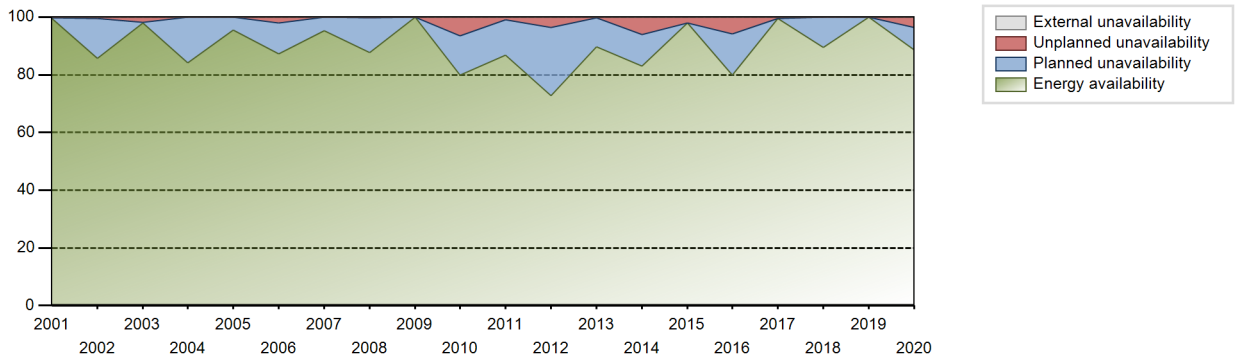


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1983	4472.80	4891	1034	76.29	76.29	66.58	73.31	11.82	10.23	13.49	0.00
1984	6088.14	6377	1032	72.02	74.45	67.16	72.60	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

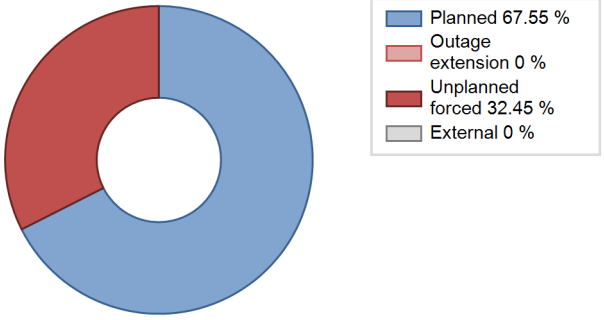
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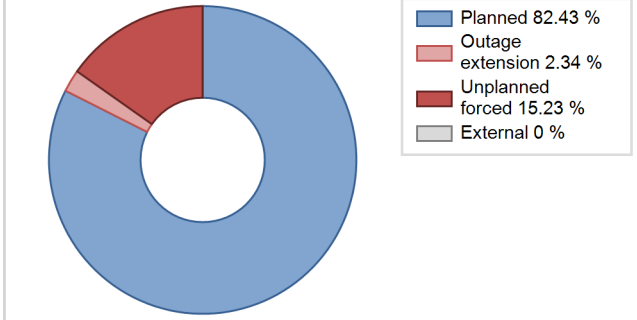
2020	9332.24	7790	1257	88.69	88.69	84.52	88.68	3.97	3.67	7.64	0.00

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1983 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					233	
B. Refuelling without maintenance	671			18		
C. Inspection, maintenance or repair combined with refuelling				772	10	
D. Inspection, maintenance or repair without refuelling				123		
E. Testing of plant systems or components				43		
H. Nuclear regulatory requirements					20	
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					28	
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)				11		
Z. Other		322		52	28	
Subtotal	671	322		1019	319	6
Total		**993**			**1344**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1983 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		8
12. Reactor I&C Systems		13
13. Reactor Auxiliary Systems		8
14. Safety Systems		12
15. Reactor Cooling Systems		39
17. Safety I&C Systems (excluding reactor I&C)		6
31. Turbine and auxiliaries		61
32. Feedwater and Main Steam System		36
33. Circulating Water System		12
34. Miscellaneous Systems		34
35. All other I&C Systems		3
41. Main Generator Systems		11
42. Electrical Power Supply Systems		20
Total		**263**

Highlights (2020)

Refueling Outage 21. The Turbine was manually tripped at approximately 15% power to start the Refueling outage at 00:52 on 3/28/20.

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2020 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

Reactor type and model	:	BWR / BWR-4 (Mark 2)
Thermal power	:	3952 MWth
Gross electrical power	:	1330 MWe
Reference unit power (net)	:	1257 MWe

Key Dates

Construction Date	:	1973-11-02
Grid Date	:	1984-07-03
Commercial Date	:	1985-02-12
Age at end of year	:	36 years

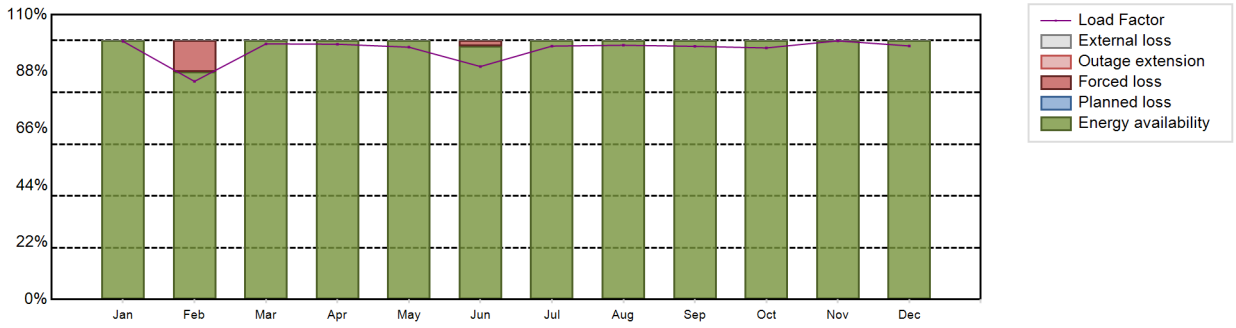
Design Characteristics

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 (2020)

Net Energy Production	:	10658.66 GW(e).h	Forced Loss Rate (FLR)	:	1.14 %
Energy Availability Factor (EAF)	:	98.86 %	Unplanned Capability Loss Factor (UCL)	:	1.14 %
Unit Capability Factor (UCF)	:	98.86 %	Planned Unavailability Factor (PUF)	:	0 %
Load Factor (LF)	:	96.53 %	Externally cause unavailability (XUF)	:	0 %
Operating Factor (OF)	:	98.85 %	Total off-line time	:	101 hours

Annual Summary



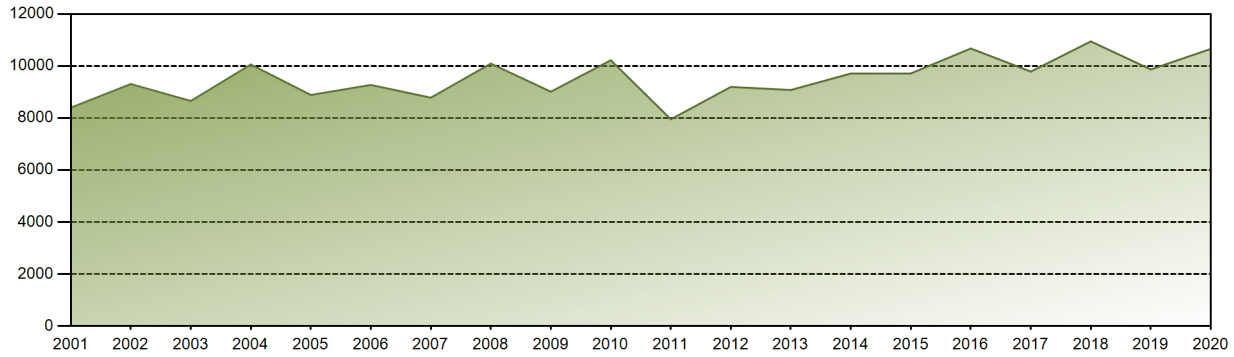
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	932.74	736.96	923.48	892.39	911.38	814.32	915.31	918.42	884.97	908.74	904.07	915.89	10658.67
EAF [%]	100.00	87.91	100.00	100.00	100.00	97.82	100.00	100.00	100.00	100.00	100.00	100.00	98.86
UCF [%]	100.00	87.91	100.00	100.00	100.00	97.82	100.00	100.00	100.00	100.00	100.00	100.00	98.86
LF [%]	99.74	84.24	98.75	98.60	97.45	89.98	97.87	98.20	97.78	97.17	99.89	97.93	96.53
OF [%]	100.00	87.93	99.87	100.00	100.00	97.78	100.00	100.00	100.00	100.00	100.00	100.00	98.85
FLR [%]	0.00	12.09	0.00	0.00	0.00	2.18	0.00	0.00	0.00	0.00	0.00	0.00	1.14
UCL [%]	0.00	12.09	0.00	0.00	0.00	2.18	0.00	0.00	0.00	0.00	0.00	0.00	1.14
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

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Historical Summary

Lifetime energy generation	:	321201.03 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.62 %
Cumulative Energy Availability Factor (EAF)	:	88.65 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.43 %
Cumulative Unit Capability Factor (UCF)	:	88.66 %	Cumulative Planned Unavailability Factor (PUF)	:	8.9 %
Cumulative Load Factor (LF)	:	87.44 %	Cumulative Externally cause unavailability (XUF)	:	0.01 %
Cumulative Operating Factor (OF)	:	88.46 %			

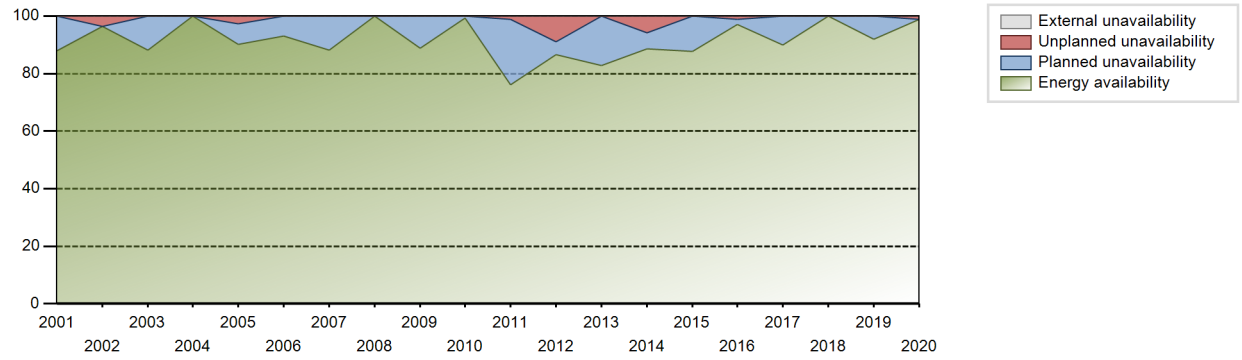
Electricity Production (net) [GWh]



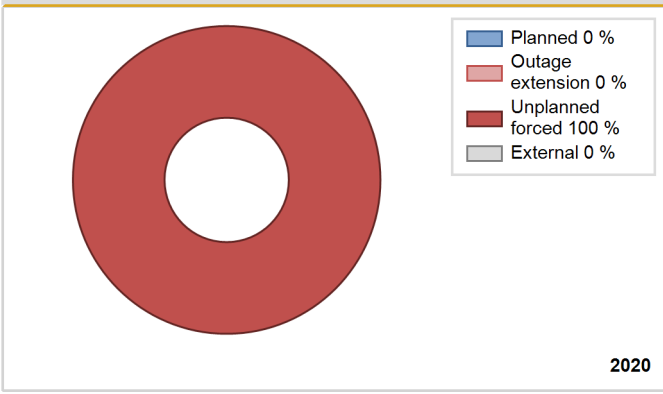
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	7323.31	7463	1032	90.18	90.61	84.07	87.24	9.39	9.39	0.00	0.43
1986	5458.36	5730	1032	63.50	63.50	60.38	65.41	16.73	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

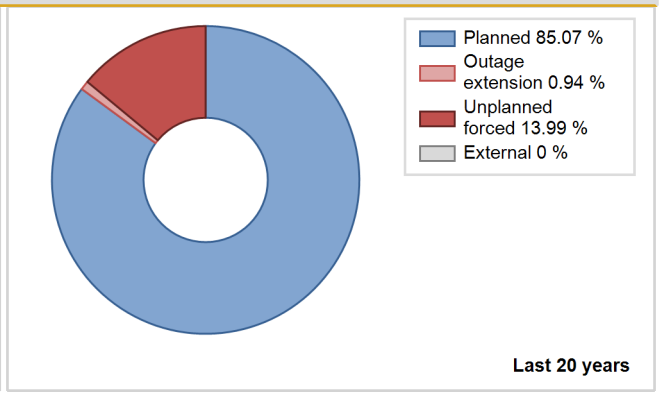
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					217	
C. Inspection, maintenance or repair combined with refuelling				714		
D. Inspection, maintenance or repair without refuelling				70		
E. Testing of plant systems or components				54		
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		100			10	
Subtotal		100		838	231	1
Total		**100**			**1070**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1985 to 2020 Average hours lost per reactor-year
11. Reactor and Accessories		13
12. Reactor I&C Systems		16
13. Reactor Auxiliary Systems		5
14. Safety Systems		6
15. Reactor Cooling Systems		18
31. Turbine and auxiliaries		38
32. Feedwater and Main Steam System		38
34. Miscellaneous Systems		30
41. Main Generator Systems		21
42. Electrical Power Supply Systems		37
Total		**222**

Highlights (2020)

Manual Scram on 02/14/20 due to degrading condenser pressure associated with Off-gas Recombiner performance. The generator was placed on line for continuous operation on 02/17/20.

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2020 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

Reactor type and model	:	PWR / WH 3LP (DRYAMB)
Thermal power	:	2644 MWth
Gross electrical power	:	829 MWe
Reference unit power (net)	:	837 MWe

Key Dates

Construction Date	:	1967-04-27
Grid Date	:	1972-11-02
Commercial Date	:	1972-12-14
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 [%]	:	33.3
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

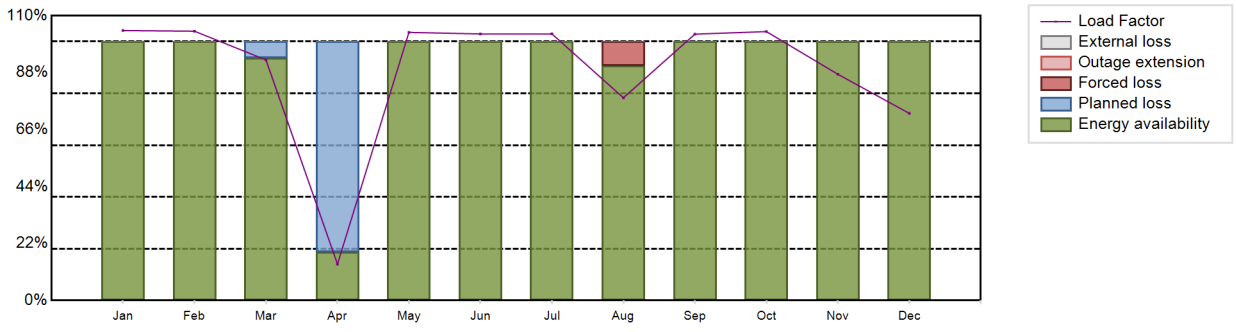
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	338
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.41
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6556.42 GW(e).h
Energy Availability Factor (EAF)	:	92.01 %
Unit Capability Factor (UCF)	:	92.01 %
Load Factor (LF)	:	89.18 %
Operating Factor (OF)	:	91.03 %

Forced Loss Rate (FLR)	:	0.85 %
Unplanned Capability Loss Factor (UCL)	:	0.79 %
Planned Unavailability Factor (PUF)	:	7.21 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	788 hours

Annual Summary



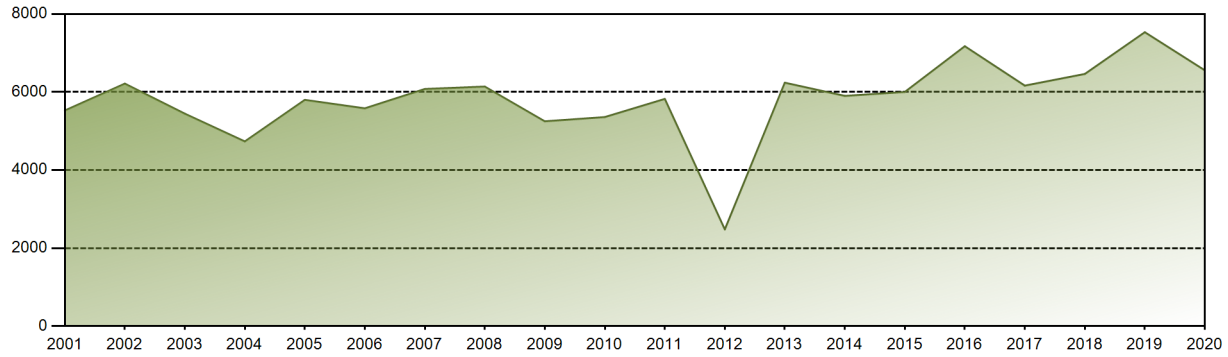
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	649.34	605.96	578.71	84.58	644.94	620.50	641.21	487.57	620.01	646.84	526.64	450.13	6556.42
EAF [%]	100.00	100.00	93.55	18.75	100.00	100.00	100.00	90.72	100.00	100.00	100.00	100.00	92.01
UCF [%]	100.00	100.00	93.55	18.75	100.00	100.00	100.00	90.72	100.00	100.00	100.00	100.00	92.01
LF [%]	104.27	104.02	92.93	14.04	103.57	102.96	102.97	78.30	102.88	103.87	87.39	72.28	89.18
OF [%]	100.00	100.00	93.41	18.75	100.00	100.00	100.00	79.30	100.00	100.00	100.00	100.00	91.03
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.28	0.00	0.00	0.00	0.00	0.85
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.28	0.00	0.00	0.00	0.00	0.79
PUF [%]	0.00	0.00	6.45	81.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.21
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

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Historical Summary

Lifetime energy generation	:	234181.22 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.95 %
Cumulative Energy Availability Factor (EAF)	:	80 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.17 %
Cumulative Unit Capability Factor (UCF)	:	80.13 %	Cumulative Planned Unavailability Factor (PUF)	:	15.7 %
Cumulative Load Factor (LF)	:	78.53 %	Cumulative Externally cause unavailability (XUF)	:	0.13 %
Cumulative Operating Factor (OF)	:	78.39 %			

Electricity Production (net) [GWh]

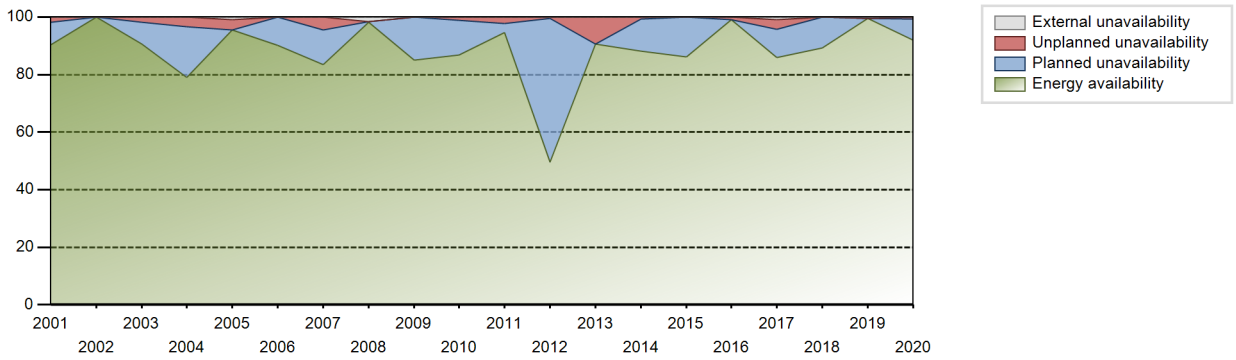


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1972	101.10	420	670	100.00	100.00	14.55	40.86	0.00	0.00	0.00	0.00
1973						Data not provided					
1974	3478.80	6090	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

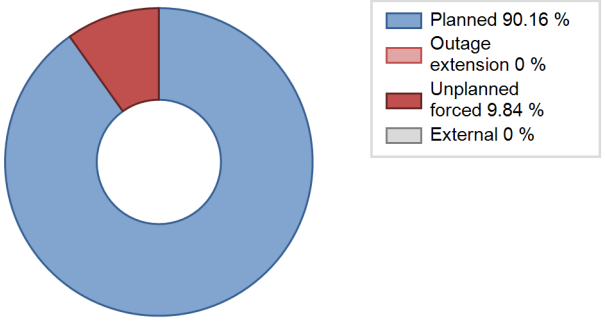
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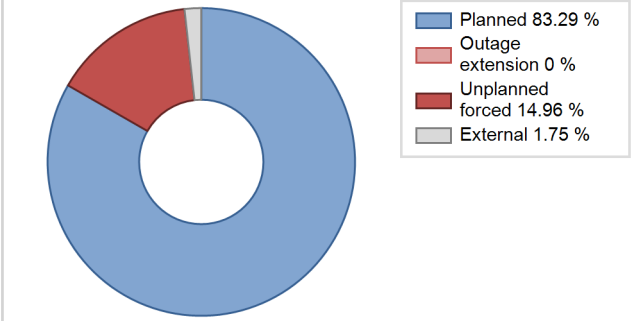
2009	5249.30	7451	693	85.06	85.06	86.47	85.06	0.00	0.00	14.94	0.00
2010	5358.09	7594	693	86.71	86.71	88.26	86.69	1.19	1.04	12.25	0.00
2011	5822.87	8291	693	94.66	94.66	95.92	94.65	2.25	2.18	3.16	0.00
2012	2477.38	4121	802	49.51	49.51	38.67	46.91	0.88	0.44	50.05	0.00
2013	6239.35	7945	802	90.70	90.70	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1972 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					380	
B. Refuelling without maintenance	633			13		
C. Inspection, maintenance or repair combined with refuelling				893		
D. Inspection, maintenance or repair without refuelling				250		
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				18	5	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						60
P. Fire					2	
Z. Other		154		146	17	
Subtotal	633	154		1329	405	63
Total		**787**			**1797**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1972 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		39
13. Reactor Auxiliary Systems		43
14. Safety Systems		17
15. Reactor Cooling Systems		78
16. Steam generation systems		21
17. Safety I&C Systems (excluding reactor I&C)		1
21. Fuel Handling and Storage Facilities		1
31. Turbine and auxiliaries		40
32. Feedwater and Main Steam System		31
33. Circulating Water System		2
34. Miscellaneous Systems		43
35. All other I&C Systems		2
41. Main Generator Systems		60
42. Electrical Power Supply Systems		12
Total		**390**

Highlights (2020)

Refueling Outage 31.

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2020 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	:	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]	:	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

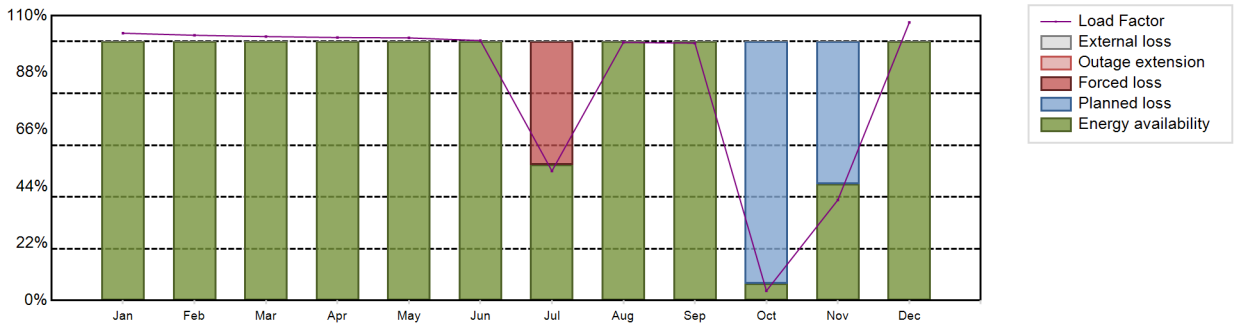
Operating coolant pressure [MPa]	:	15.7
Reactor outlet temperature [°C]	:	338
Number of SG	:	3
Containment type	:	-
Containment design pressure [MPa]	:	0.41
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	6062.56 GW(e).h
Energy Availability Factor (EAF)	:	83.54 %
Unit Capability Factor (UCF)	:	83.54 %
Load Factor (LF)	:	84.07 %
Operating Factor (OF)	:	83.54 %

Forced Loss Rate (FLR)	:	4.6 %
Unplanned Capability Loss Factor (UCL)	:	4.03 %
Planned Unavailability Factor (PUF)	:	12.43 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1446 hours

Annual Summary



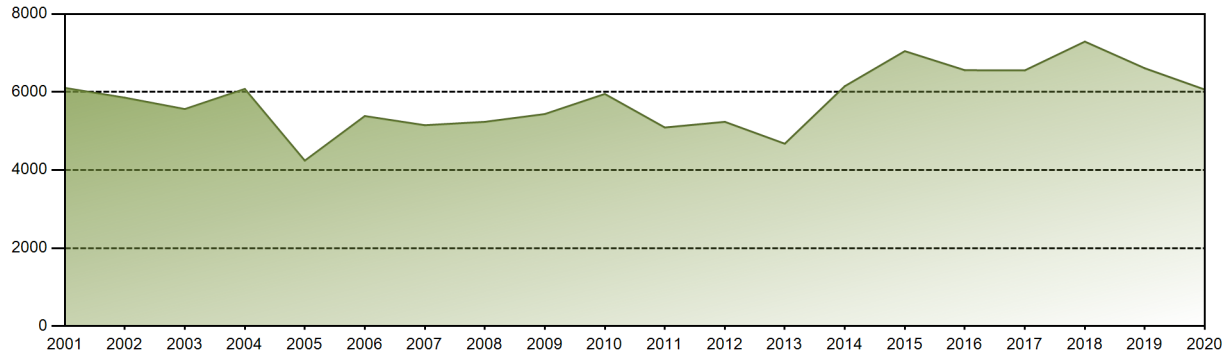
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	630.57	585.37	622.61	600.45	619.52	593.45	305.60	608.84	587.64	22.84	229.54	656.13	6062.56
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	52.45	100.00	100.00	6.45	45.01	100.00	83.54
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	52.45	100.00	100.00	6.45	45.01	100.00	83.54
LF [%]	103.23	102.44	101.93	101.58	101.42	100.39	50.03	99.68	99.41	3.74	38.83	107.42	84.07
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	52.42	100.00	100.00	6.45	45.14	100.00	83.54
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	47.55	0.00	0.00	0.00	0.00	0.00	4.60
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	47.55	0.00	0.00	0.00	0.00	0.00	4.03
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.55	54.99	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

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Historical Summary

Lifetime energy generation	:	233096.47 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	4.92 %
Cumulative Energy Availability Factor (EAF)	:	80.28 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	4.16 %
Cumulative Unit Capability Factor (UCF)	:	80.32 %	Cumulative Planned Unavailability Factor (PUF)	:	15.52 %
Cumulative Load Factor (LF)	:	78.59 %	Cumulative Externally cause unavailability (XUF)	:	0.04 %
Cumulative Operating Factor (OF)	:	78.93 %			

Electricity Production (net) [GWh]

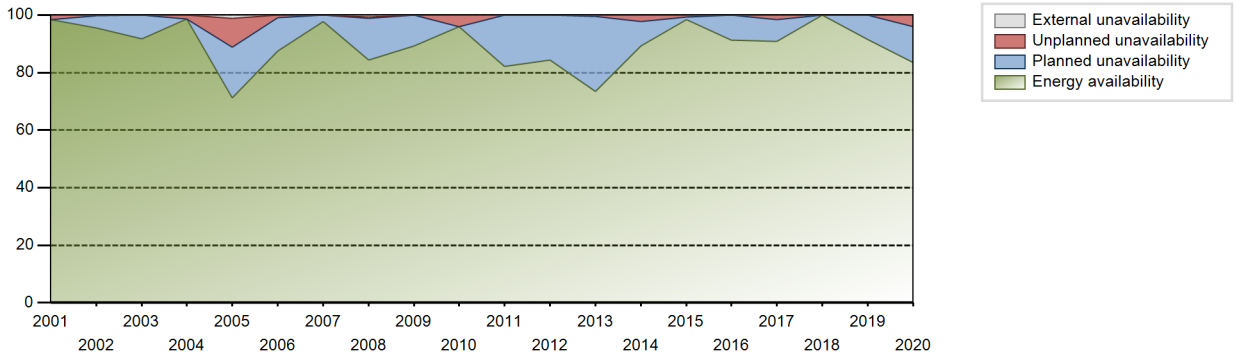


Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1973	Data not provided										
1974	4513.40	6759	728	100.00	100.00	70.77	77.16	0.00	0.00	0.00	0.00
1975	3991.90	6172	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

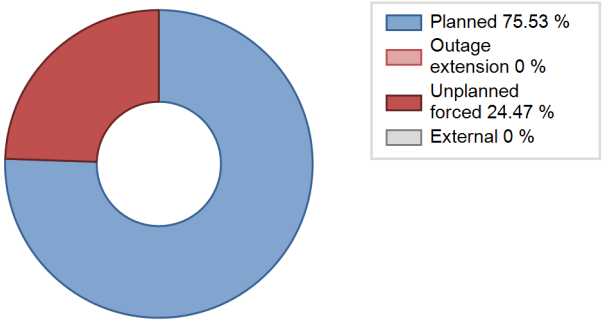
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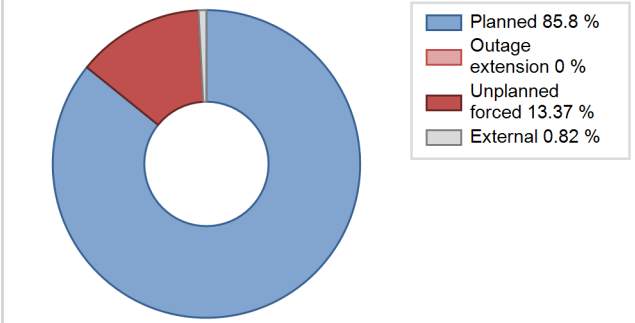
2010	5949.82	8397	693	95.87	95.87	98.01	95.86	4.13	4.13	0.00	0.00
2011	5089.88	7202	693	82.24	82.24	83.84	82.21	0.00	0.00	17.76	0.00
2012	5235.36	7416	693	84.44	84.44	86.00	84.43	0.00	0.00	15.56	0.00
2013	4674.70	6156	802	73.43	73.43	68.84	70.27	0.65	0.48	26.09	0.00
2014	6149.85	7828	802	89.35	89.35	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause		2020 Hours Lost			1973 to 2020 Average hours lost per reactor-year		
		Planned	Unplanned	External	Planned	Unplanned	External
A.	Plant equipment problem/failure					304	
B.	Refuelling without maintenance	1092			24		
C.	Inspection, maintenance or repair combined with refuelling				1135		
D.	Inspection, maintenance or repair without refuelling				234	61	
E.	Testing of plant systems or components				5	1	
J.	Grid limitation, failure or grid unavailability						2
L.	Human factor related					10	
N.	Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						50
Z.	Other		354			9	
Subtotal		1092	354		1398	385	52
Total			**1446**			**1835**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1973 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		67
12. Reactor I&C Systems		17
13. Reactor Auxiliary Systems		3
14. Safety Systems		4
15. Reactor Cooling Systems		76
16. Steam generation systems		80
31. Turbine and auxiliaries		52
32. Feedwater and Main Steam System		23
33. Circulating Water System		3
34. Miscellaneous Systems		28
35. All other I&C Systems		2
41. Main Generator Systems		2
42. Electrical Power Supply Systems		41
Total		**398**

Highlights (2020)

Cycle 32 Refueling Outage (PT432 RFO)

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2020 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

Reactor type and model	:	PWR / WH 4LP (DRYAMB)
Thermal power	:	3626 MWth
Gross electrical power	:	1229 MWe
Reference unit power (net)	:	1150 MWe

Key Dates

Construction Date	:	1976-08-01
Grid Date	:	1987-03-27
Commercial Date	:	1987-06-01
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]	:	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

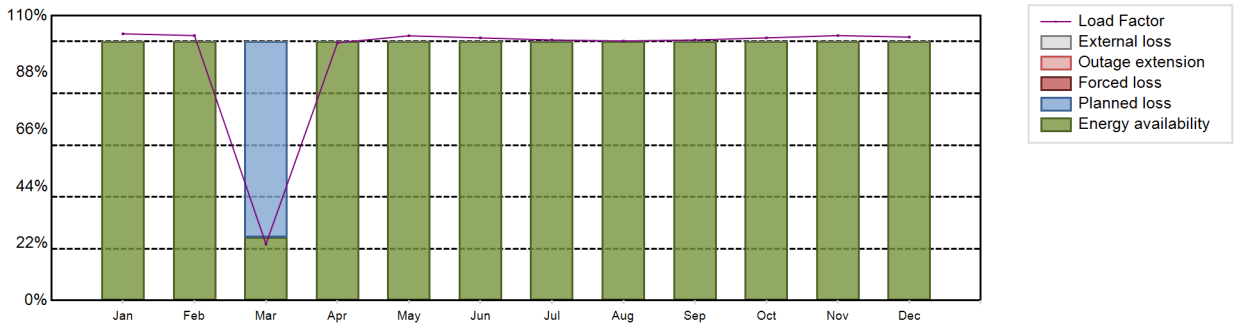
Operating coolant pressure [MPa]	:	15.82
Reactor outlet temperature [°C]	:	325
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.365
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP 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	:	2
Non-electrical applications	:	none

Annual Production Results (2020)

Net Energy Production	:	9562.45 GW(e).h
Energy Availability Factor (EAF)	:	93.6 %
Unit Capability Factor (UCF)	:	93.6 %
Load Factor (LF)	:	94.66 %
Operating Factor (OF)	:	93.59 %

Forced Loss Rate (FLR)	:	0 %
Unplanned Capability Loss Factor (UCL)	:	0 %
Planned Unavailability Factor (PUF)	:	6.4 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	563 hours

Annual Summary



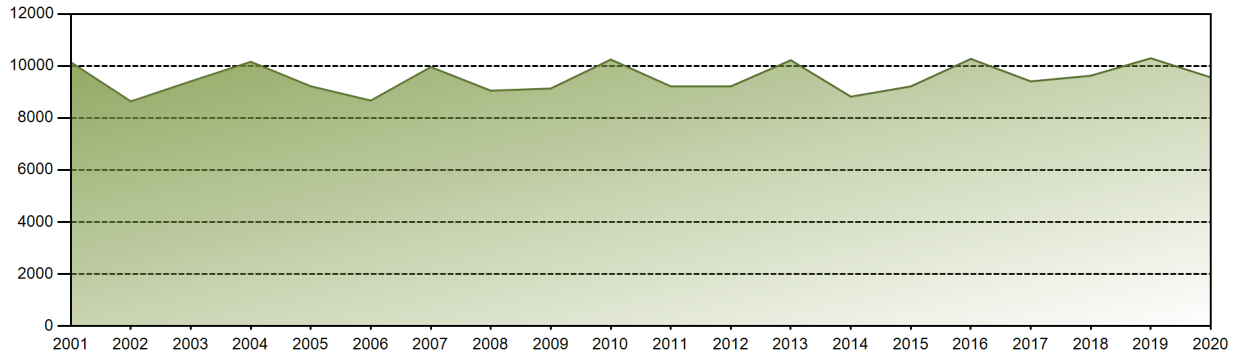
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	881.27	818.98	186.53	824.17	874.68	839.82	860.83	857.59	833.04	867.93	847.22	870.39	9562.45
EAF [%]	100.00	100.00	24.46	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.60
UCF [%]	100.00	100.00	24.46	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.60
LF [%]	103.00	102.32	21.80	99.54	102.23	101.43	100.61	100.23	100.61	101.44	102.32	101.73	94.66
OF [%]	100.00	100.00	24.33	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	93.59
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	75.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.40
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

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Historical Summary

Lifetime energy generation	:	338695.08 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.61 %
Cumulative Energy Availability Factor (EAF)	:	91.45 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.5 %
Cumulative Unit Capability Factor (UCF)	:	91.47 %	Cumulative Planned Unavailability Factor (PUF)	:	7.04 %
Cumulative Load Factor (LF)	:	91.82 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	91.48 %			

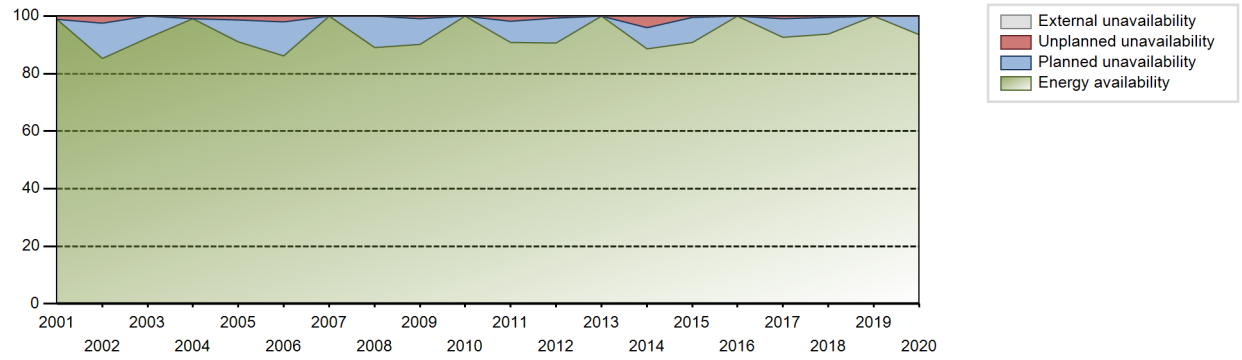
Electricity Production (net) [GWh]



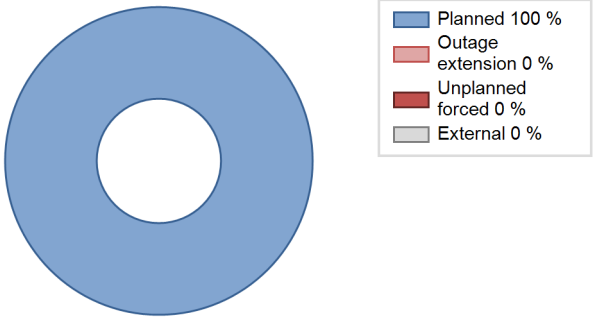
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1987	Data not provided										
1988	6799.71	6569	1079	74.25	74.25	71.74	74.78	12.68	10.78	14.97	0.00
1989	8709.38	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

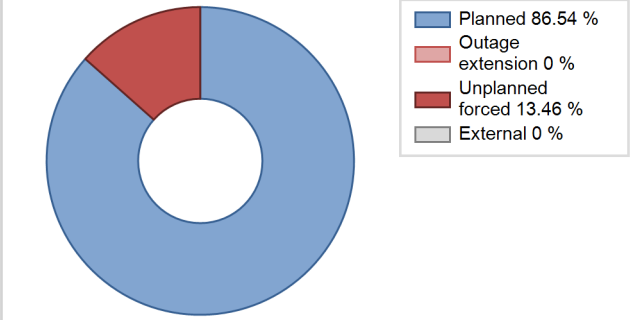
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1987 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					114	
B. Refuelling without maintenance	562			17		
C. Inspection, maintenance or repair combined with refuelling				575		
D. Inspection, maintenance or repair without refuelling				18		
E. Testing of plant systems or components				2	0	
H. Nuclear regulatory requirements					6	
L. Human factor related					9	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						1
Z. Other				2	0	2
Subtotal	562			614	129	3
Total	**562**			**746**		

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1987 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		7
13. Reactor Auxiliary Systems		1
14. Safety Systems		23
15. Reactor Cooling Systems		24
16. Steam generation systems		5
17. Safety I&C Systems (excluding reactor I&C)		7
31. Turbine and auxiliaries		4
32. Feedwater and Main Steam System		23
34. Miscellaneous Systems		0
35. All other I&C Systems		2
41. Main Generator Systems		19
42. Electrical Power Supply Systems		8
Total		**123**

Highlights (2020)

Refueling Outage 22 (1R22).

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2020 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	:	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]	:	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

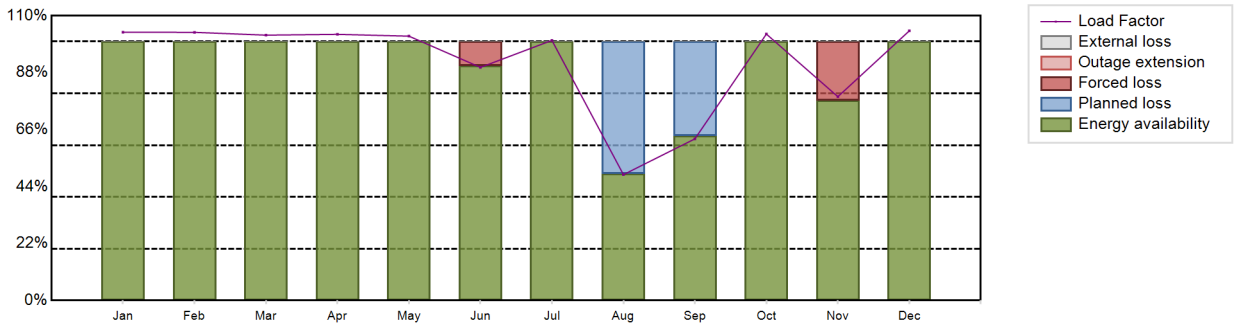
Operating coolant pressure [MPa]	:	15.82
Reactor outlet temperature [°C]	:	325
Number of SG	:	4
Containment type	:	Single
Containment design pressure [MPa]	:	0.365
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP 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 (2020)

Net Energy Production	:	9295.37 GW(e).h
Energy Availability Factor (EAF)	:	90.09 %
Unit Capability Factor (UCF)	:	90.09 %
Load Factor (LF)	:	91.86 %
Operating Factor (OF)	:	90.08 %

Forced Loss Rate (FLR)	:	2.83 %
Unplanned Capability Loss Factor (UCL)	:	2.62 %
Planned Unavailability Factor (PUF)	:	7.29 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	871 hours

Annual Summary



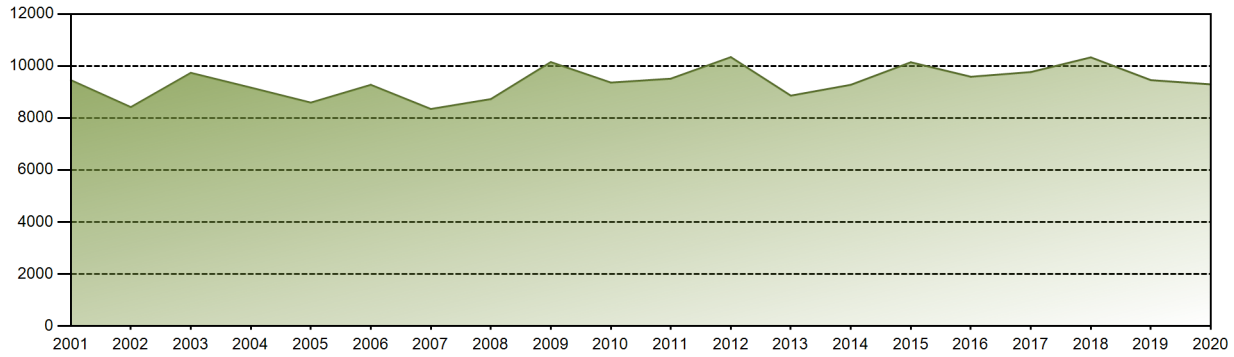
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	888.23	830.42	878.45	852.62	875.11	746.84	861.21	416.76	517.87	882.05	653.00	892.80	9295.37
EAF [%]	100.00	100.00	100.00	100.00	100.00	90.72	100.00	49.06	63.72	100.00	77.26	100.00	90.09
UCF [%]	100.00	100.00	100.00	100.00	100.00	90.72	100.00	49.06	63.72	100.00	77.26	100.00	90.09
LF [%]	103.63	103.57	102.49	102.79	102.10	90.04	100.48	48.62	62.44	102.91	78.73	104.17	91.86
OF [%]	100.00	100.00	99.87	100.00	100.00	90.69	100.00	49.06	63.75	100.00	77.36	100.00	90.08
FLR [%]	0.00	0.00	0.00	0.00	0.00	9.28	0.00	0.00	0.00	0.00	22.74	0.00	2.83
UCL [%]	0.00	0.00	0.00	0.00	0.00	9.28	0.00	0.00	0.00	0.00	22.74	0.00	2.62
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.94	36.28	0.00	0.00	0.00	7.29
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

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Historical Summary

Lifetime energy generation	:	285177 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	1.67 %
Cumulative Energy Availability Factor (EAF)	:	91.61 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	1.56 %
Cumulative Unit Capability Factor (UCF)	:	91.62 %	Cumulative Planned Unavailability Factor (PUF)	:	6.82 %
Cumulative Load Factor (LF)	:	91.74 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	91.63 %			

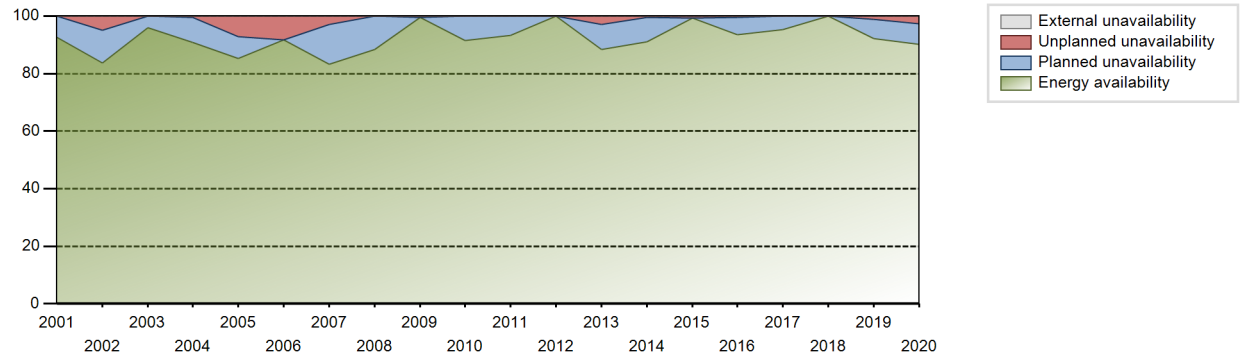
Electricity Production (net) [GWh]



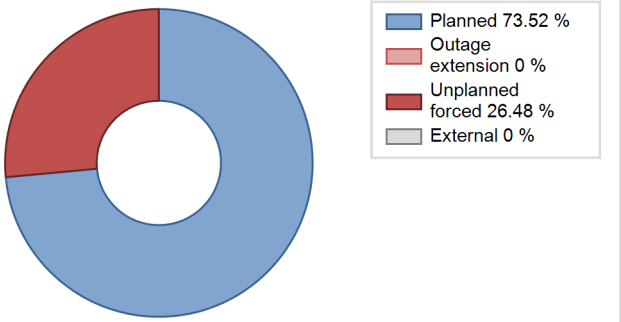
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1989	5547.17	5104	1110	95.42	95.42	96.38	95.60	2.29	2.24	2.34	0.00
1990	6868.02	7125	1110	81.06	81.06	70.63	81.34	1.91	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

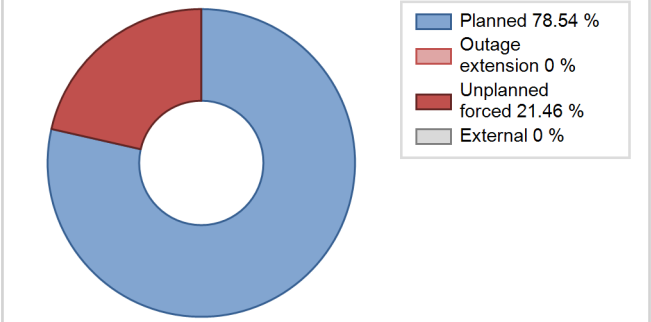
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1989 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					99	
B. Refuelling without maintenance	640			20		
C. Inspection, maintenance or repair combined with refuelling				523		
D. Inspection, maintenance or repair without refuelling				49		
E. Testing of plant systems or components				1		
L. Human factor related					24	
Z. Other		231		2	14	1
Subtotal	640	231		595	137	1
Total		**871**			**733**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1989 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		8
13. Reactor Auxiliary Systems		8
14. Safety Systems		10
15. Reactor Cooling Systems		24
16. Steam generation systems		2
31. Turbine and auxiliaries		1
32. Feedwater and Main Steam System		25
34. Miscellaneous Systems		2
35. All other I&C Systems		5
41. Main Generator Systems		15
42. Electrical Power Supply Systems		2
Total		**102**

Highlights (2020)

B Phase Main Step-Up transformer failure. Placed spare transformer in service.

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2020 Operating Experience

US-382 WATERFORD-3 UNITED STATES OF AMERICA



Status at end of year	:	**Operational**
Operator	:	ENTERGY (Entergy Nuclear Operations, Inc.)
Owner	:	ENTLA (ENTERGY 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	:	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 [%]	:	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

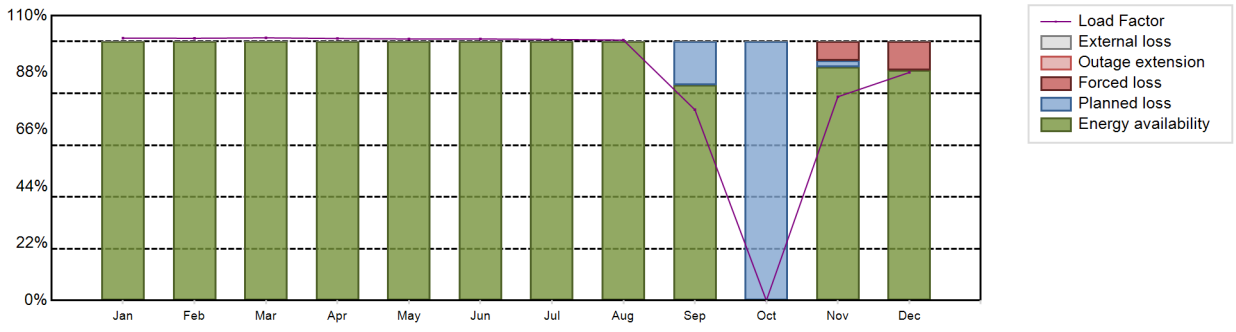
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	322
Number of SG	:	2
Containment type	:	-
Containment design pressure [MPa]	:	0.309
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	8961.22 GW(e).h
Energy Availability Factor (EAF)	:	88.42 %
Unit Capability Factor (UCF)	:	88.42 %
Load Factor (LF)	:	87.34 %
Operating Factor (OF)	:	88.42 %

Forced Loss Rate (FLR)	:	1.72 %
Unplanned Capability Loss Factor (UCL)	:	1.55 %
Planned Unavailability Factor (PUF)	:	10.03 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1017 hours

Annual Summary



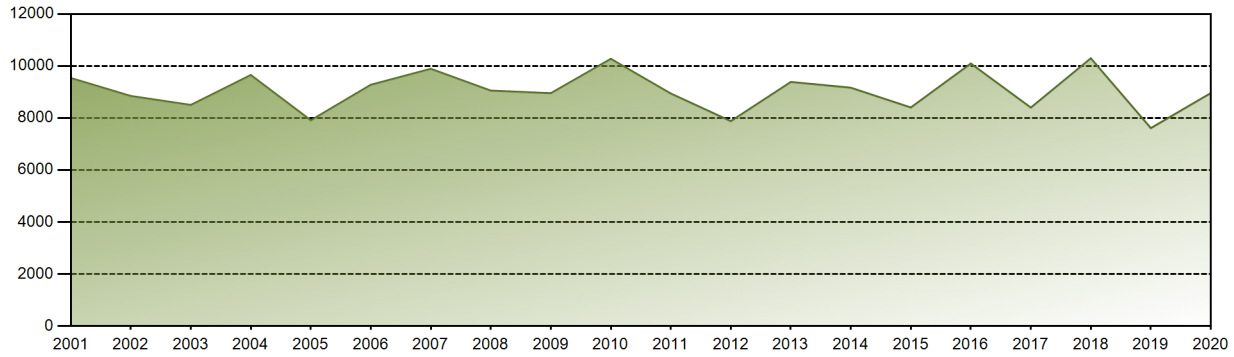
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	880.61	823.35	881.61	850.98	877.84	849.66	876.17	874.04	619.65	0.00	661.86	765.43	8961.22
EAF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	83.32	0.00	90.25	88.88	88.42
UCF [%]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	83.32	0.00	90.25	88.88	88.42
LF [%]	101.34	101.28	101.45	101.19	101.02	101.03	100.83	100.58	73.68	0.00	78.70	88.08	87.34
OF [%]	100.00	100.00	99.87	100.00	100.00	100.00	100.00	100.00	83.33	0.00	90.42	88.84	88.42
FLR [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.59	11.12	1.72
UCL [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.41	11.12	1.55
PUF [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.68	100.00	2.34	0.00	10.03
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

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Historical Summary

Lifetime energy generation	:	330911.18 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.7 %
Cumulative Energy Availability Factor (EAF)	:	87.48 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.44 %
Cumulative Unit Capability Factor (UCF)	:	87.73 %	Cumulative Planned Unavailability Factor (PUF)	:	9.83 %
Cumulative Load Factor (LF)	:	87.11 %	Cumulative Externally cause unavailability (XUF)	:	0.25 %
Cumulative Operating Factor (OF)	:	87.38 %			

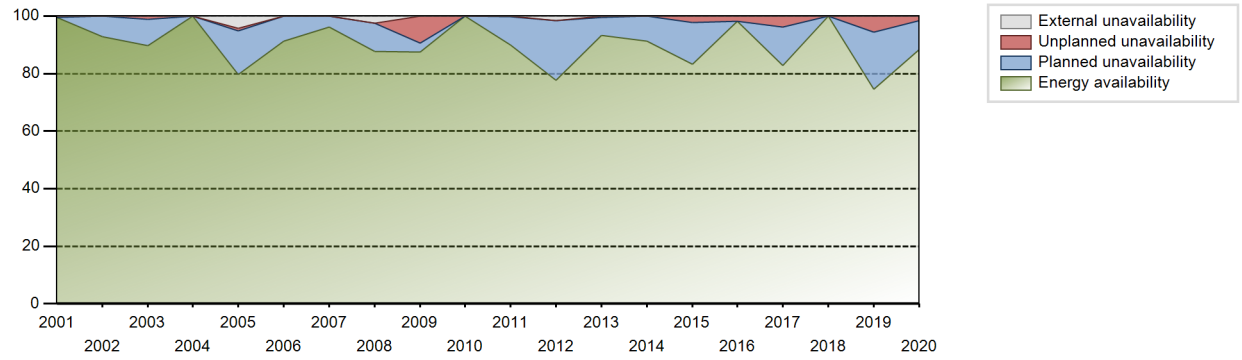
Electricity Production (net) [GWh]



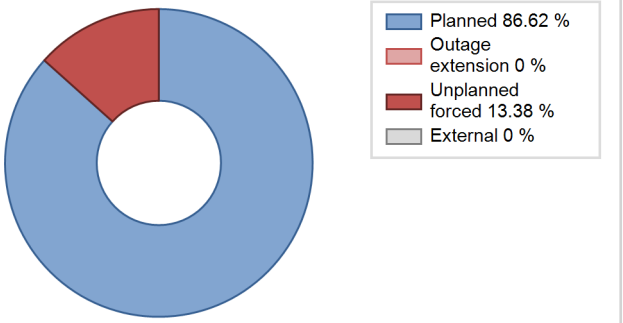
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	2773.07	3372	1099	75.85	75.85	69.71	75.51	23.80	23.69	0.46	0.00
1986	7308.38	6921	1096	79.47	79.47	76.07	79.01	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

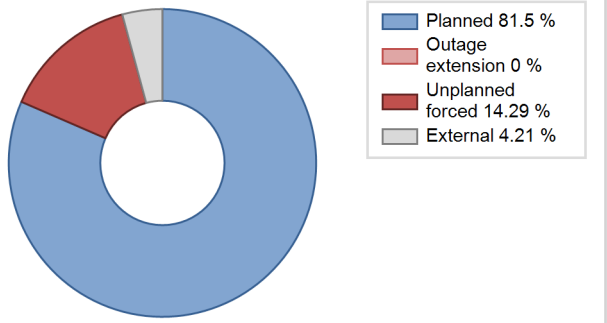
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1985 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					199	
B. Refuelling without maintenance	881			25		
C. Inspection, maintenance or repair combined with refuelling				764		
D. Inspection, maintenance or repair without refuelling				77		
E. Testing of plant systems or components				1		
J. Grid limitation, failure or grid unavailability						1
L. Human factor related					9	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						24
Z. Other		136			6	
Subtotal	881	136		867	214	25
Total		**1017**			**1106**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		14
13. Reactor Auxiliary Systems		9
14. Safety Systems		2
15. Reactor Cooling Systems		65
17. Safety I&C Systems (excluding reactor I&C)		24
31. Turbine and auxiliaries		40
32. Feedwater and Main Steam System		21
33. Circulating Water System		2
34. Miscellaneous Systems		3
35. All other I&C Systems		13
41. Main Generator Systems		11
42. Electrical Power Supply Systems		3
Total		**207**

Highlights (2020)

Automatic reactor trip from 43% power during RF23 startup. An electrical fault in the motor generator system resulted in control rods dropping.

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2020 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	:	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 [%]	:	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

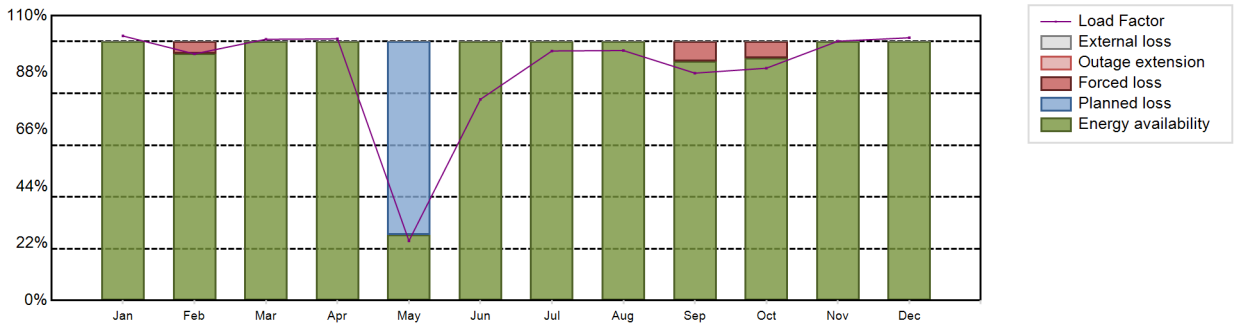
Operating coolant pressure [MPa]	:	15.71
Reactor outlet temperature [°C]	:	326
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.105
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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 (2020)

Net Energy Production	:	9075.1 GW(e).h
Energy Availability Factor (EAF)	:	92.16 %
Unit Capability Factor (UCF)	:	92.16 %
Load Factor (LF)	:	89.29 %
Operating Factor (OF)	:	91.03 %

Forced Loss Rate (FLR)	:	1.63 %
Unplanned Capability Loss Factor (UCL)	:	1.52 %
Planned Unavailability Factor (PUF)	:	6.32 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	788 hours

Annual Summary



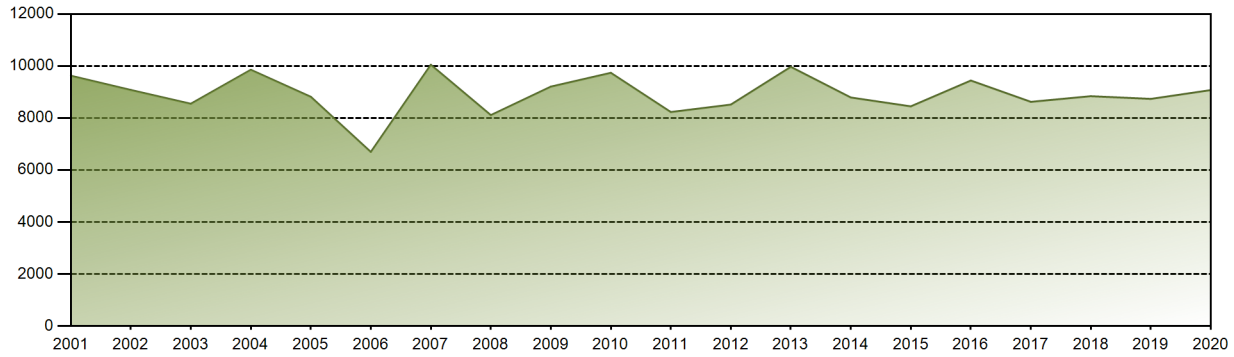
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	879.48	766.98	868.54	841.88	198.40	647.33	829.62	831.11	731.49	772.41	834.32	873.53	9075.10
EAF [%]	100.00	95.42	100.00	100.00	25.40	100.00	100.00	100.00	92.38	93.68	100.00	100.00	92.16
UCF [%]	100.00	95.42	100.00	100.00	25.40	100.00	100.00	100.00	92.38	93.68	100.00	100.00	92.16
LF [%]	102.17	95.25	100.90	101.06	23.05	77.71	96.38	96.55	87.81	89.73	100.15	101.48	89.29
OF [%]	100.00	95.40	99.87	100.00	25.40	86.39	100.00	100.00	92.36	93.68	100.00	100.00	91.03
FLR [%]	0.00	4.58	0.00	0.00	0.00	0.00	0.00	0.00	7.62	6.32	0.00	0.00	1.63
UCL [%]	0.00	4.58	0.00	0.00	0.00	0.00	0.00	0.00	7.62	6.32	0.00	0.00	1.52
PUF [%]	0.00	0.00	0.00	0.00	74.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.32
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

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Historical Summary

Lifetime energy generation	:	198662.68 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	2.56 %
Cumulative Energy Availability Factor (EAF)	:	90.03 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	2.37 %
Cumulative Unit Capability Factor (UCF)	:	90.06 %	Cumulative Planned Unavailability Factor (PUF)	:	7.58 %
Cumulative Load Factor (LF)	:	89.87 %	Cumulative Externally cause unavailability (XUF)	:	0.02 %
Cumulative Operating Factor (OF)	:	89.97 %			

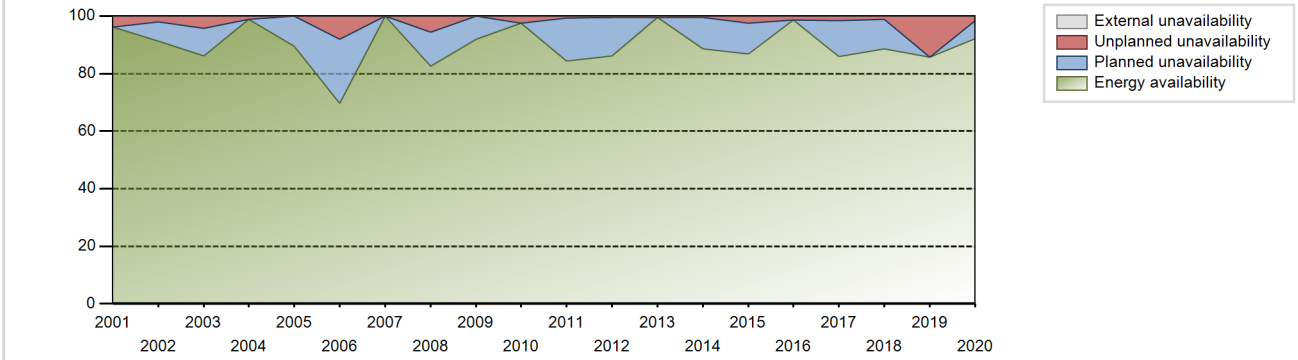
Electricity Production (net) [GWh]



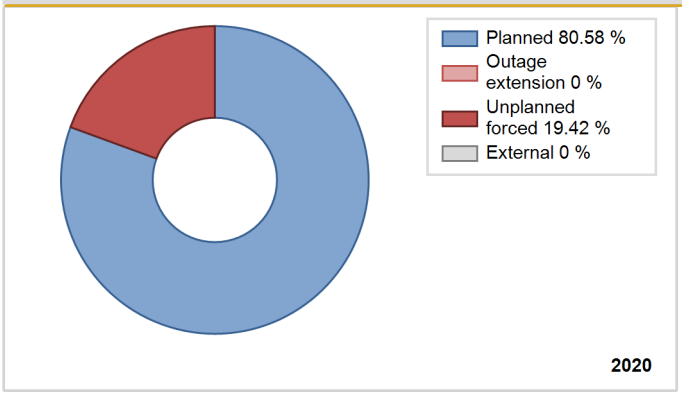
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1996	5544.23	5491	1109	90.65	90.65	88.78	91.16	0.21	0.19	9.17	0.00
1997	7600.09	7269	1117	82.27	82.27	77.67	82.98	5.73	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

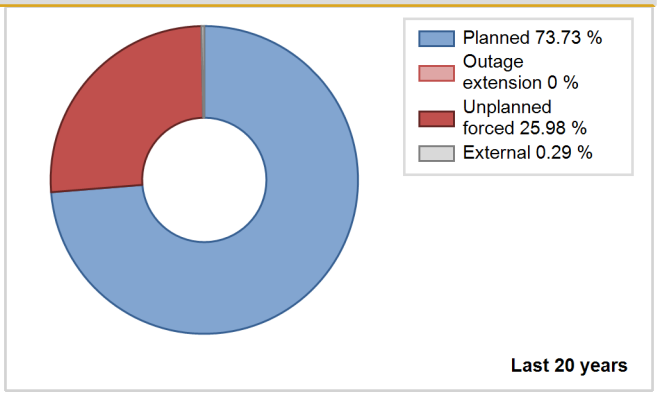
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020 Hours Lost			1996 to 2020 Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					158	
B. Refuelling without maintenance	653			27		
C. Inspection, maintenance or repair combined with refuelling				612		
D. Inspection, maintenance or repair without refuelling				60		
E. Testing of plant systems or components				29		
J. Grid limitation, failure or grid unavailability						2
L. Human factor related					16	
P. Fire					2	
Z. Other		134		51	12	
Subtotal	653	134		779	188	2
Total		**787**			**969**	

Equipment Related Unplanned Full Outages, Analysis by System

System	2020 Hours Lost	1996 to 2020 Average hours lost per reactor-year
12. Reactor I&C Systems		2
14. Safety Systems		8
15. Reactor Cooling Systems		19
16. Steam generation systems		2
31. Turbine and auxiliaries		56
32. Feedwater and Main Steam System		38
33. Circulating Water System		11
35. All other I&C Systems		2
41. Main Generator Systems		14
42. Electrical Power Supply Systems		14
Total		**166**

Highlights (2020)

Repair U1 GV 1

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2020 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	:	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]	:	-
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

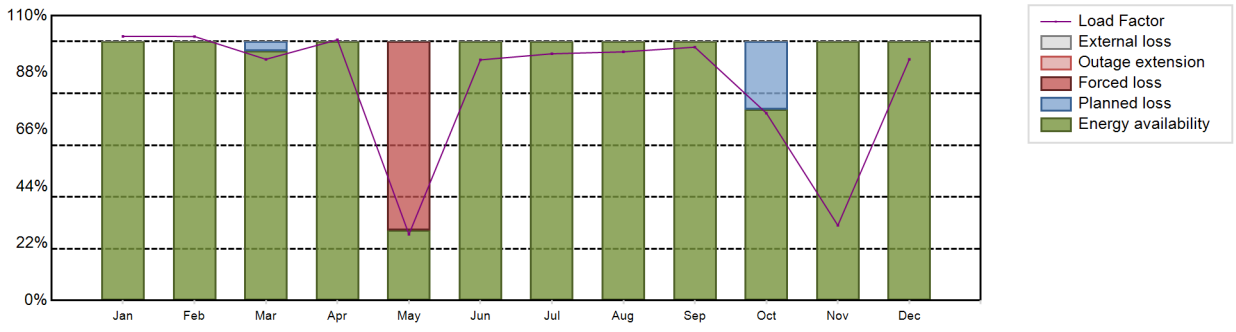
Operating coolant pressure [MPa]	:	15.71
Reactor outlet temperature [°C]	:	326
Number of SG	:	4
Containment type	:	Double
Containment design pressure [MPa]	:	1.05
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP 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	:	none

Annual Production Results (2020)

Net Energy Production	:	8513.91 GW(e).h
Energy Availability Factor (EAF)	:	91.31 %
Unit Capability Factor (UCF)	:	91.31 %
Load Factor (LF)	:	83.27 %
Operating Factor (OF)	:	85.93 %

Forced Loss Rate (FLR)	:	6.33 %
Unplanned Capability Loss Factor (UCL)	:	6.17 %
Planned Unavailability Factor (PUF)	:	2.52 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	1236 hours

Annual Summary



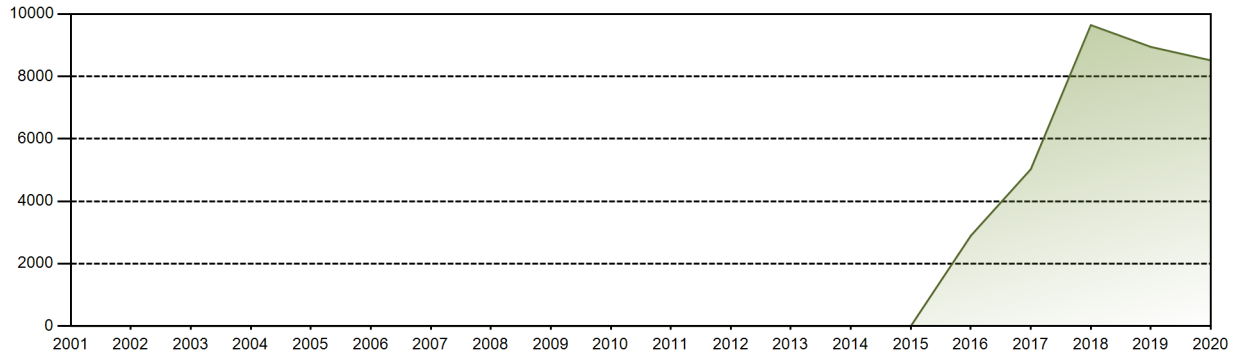
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	883.57	826.11	806.75	843.95	221.46	778.87	825.24	831.68	819.94	626.70	243.17	806.46	8513.91
EAF [%]	100.00	100.00	96.46	100.00	27.13	100.00	100.00	100.00	100.00	73.79	100.00	100.00	91.31
UCF [%]	100.00	100.00	96.46	100.00	27.13	100.00	100.00	100.00	100.00	73.79	100.00	100.00	91.31
LF [%]	102.03	101.97	93.16	100.70	25.57	92.93	95.29	96.04	97.84	72.37	29.02	93.12	83.27
OF [%]	100.00	100.00	96.37	100.00	27.15	97.50	100.00	100.00	100.00	73.79	36.94	100.00	85.93
FLR [%]	0.00	0.00	0.00	0.00	72.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.33
UCL [%]	0.00	0.00	0.00	0.00	72.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.17
PUF [%]	0.00	0.00	3.54	0.00	0.00	0.00	0.00	0.00	0.00	26.21	0.00	0.00	2.52
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

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Historical Summary

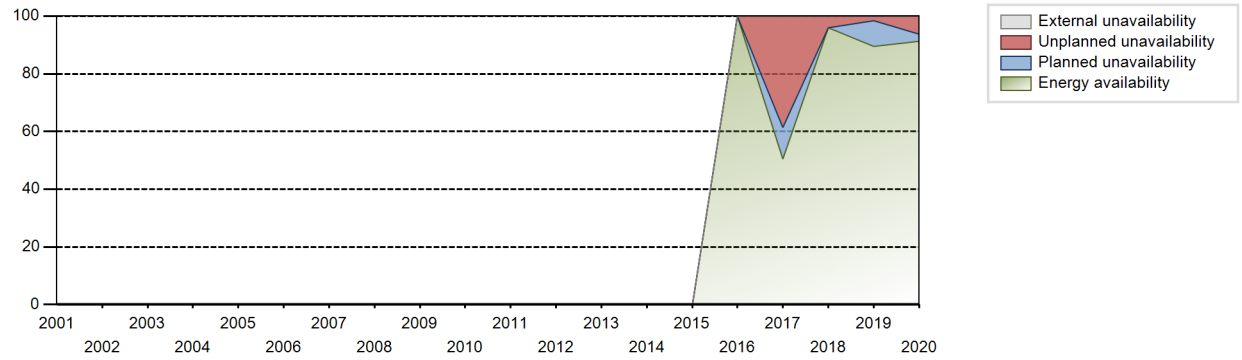
Lifetime energy generation	:	-141918.54 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	12.77 %
Cumulative Energy Availability Factor (EAF)	:	82.55 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	12.09 %
Cumulative Unit Capability Factor (UCF)	:	82.55 %	Cumulative Planned Unavailability Factor (PUF)	:	5.36 %
Cumulative Load Factor (LF)	:	79.6 %	Cumulative Externally cause unavailability (XUF)	:	0 %
Cumulative Operating Factor (OF)	:	81.17 %			

Electricity Production (net) [GWh]

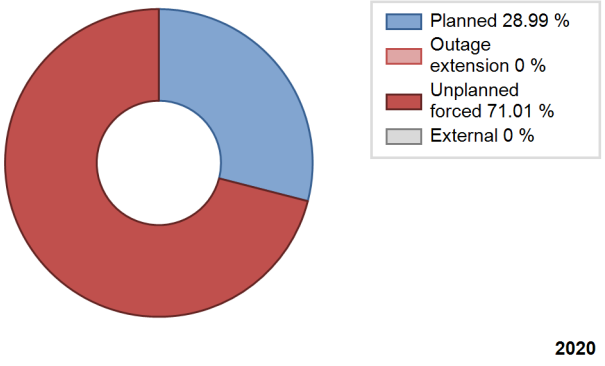


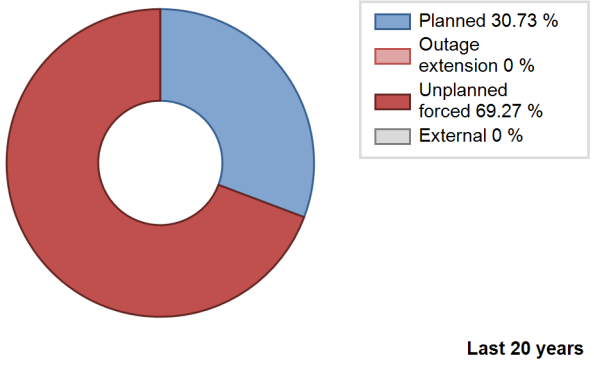
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2016	2893.72	2593	1165	100.00	100.00	101.05	100.00	0.00	0.00	0.00	0.00
2017	5026.65	4421	1165	50.46	50.46	49.25	50.47	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

Key Factors in Last 20 Years [%]



Energy Losses by Type





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Full Outages, Analysis by Cause

Outage Cause	2020			2016 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					969	
B. Refuelling without maintenance	650			156		
C. Inspection, maintenance or repair combined with refuelling				422		
D. Inspection, maintenance or repair without refuelling	26			6		
L. Human factor related					15	
Z. Other		560			134	
Subtotal	676	560		584	1118	
Total	**1236**			**1702**		

Equipment Related Unplanned Full Outages, Analysis by System

System	2020	2016 to 2020
	Hours Lost	Average hours lost per reactor-year
12. Reactor I&C Systems		19
15. Reactor Cooling Systems		10
31. Turbine and auxiliaries		108
32. Feedwater and Main Steam System		710
34. Miscellaneous Systems		47
Total		**894**

Highlights (2020)

Refueling Outage 3.

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2020 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	:	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 [%]	:	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

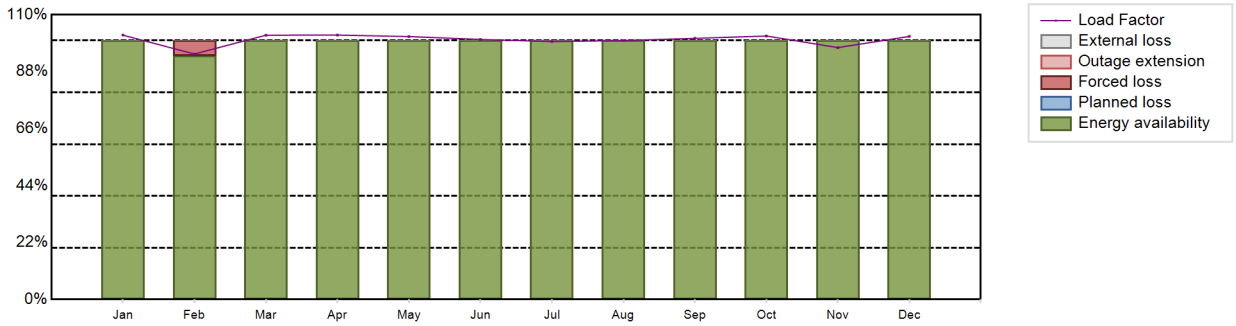
Operating coolant pressure [MPa]	:	15.8
Reactor outlet temperature [°C]	:	326
Number of SG	:	4
Containment type	:	-
Containment design pressure [MPa]	:	0.42
Secondary systems		
Number of turbine-generators per unit/reactor	:	1
Turbine speed [rpm]	:	1800
Number of LP cylinders per turbine	:	-
HP cylinder 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	:	none

Annual Production Results (2020)

Net Energy Production	:	10582.48 GW(e).h
Energy Availability Factor (EAF)	:	99.55 %
Unit Capability Factor (UCF)	:	99.55 %
Load Factor (LF)	:	100.4 %
Operating Factor (OF)	:	99.53 %

Forced Loss Rate (FLR)	:	0.45 %
Unplanned Capability Loss Factor (UCL)	:	0.45 %
Planned Unavailability Factor (PUF)	:	0 %
Externally cause unavailability (XUF)	:	0 %
Total off-line time	:	41 hours

Annual Summary



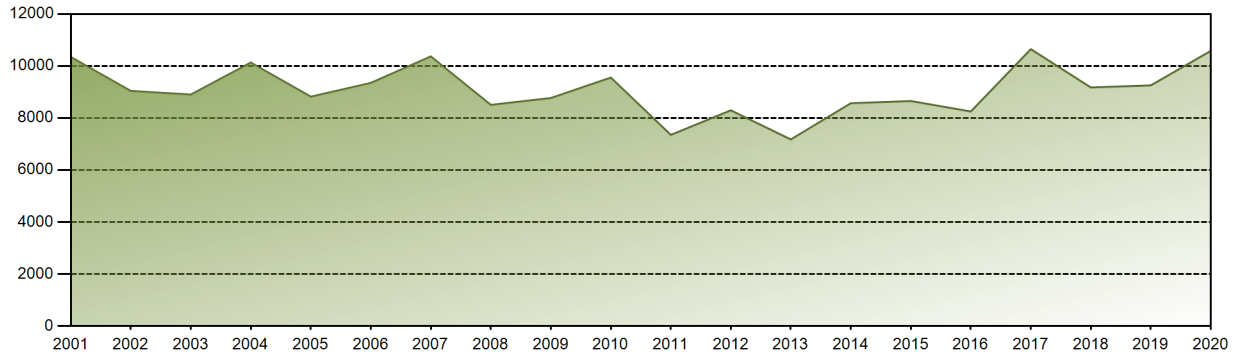
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
GW(e)-h	911.52	791.95	911.47	882.42	906.77	867.88	889.61	892.89	871.48	908.72	840.65	907.12	10582.48
EAF [%]	100.00	94.27	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.55
UCF [%]	100.00	94.27	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.55
LF [%]	102.10	94.82	102.09	102.13	101.57	100.45	99.64	100.01	100.87	101.78	97.30	101.60	100.40
OF [%]	100.00	94.25	99.87	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.53
FLR [%]	0.00	5.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
UCL [%]	0.00	5.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	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	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

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Historical Summary

Lifetime energy generation	:	391653.71 GW(e).h	Cumulative Forced Loss Rate (FLR)	:	3.83 %
Cumulative Energy Availability Factor (EAF)	:	85.85 %	Cumulative Unplanned Capability Loss Factor (UCL)	:	3.42 %
Cumulative Unit Capability Factor (UCF)	:	85.9 %	Cumulative Planned Unavailability Factor (PUF)	:	10.68 %
Cumulative Load Factor (LF)	:	85.5 %	Cumulative Externally cause unavailability (XUF)	:	0.04 %
Cumulative Operating Factor (OF)	:	85.85 %			

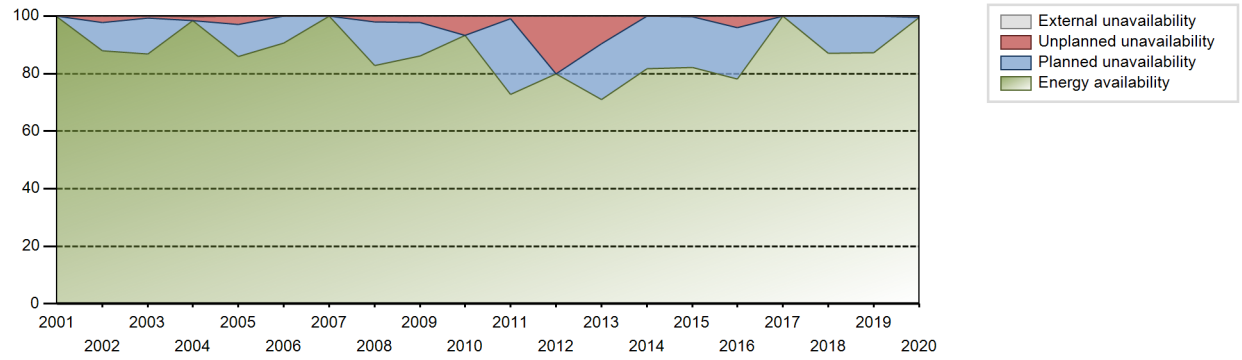
Electricity Production (net) [GWh]



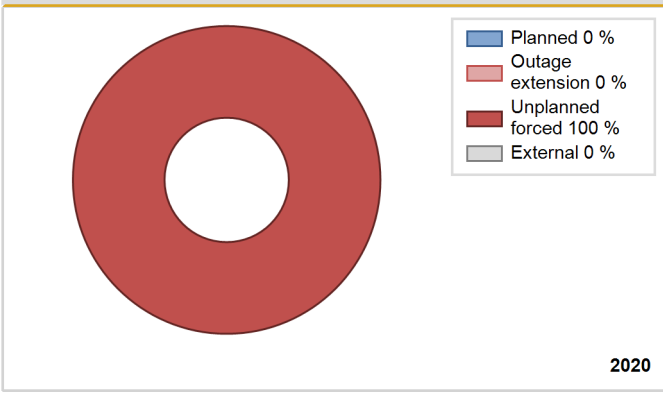
Year	Energy	Time Online	Reference Unit Power	Performance for Years of Commercial Operation							
				EAF	UCF	LF	OF	FLR	UCL	PUF	XUF
	[GW-h]	[Hours]	[MW]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1985	3814.03	4350	1144	100.00	100.00	90.60	96.21	0.00	0.00	0.00	0.00
1986	6966.06	6416	1128	73.01	73.01	70.50	73.24	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

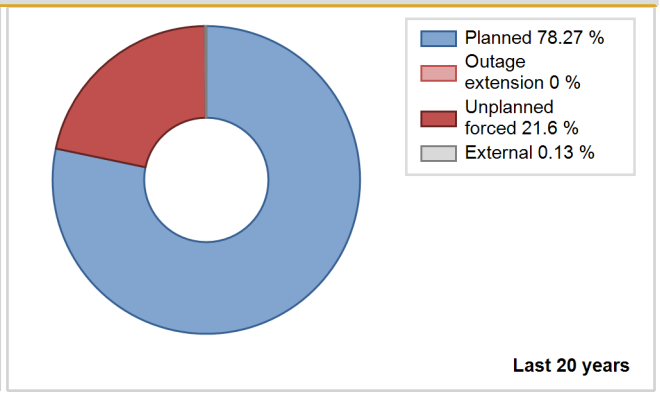
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Key Factors in Last 20 Years [%]



Energy Losses by Type





Full Outages, Analysis by Cause

Outage Cause	2020			1985 to 2020		
	Hours Lost			Average hours lost per reactor-year		
	Planned	Unplanned	External	Planned	Unplanned	External
A. Plant equipment problem/failure					200	
C. Inspection, maintenance or repair combined with refuelling				889	10	
D. Inspection, maintenance or repair without refuelling				52		
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					79	
N. Environmental conditions (lack of cooling water due to dry weather, cooling water temperature limits, flood, storm, lightning, etc.)						4
Z. Other		40			7	
Subtotal		40		941	299	7
Total		**40**			**1247**	

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Equipment Related Unplanned Full Outages, Analysis by System

System	2020	1985 to 2020
	Hours Lost	Average hours lost per reactor-year
11. Reactor and Accessories		19
12. Reactor I&C Systems		10
15. Reactor Cooling Systems		11
16. Steam generation systems		29
17. Safety I&C Systems (excluding reactor I&C)		5
31. Turbine and auxiliaries		3
32. Feedwater and Main Steam System		49
33. Circulating Water System		3
34. Miscellaneous Systems		10
35. All other I&C Systems		6
41. Main Generator Systems		59
42. Electrical Power Supply Systems		5
Total		**209**

Highlights (2020)

Shutdown due to containment leakage rate exceeding acceptance criteria. Adjustment of a retaining ring and T-Ring were completed. Event Notification 54508 was made. LER is pending.

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6. NON-ELECTRICAL APPLICATION OF NUCLEAR ENERGY IN MEMBER STATES

Table 6.1: District heating and process heat in 2020

Country	Reactor	District heating [Gcal]	Process heat [Gcal]	Total heat [Gcal]
Bulgaria	**Kozloduy-5**	107837	NA	107837
	Kozloduy-6	22981	NA	22981
Czech Republic	**Temelin-1**	90554	NA	90554
Hungary	**Paks-2**	145	NA	145
	Paks-3	5270	NA	5270
	Paks-4	40391	NA	40391
India	**Rajasthan-2**	NA	35089	35089
	Rajasthan-3	NA	326010	326010
	Rajasthan-4	NA	14290	14290
Romania	**Cernavoda-1**	45834	NA	45834
	Cernavoda-2	37425	NA	37425
Russia	**Balakovo-1**	18843	0	18843
	Balakovo-2	12612	0	12612
	Balakovo-3	6500	0	6500
	Balakovo-4	11779	0	11779
	Beloyarsk-3	248434	0	248434
	Bilibino-2	38919	NA	38919
	Bilibino-3	69022	NA	69022
	Bilibino-4	66134	NA	66134
	Kalinin-1	15929	0	15929
	Kalinin-2	209526	0	209526
	Kalinin-3	76329	0	76329
	Kalinin-4	67592	0	67592
	Kola-1	5062	0	5062
	Kola-2	2965	0	2965
	Kola-3	5926	0	5926
	Kola-4	1222	0	1222
	Kursk-1	63263	3467	66730
	Kursk-2	316477	300	316777
	Kursk-3	180992	22222	203214
	Kursk-4	329716	23262	352978
	Leningrad-2	45010	0	45010
	Leningrad-3	205222	0	205222
	Leningrad-4	303913	0	303913
	Novovoronezh-4	244630	0	244630
	Novovoronezh-5	13717	0	13717
	Smolensk-1	174343	6318	180661
	Smolensk-2	260543	22920	283463
	Smolensk-3	166882	5462	172344
Slovakia	**Bohunice-3**	216518	0	216518
	Bohunice-4	168495	0	168495
Switzerland	**Beznau-1**	119087	NA	119087
	Beznau-2	11451	NA	11451
	Goesgen	NA	71144	71144

Ukraine	**Khmelnitski-1**	106857	NA	106857
	Khmelnitski-2	143816	NA	143816
	Rovno-1	34386	NA	34386
	Rovno-2	66026	NA	66026
	Rovno-3	91094	NA	91094
	Rovno-4	131891	NA	131891
	South Ukraine-1	76186	NA	76186
	South Ukraine-2	121567	NA	121567
	South Ukraine-3	137806	NA	137806
	Zaporozhye-1	127721	NA	127721
	Zaporozhye-2	88562	NA	88562
	Zaporozhye-3	70431	NA	70431
	Zaporozhye-4	63879	NA	63879
	Zaporozhye-5	72949	NA	72949
	Zaporozhye-6	54330	NA	54330

Table 6.2: Water desalination in 2020

Country	**Reactor**	**Thermal energy [Gcal]**	**Electrical energy for reverse osmosis [MWh]**	**Water produced [m3]**
Japan	**Genkai-3**	11781	NA	167552
	Genkai-4	3981	NA	59804
	Ohi-3	0	NA	694476
	Takahama-3	0	NA	290788