# Country Nuclear Power Profiles

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# FOREWORD

The preparation of Country Nuclear Power Profiles was initiated within the framework of the IAEA's programme for nuclear power plant performance assessment and feedback. It responded to a need for a database and a technical document containing a description of the energy and economic situation and the primary organizations involved in nuclear power in IAEA Member States. The task was included in the IAEA's programmes for 1993/1994 and 1995/1996.

In March 1993, the IAEA organized a Technical Committee meeting to discuss the establishment of country data "profiles", to define the information to be included in the profiles and to review the information already available in the IAEA. Two expert meetings were convened in November 1994 to provide guidance to the IAEA on the establishment of the country nuclear profiles, on the structure and content of the profiles, and on the preparation of the publication and the electronic database. In June 1995, an Advisory Group meeting provided the IAEA with comprehensive guidance on the establishment and dissemination of an information package on industrial and organizational aspects of nuclear power to be included in the profiles. The group of experts recommended that the profiles focus on the overall economic, energy and electricity situation in the country and on its nuclear power industrial structure and organizational framework. In its first release, the compilation would cover all countries with operating power plants by the end of 1995. It was also recommended to further promote information exchange on the lessons learned from the countries engaged in nuclear programmes.

For the preparation of this publication, the IAEA received contributions from the 29 countries operating nuclear power plants and Italy. A database has been implemented and the profiles are supporting programmatic needs within the IAEA; it is expected that the database will be publicly accessible in the future.

The IAEA is grateful to M.J. Crijns, R. Chehade and S. Hämäläinen for the preparation of this publication. The IAEA officer responsible for overall co-ordination and preparation was R. Spiegelberg-Planer of the Nuclear Power Engineering Section, Division of Nuclear Power and the Fuel Cycle.

## *EDITORIAL NOTE*

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# INTRODUCTION

# INTRODUCTION

## BACKGROUND

Nuclear power provides about 17% of the world's electricity, as more than 440 plants are operating in about 30 countries. As part of its programmes in the field of nuclear power, the IAEA compiles information from its Member States about the operational and institutional framework of their nuclear power programmes, among other aspects. Technical data additionally is maintained and analyzed through the IAEA's databases covering energy, electricity, and nuclear power status and trends. These include the Power Reactor Information System (PRIS) and the Energy and Economic Data Bank (EEDB), which have long assisted Member States by serving as central sources of reliable information in the field.

This publication compiles background information on the status and development of nuclear power programmes in countries having operating nuclear plants as of 1 January 1996; presents historical information on energy supply and demand provided in the period 1995–1996; reviews the organizational and industrial aspects of nuclear power programmes in participating countries for the same period; and provides information about the relevant legislative, regulatory, and international framework in each country at year end 1996. Topics such as radioactive waste management and research programmes are for the most part not discussed in detail. Statistical data about nuclear plant operations and energy use are largely drawn from the PRIS and EEDB sources as of year end 1996 and 1994, respectively, although national contributions sometimes contain 1993 statistical data.

The compilation's main objectives are to consolidate information about the nuclear power infrastructures in participating countries, and to present factors related to the effective planning, decision-making, and implementation of nuclear power programmes that together lead to safe and economic operations. Altogether 29 IAEA Member States having operating nuclear power plants as of 1 January 1996 and Italy contributed information to the document's major sections. Designated experts from these countries participated in a series of advisory and consultants meetings covering specific subject areas, as well as the structure, scope, and preparation of the publication. Its descriptive and statistical overview of the overall economic, energy, and electricity situation in each country, and its nuclear power framework is intended to serve as an integrated source of key background information about nuclear power programmes in the world. It is planned to update the publication biannually and to expand its scope of coverage.

Although each of the 30 profiles in this publication is self-standing and contains information provided by the respective national authorities, some general findings were reported by a Group of Experts convened by the IAEA in June 1995 to review the available information. These general findings follow:

Each country has adopted specific structures and set up its procedures for nuclear power development and use which generally reflect its political and economic situation as well as the international context. The review shows that in the main, countries have kept their initially established nuclear power sector structure, state-owned, private or joint, except for some marginal changes. In the United Kingdom the electricity supply industry was privatized in 1990. Their experience was that the principles and procedures utilized to privatize other sectors of electricity generation could not then be directly applied to the nuclear power sector, which still remains in the public sector.

Even in countries where private ownership of public services is the general rule, the capital stock of all companies involved in the nuclear industry s is not totally private. For example, in the USA, there are federal agencies such as Tennessee Valley Authority (TVA) and municipalities that are shareholders of some power stations, and in Japan State-owned reactors are connected to the electricity network.

The development of nuclear energy in the profiled countries indicates that the technical and economic performance of nuclear power is not dependent on whether it is privately or government owned. Some countries, including Argentina, developed efficient nuclear electricity generation programmes in the hands of the public sector, whereas others have attained similar results under a majority private ownership. In most countries the scientific and technological development of nuclear power is mainly financed through public funds. In certain cases, the government co-operates with private enterprise during the stages of technological transfer and industrial development. Some countries show relatively low capital costs and construction times, often based on the use of standard designs and stable long-term nuclear polices. Such policies imply a long-term planning framework and close co-ordination between the designers and operators of nuclear facilities and the government, which provide stability of the licensing procedures and regulatory regimes.

The cost structure of nuclear generated electricity, which calls for a major initial capital investment, makes the economics of its development very sensitive to the rate of return required by the plant's financiers. The competitiveness of nuclear power has been demonstrated in many countries which have developed nuclear programmes based upon a long-term strategy. On the other hand, in countries where licensing processes and regulations have changed substantially over short periods of time, the changes have proven to be highly detrimental to the competitiveness of nuclear power particularly through increasing investments costs. In reviewing past experience of the nuclear electricity generating sector, it is found that in some cases investment costs have contributed to the high indebtedness of electric utilities. In some cases, the government has had to assume the debts while in other cases the government has encouraged the development of the sector with low interest rate loans. Trends towards the use of market-based rates of interest have been an important additional motivating factor in directing reactor research and development towards plants with lower specific investment costs.

While some countries have postponed their nuclear plans for various reasons, others have adopted short and medium-term policies which favor nuclear power, on the grounds that inter alia:

- it is a low environmental impact generation source;
- it has reached commercial maturity;
- it contributes significantly to electricity supplies at a stable cost;
- it widens the diversification of energy sources and improves security of supply;
- it provides opportunities to develop and implement advanced technologies.

A review of the countries profiled here allows the following general findings to be drawn:

- initially, the government took the lead in launching nuclear programmes;
- in all countries, the government's contribution to research and development is significant and in particular the government usually leads the development of new types of reactors;
- nuclear electricity generating programmes have been undertaken only with explicit and continuing support from the government;
- policy issues applicable to nuclear activities rest mainly with public authorities;
- in all countries the government has the responsibility for safety regulation and ensures that nuclear safety is a prime requirement for nuclear power programmes;
- in the countries where the issue was addressed, the government is generally highly involved in the back-end of the fuel cycle, i.e., spent fuel management, final disposal of radioactive waste and decommissioning.

Specific characteristics of the nuclear electric sector which require special attention include the:

- need for long-term policies;
- unique aspects of nuclear activity related to potential accident liabilities;
- economic impact of evolving regulatory requirements;
- issues related to spent fuel management, final disposal of radioactive waste, and decommissioning.

## STRUCTURE AND CONTENTS OF THE PROFILES

The following structure was developed by participating national experts in 1995 and has been used by the national contributors as a guidance to complete their country nuclear power profile.

1. GENERAL INFORMATION

**1.1. General Overview**

- Geographic situation, climate, etc. (brief description covering only information which is relevant in connection with energy/nuclear power) {1}.
- Population (total, density, growth rate) {2}.

**1.2. Economic Indicators {2}**

- Gross Domestic Product (GDP) (total, per capita, per sector, growth rate).

**1.3. Energy Situation {2}**

- Primary energy resources and reserves (fossil fuels, renewable sources, uranium).
- Primary energy consumption (energy supply/demand balance last year and time series, energy consumption per capita and per sector, import/export balance).

**1.4. Energy Policy {1}**

Brief description of current energy policy in terms of independence of the sector, use of domestic resources, market driven, etc.

2. ELECTRICITY SECTOR

**2.1. Structure of the Electricity Sector {1}**

Description of the overall structure of electricity sector (Utilities, Independent Producers, Transmission and Distribution), indicating whether centralized or decentralized, private or public owned.

**2.2. Decision Making Process {1}**

General description of the decision making process in the electricity sector, including planning the electricity system expansion.

**2.3. Main Indicators {2}**

- Total electricity production and consumption and per capita consumption;
- Installed generation capacity, production, load factor by source (fossil fuels, nuclear, hydro, other renewable sources);
- Share of electricity in total energy consumption.

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{1} Information to be supplied by experts from Member States.
{2} Information already available to the IAEA Secretariat. However, additional information may be provided by national experts and will be taken into account by the Secretariat.

3. NUCLEAR POWER SITUATION

### 3.1. Historical Development {1}

Brief overview on the main decisions and events related to the implementation and development of the nuclear programme.

### 3.2. Current Policy Issues {1}

Main issues related to present nuclear power policy, e.g., moratorium, public acceptance, privatization, safety and waste management issues, availability of funding.

### 3.3. Status and Trends of Nuclear Power

- Nuclear power plants (NPPs) in operation, under construction, closed down {2}.
- Performance of NPPs {2}.
- Nuclear electricity generation, share in total electricity generation {2}.
- Nuclear power development projections and plans {1/2}.

### 3.4. Organizational Chart(s) {1}

The chart(s) might cover institutional relationships, e.g., licensing authorization, financial relationships, i.e., share holding, and technical/operational relationship, i.e., supply of equipment, materials or services.

4. NUCLEAR POWER INDUSTRY {1}

Main organizations, institutes and companies involved in nuclear power related activities; the boundaries of 'nuclear power activities' might be adapted to the national situation according to the judgment of the drafter; whenever possible, organizational charts should be provided, a short text describing the various entities is desirable but not essential. Each country should indicate the criteria to choose the main organizations presented in this section.

### 4.1. Supply of NPPs

Including architect engineer, NSS and main component suppliers.

### 4.2. Operation of NPPs

Indicating owners/operators if relevant, operation and maintenance service suppliers and operator training.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management Service Supply

Covering all activities from uranium mining to spent fuel management and waste disposal.

### 4.4. Research and Development Activities

Institutes, research centres, etc., independent from the companies listed above, e.g., Atomic Energy Commissions, National Laboratories.

### 4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

Brief description of research and development activities carried out jointly with other countries and/or within the framework of international projects, technical and industrial co-operation, transfer of know-how and technology.

5. REGULATORY FRAMEWORK {1}

### 5.1. Safety Authority and the Licensing Process

Brief description of the role and responsibilities of the safety authority and the overall licensing process for nuclear facilities.

### 5.2. Main National Laws and Regulations

List of the essential legal texts regulating nuclear power in the country, with reference to the original publications; including a brief summary of the mechanisms in place for financing decommissioning and waste disposal.

### 5.3. International, Multilateral and Bilateral Agreements

List of international conventions, bilateral agreements, etc. signed/ratified by the country in the field of nuclear power.

ANNEX 1 {1}

Directory of the main organizations, institutions and companies involved in nuclear power related activities, as mentioned in Chapter IV (name, address, contact point, i.e. telephone, telefax, e-mail, main activities, share holders, production capabilities).

ANNEX 2 {1/2}

References (used in the profile).
Bibliography (suggested reading for more detailed information).

# ARGENTINA

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## ARGENTINA

# 1. GENERAL INFORMATION

## 1.1. General Overview

Located in southern South America, Argentina is bounded by Bolivia and Paraguay on the north; by Brazil, Uruguay, and the Atlantic Ocean on the east; by the Atlantic Ocean and Chile on the south; and by Chile on the west. The north to south length of Argentina is about 3,330 km; its extreme width is about 1,384 km. The area of Argentina is 2,766,889 square km; it is the second largest South American country. The Argentine coastline measures 2,665 km in length.

Table 1 shows historical population information. Argentina's population was 34,182,000; about 85% of which live in urban areas, in 1994. More than one-third of the population (2,960,976 in 1991) lives in or around of Buenos Aires, the capital and the largest city. The heavy populated suburban areas had a population of 8,294,642 the same year. Other important cities are Córdoba (metropolitan area population of 1,119,926), a major manufacturing and university city; the river port of Rosario (metropolitan area population of 1,095,906); Mendoza (metropolitan area population of 773,559); Tucumán (population 622,348); Mar del Plata (519,707).

Argentina is comprised of 23 provinces and the self-governing Federal District of Buenos Aires. According to the constitution (amended in 1994), Argentina is a federal republic headed by a president, assisted by ministers and secretaries.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 20.6 | 24.0 | 28.1 | 32.5 | 33.8 | 34.2 | 1.4 |
| Population density (inhabitants/km²) | 7.5 | 8.7 | 10.2 | 11.8 | 12.2 | 12.4 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 1.2 |
| Area (1000 km²) | 2766.9 |
| Urban population in 1993 as percent of total | 87.0 |

Source: IAEA Energy and Economic Data Base

Argentina has a diverse territory of mountains, upland areas, and plains. The western boundary of the country is within the Andes mountain system. Eastward from the base of the Andean system, the terrain of Argentina is almost entirely flat or gently undulating plain. The Pampas, treeless plains that include the most productive agricultural sections of the country, extend nearly 1,600 km south from Chaco. In Patagonia, south of the Pampas, the terrain is largely arid, desolate steppes.

Temperate weather conditions prevail throughout most of Argentina, except for a small tropical area in the north-east and the subtropical Chaco region in the north. Near Buenos Aires the average annual temperature is a mild 16.1°C. January and July averages for this area are 23.3° C and 9.4° C, respectively. Considerably higher temperatures prevail near the tropic of Capricorn in the north. The annual average temperature in this region is 23.3°C with extremes as high as 45°C. Weather is generally cold in Patagonia and Tierra del Fuego. In the western section of Patagonia winter temperatures average about 0°C. In most coastal areas, however, the ocean exerts a moderating influence on temperatures.

Precipitation in Argentina has wide regional variations: south and west are semiarid, but the extreme north gets more than 152 cm of rainfall annually. Near Buenos Aires annual rainfall is about 102 cm.

## 1.2. Economic Indicators

Table 2 shows the Gross Domestic Product (GDP), GDP per capita, their growth rates and the GDP by sector.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 31,424 | 82,559 | 141,350 | 255,595 | 281,924 | 9.2 |
| GDP (millions of constant 1990 US$) | 120,338 | 154,856 | 141,350 | 177,353 | 190,513 | 1.5 |
| GDP per capita (current US$/capita) | 1,311 | 2,937 | 4,343 | 7,566 | 8,248 | 7.7 |
| GDP by sector : Agriculture 6%, Industry 31%, Services 63% | | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.3. Energy Situation

Most rivers and waterfalls with potential energy are far from the industrial centres, but despite these limitations water resources have been widely developed in Argentina (hydraulic resource potential is 1,926,000 Tj). Major hydroelectric projects undertaken in the 1970's and 1980's are in the northern Patagonia, on the Paraná River (a joint project with Paraguay), and on the Uruguay River (in co-operation with Uruguay).

Although the country has a variety of mineral deposits (only one fifth of the country has been surveyed), mining has been relatively unimportant, contributing only 0.2% to Gross Domestic Product (GDP). Since the gas and petroleum sector privatisation, exploration for hydrocarbons has increased significantly. Proven natural gas reserves amount to 579 million metric tons. Coal reserves in Argentina are limited: lignite deposits are estimated at 195 million Mt and peat at 90 million Mt. Argentina has moderate uranium resources (proven reserves of 2,190 metric tons), see Table 3. Table 4 shows the energy statistics.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 2.94 | 9.03 | 23.74 | 3.05 | 51.57 | 90.33 |

[1] This total represents essentially recoverable reserves.

[2] For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.

Source: IAEA Energy and Economic Data Base

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[(1)] | 0.68 | 1.26 | 1.77 | 2.05 | 2.38 | 2.47 | 4.87 | 2.39 |
| - Solids[(2)] | 0.04 | 0.10 | 0.11 | 0.09 | 0.09 | 0.10 | 4.56 | -0.31 |
| - Liquids | 0.58 | 0.94 | 1.10 | 0.84 | 0.98 | 0.93 | 3.22 | -1.18 |
| - Gases | 0.05 | 0.21 | 0.40 | 0.88 | 0.99 | 1.09 | 11.15 | 7.45 |
| - Primary electricity[(3)] | 0.01 | 0.01 | 0.17 | 0.25 | 0.32 | 0.35 | 15.83 | 5.29 |
| Energy production | | | | | | | | |
| - Total | 0.44 | 1.15 | 1.66 | 2.18 | 2.61 | 2.87 | 6.80 | 4.00 |
| - Solids | | 0.08 | 0.08 | 0.06 | 0.07 | 0.07 | 15.94 | -1.02 |
| - Liquids | 0.38 | 0.85 | 1.08 | 1.09 | 1.32 | 1.47 | 5.31 | 2.21 |
| - Gases | 0.05 | 0.21 | 0.33 | 0.79 | 0.92 | 1.00 | 10.06 | 8.29 |
| - Primary electricity[(3)]) | 0.01 | 0.01 | 0.17 | 0.24 | 0.30 | 0.34 | 15.82 | 5.10 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.25 | 0.12 | 0.14 | -0.11 | -0.20 | -0.38 | -2.85 | -7.41 |
| - Solids | 0.04 | 0.02 | 0.02 | 0.03 | 0.02 | 0.03 | -2.82 | 1.96 |
| - Liquids | 0.21 | 0.10 | 0.05 | -0.22 | -0.29 | -0.50 | -7.19 | -18.34 |
| - Gases | | | 0.07 | 0.09 | 0.07 | 0.09 | | 1.80 |

[(1)] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*

[(2)] *Solid fuels include coal, lignite and commercial wood.*

[(3)] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*

Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

As a result of governmental policies during the last 30 years the electricity sector has been characterised by:

- *Diversification of energy source technologies:* The utilisation of hydroelectric resources and the development of nuclear technology have reduced the share of fossil fuels to 42% of the total in 1994 relative to 93% in 1972.
- *Reduced consumption of oil in thermal power stations:* Current oil consumption (1 440 000 toe in 1990) is comparable to that of the early 50's, even though power generated by thermal stations has increased fivefold - as a result of intensive use of natural gas.
- *Nation-wide electric transmission and distribution system:* Electrification index is 95% in urban areas and above 86% at the national level.
- *Low participation to self-generation in Argentina's supply of electricity:* Currently self-generation accounts for only 11% of electricity generation relative to 20% in the late 1960's;
- A highly integrated interconnected system.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

In the forties Argentina began establishing state-owned energy companies, nationalising foreign owned energy utilities and defining energy plans to fully integrate the national planning scheme. The plans used advanced planning methodologies and considered the integration of electricity within the global energy system. Plans were mainly promulgated by the Secretary of Energy and agencies in charge of global economic planning with the participation of national public energy companies.

Despite the political instability and the successive changes in the economic and institutional policies, the plans designed by the state owned energy companies transformed the electricity system. The electricity system expanded significantly from 1970 when it covered 54% of the population to today's 90% of the population. An interconnected electrical grid system now supplies 90% of the country's requirements. Domestic energy resources are utilised, particularly renewable sources, thus diversifying the mix of primary energy sources.

In 1980's the country's economical crisis, together with a burdensome foreign debt, resulted in critical conditions for the electricity system. At the same time, institutional decentralisation led to the proliferation of many provincial electricity distribution and production companies, and to the dispersion of tariffs and economic regulations within the electricity system. Later, due to State reform initiated in 1990, the institutional structure and regulation of all energy-related activities underwent substantial modifications. The energy policy was based on a free market economy bolstered by private sector investments in the energy system.

Materialisation of this policy began with privatisation of Servicios Eléctricos Gran Buenos Aires (SEGBA), along with Agua y Energía's hydro and fossil fuel stations, hydropower stations owned by Hidronor, and the Sistema Interconectado Nacional (high voltage transmission network).

From the organizational point of view, Argentina's electricity sector shows a historical development similar to that of most European and Latin American countries. Since its origins until after the World War II, electricity supply was in private hands, subject to the control of local authorities who granted operation licenses and developed franchises within their respective jurisdictions.

State companies involved in the supply of electricity have grown since 1945, and in 1990 they owned 84% of Argentina's generating capacity. In the late 1980's, the government introduced changes to the organization, regulation, and the ownership of electricity companies including the privatisation of most facilities owned by SEGBA, Hidronor and Agua y Energía. Before the reform, electricity was supplied by a number of utilities with different legal standings and functional dependencies, although state agencies controlled 99% of the installed generating capacity.

In the mid 1960's a decentralisation process began with the creation of state-owned generating companies. Decentralisation was further intensified in 1980 with the transfer of distribution networks from one of the state companies, Agua y Energía, to the provincial governments. This decision from central administration encouraged the creation of new provincial agencies and made regulation more complex.

The federal government kept the primary responsibility for planning expansions in electricity generation and high voltage transmission. Six state agencies are responsible for the construction and operation of the facilities. Decentralised power generation led to a significant wholesale electricity market regulated by the federal government through the Load Dispatching Centre (Despacho Nacional de Cargas).

Electricity distribution to end-users was carried out by more than 600 organizations: two state companies (supplying 55% of electricity consumption nation-wide), 21 provincial companies (34% of consumption) and some 580 co-operatives (11% of consumption). Provincial companies can only operate within the boundaries of their respective provinces, while co-operatives can provide services in municipal areas. The right of provincial and municipal regulators to determine the end-users' electricity tariffs and their independence to fix taxes on electricity consumption within their jurisdictions led to a great price discrepancy among users with similar consumption patterns.

Institutional changes and a stiff regulatory framework impaired the performance of the electricity sector before the sector reform. Efficiency of state-owned utilities was affected by politically fixed low tariffs and indebtedness in recent years which lead to supply crisis. The most noticeable signs in the technical phase were the unavailability of thermal generating equipment which necessitated streamlined electricity consumption in 1988/89 under conditions of low water inflows; increase in distribution losses up to 23% of sales; and construction delays which increased average fuel consumption through expanded use of gas turbines. Reorganization of Argentina's electricity sector, both on regulatory and institutional levels, was realised upon the approval of Law 24,065 of January 1992, which sanctioned the transfer of facilities to private hands through the privatisation process begun in May 1992.

The new legal framework has organizational and regulatory impacts on the activities that are carried out under national jurisdiction, since the provinces have only partially joined the national framework. Despite of the diversity of regulatory jurisdictions, the fact that the state companies dominated electricity generation and transmission systems before the reform has assured national jurisdiction over these industry segments that are central to the wholesale electricity market. Between April 1992 and April 1995, 9830 MW(e) of installed capacity held by SEGBA (2,480 MW(e)), Agua y Energía (2,800 MW(e)) and Hidronor (4,290 MW(e)) were transferred to private operators. Of the above capacity, 37 % is fossil fuel fired steam turbines; 15% gas turbines and the remaining 48% hydro stations.

Provincial jurisdiction covers primarily electricity distribution, which is carried out largely by provincial companies who buy electricity at the wholesale market. Provincial companies who own power stations are subject to national rules for the operation of the system if they use transmission lines or sell their excess generation in the wholesale market. The new regulatory regime covers the electricity industry where institutional organization and ownership patterns differ from regulations that were in effect until the late 1991. Horizontal and vertical partitioning of national companies was assumed to encourage competition and to promote efficiency. The objectives of these changes, inspired to a large extent by the reforms in Great Britain, are to protect users' rights; promote market competitiveness; encourage private investment for long term supply; promote reliable operation and free access to service; regulate transmission and distribution and assure reasonable tariffs.

Participants in the electricity sector are:

i) producers, whether independent, national, bi-national or provincial, and interconnected foreign electric utilities;
ii) distributors, large consumers and interconnected foreign electric utilities;
iii) transmission companies;
iv) regulatory agencies: The Electricity Regulator (Ente Nacional Regulador de la Electricidad - ENRE) and the Wholesale Electricity Market Administrator (Compañía Administradora del Mercado Mayorista Eléctrico - CAMMESA).

Participants in each class are semi-autonomous, that is, they have limited influence outside their individual areas. The independence of transmission companies ensures free electrical grid access to third parties. Distributors have to provide for the excess electricity if they have spare capacity. Any party authorised by the Secretary of Energy to participate in the wholesale electricity market must abide by the prescribed market rules. Because of their monopolistic characteristics, power transmission and distribution systems are regulated and require granted concessions. Grid expansions are subject to market mechanisms.

Producers are subject to concessions only if they operate hydroelectric power stations. Installation of thermal power stations requires authorisation for grid connection and compliance with applicable public safety and environmental protection regulations.

Distribution is largely (65%) in the hands of provincial utilities and co-operatives due to privatisation of Agua y Energía and the transfer of its services. Of the distribution systems held by state companies, only the service in the concession area of the former SEGBA is in private hands, where now three private distribution companies are supplying some 35% of the retail electricity market.

Prior to April 1995 only one provincial distribution company Empresa Distribution de Energia de Salta (EDESAL), had been privatised, although several provinces had announced interest to privatise their services and were in process of adjusting the provincial regulatory framework to allow private electricity operators inside their jurisdictions. The role of CAMMESA is that of a wholesale electricity market administrator in commercial agreements between parties (forward contracts).

General supervision and regulation of the industry under national jurisdiction is in the hands of ENRE (Ente Nacional Regulador de la Electricidad), chartered as an independent agency within the Secretary of Energy. ENRE's main duties are:

i) enforcement of concession contracts;
ii) prevention of anti-competitive, monopolistic or discriminatory behaviour;
iii) participation to the selection of concession holders;
iv) organization and implementation of public hearings to clarify conflicts between parties;
v) environmental protection and public safety issues associated to the electricity sector.

ENRE supervises national distribution companies and settles disputes between parties as long as they operate under the national jurisdiction. The office of the Energy Secretary is the a national agency, which interacts with provincial governments in matters relating to the electricity supply industry.

All electricity supplied to the interconnected electrical system is commercialised through the wholesale electricity market. This market includes a contract market and a spot market.

The end user market is also divided into a regulated and a non-regulated segment. The non-regulated segment is open to competition among bidders, particularly large consumers. The minimum consumption threshold to access the wholesale electricity market was initially 5 MW(e), but it has now been reduced to 1 MW(e). Access thresholds must be authorised by ENRE.

State owned generating companies are under a provisional regime until privatisation is realised. Secretary of Energy establishes the rates for nuclear power, while other state owned power producers are only allowed to recover operating and maintenance costs.

Differences between outlays that state owned producers should have invoiced according to prevailing spot prices and the receipts actually received are assigned to Unified Fund for debt servicing and to fund investments for the completion of any construction in progress at the time of the reform.

### 2.2. Policy and Decision Making Process

Privatisation of state companies was implemented to encourage market competition. For this purpose, separation of generation, transmission, and distribution systems was established.

Within this framework, the Energy Secretary is responsible for:

i) defining the policies for the electricity sector;
ii) licensing newcomers to the wholesale electricity market;
iii) establishing the rules with which the electricity supply industry must comply;
iv) authorising the allocation of funds to state companies; and,
v) deciding on the respective awards during the privatisation process.

In order to attend to the technical management of the system and to administer the wholesale electricity market, Load Dispatching Centre became a stock corporation, CAMMESA, with an equity interest held by the Secretary of Energy and by different utilities in the wholesale market. The Secretary of Energy may reduce its capital share in CAMMESA to 10%, and still retain the power of veto to Board decisions. CAMMESA is the electricity system's technical authority.

Presently Argentina plans to develop an integrated resource planning and decision making process aimed at co-ordinating the functions of its diverse institutional system and assuring thorough participation of all sectors, public and private. Mechanisms related to the electrical system expansion, economic management and regulation with mitigating impact on the environment have not been defined.

In accordance with constitutional principles, riverside provinces own the water resources utilised by the hydroelectric companies. The provinces grant licenses for commercial operations, even though existing facilities belong to the Federal State, and collect generation royalties.

Provincial governments also authorise the construction of new projects in their respective territories, provided that the new companies do not join the wholesale electricity market through business transactions or through transmission or distribution networks under national jurisdiction.

In the regulated segment, a distributor is assured a monopoly and has to meet the required electrical demand pursuant to the terms of the concession contract. If no private investors are interested in distributing electricity to certain areas, then the State has the obligation to supply the service there.

Concession contracts specify technical and commercial quality of service which concession holders are obligated to provide. The obligations of the company are not subject to electricity availability in the wholesale market, and the State takes no commitment to solve potential power shortages.

The tariffs in this market segment cover all distribution costs (network expansion, operation and maintenance, marketing and the cost of purchasing electricity in the wholesale market) including a rate of return fixed by ENRE. In the future, wholesale spot price variations will be passed by distributors directly to customers.

Everyone in the wholesale electricity market participates directly or indirectly in the spot market. The operation of this market is managed by CAMMESA. The operation of interconnected generating units is scheduled by CAMMESA for six month seasonal periods to cover demand forecasts with the reserve agreed between the parties (economic load dispatching). The average seasonal marginal cost is the base price from which the price to the distributors is calculated. Distributors pay a differential price depending on their location in the system, which reflects their contribution to transmission losses.

Distributors also pay a fixed charge for their average estimated demand for power over the next five years. The risk associated with this estimate is borne by the distributors who must assume the payments in the event of overestimation of demand and are penalised in the event of underestimation. In addition, distributors contribute toward CAMMESA's expenses by paying a fixed connection charge and a transmission capacity charge to transmission companies.

Electricity suppliers are compensated for:

i) the energy supplied by a plant run according to schedule, at the system's marginal cost;
ii) the energy supplied by a plant required to run as a result of technical constraints, and costs are reimbursed;
iii) start-up costs derived from CAMMESA's requests;

iv) power made available to the system (cold reserve), at a price fixed by bidding among generators.

The price for power supplied by bi-national producers is determined in the terms of their contracts. Foreign interconnected utility companies have to apply for authorisation from the Secretary of Energy to participate in the wholesale electricity market. In this way they are assured of their reserve and do not resort to sell at dumping prices.

Payment to transmission companies includes a connection charge, a fixed charge for transmission capacity and a variable charge for the energy actually transmitted. The variable charge is proportional to the transmission losses.

Distributors and large users may enter into supply contracts with producers at the prices defined in their contracts. State companies are excluded from this market. ENRE does not intervene in the supervision of these contracts or in any contractual disputes.

Entering into forward contracts does not prevent distributors from power purchases in the spot market at stabilised prices unless they have contracted more than 60% of their demand, in which case they are considered to be occasional users and their transactions are subject to availability determined at the hourly price paid to generators. Large users, on the contrary, must be supplied by the local distributor unless supply is contracted with a producer for at least 50% of their demand.

The operation in real time is carried out irrespective of any forward contracts signed with producers with the premise that any departure from contract volumes and the actual operation will be channelled through the spot market. A similar criterion applies for demand departures pertaining to the large users under contract. These are subject to penalties similar to those applied to distributors in the event of forecasting errors in their own demand.

A Stabilisation Fund managed by the Secretary of Energy has been created to account for the differences between the expenditures paid by purchasers and the revenue received by generation and transmission companies.

### 2.3. Main Indicators

Argentina's electricity consumption grew at an average annual rate of almost 8% between 1970 and 1980, levelling off to 2.5% average rate during 1980-1991. This is partly explained by production increases in the metallurgy, which is an energy intensive industry. Energy consumption in residential and commercial sectors, however, suffered the most due to the imposed rationing system during the energy crisis, although the number of customers grew and electricity billed per customer during the 1980-1987 amounted to 4,000 kW·h/year. In 1993 per capita electricity consumption was 1,903 kW·h, a figure slightly above the Latin American average. Table 5 shows the historical energy production and the installed capacity and Table 6 the energy related ratios.

Total electricity consumption in 1993 was 64.3 TW·h. Total net installed capacity of electricity generating plants in 1993 was 18,035 MW, of which thermal accounted for 10,026 MW, hydro 6,991 MW and nuclear 1,018 MW. Of the total electricity generated, 44.5% comes from hydroelectric power stations, thermal energy sources account for 41% and nuclear 13%.

Electricity consumption is frequently viewed as an indicator of the level of economic activity. Thus, an increase in electricity consumption is immediately associated to an increase in economic production. However, a few comparisons conflict with this view: in the 1970-1991 period per capita electricity consumption grew at an average annual rate of 3.4% whereas per capita GDP grew by 1.2%. Moreover, during the 1980-1991 period, if the same figures are considered, as GDP decreased to 0.77%, per capita electricity consumption grew to almost 1% per annum. In 1975, 1978 and 1982, while GDP decreased, electricity consumption did not follow the same trend.

Electricity consumption can also be regarded as an indicator of trends in the informal economy, where electricity is used for production, but is not recorded as an economic activity in formal statistical surveys or considered in GDP measurements.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 10.46 | 21.73 | 39.68 | 50.91 | 62.53 | 66.20 | 6.89 | 3.72 |
| - Thermal | 9.53 | 20.17 | 22.19 | 26.15 | 31.21 | 31.13 | 4.31 | 2.45 |
| - Hydro | 0.93 | 1.56 | 15.15 | 18.13 | 24.15 | 27.39 | 14.99 | 4.32 |
| - Nuclear | | | 2.34 | 6.62 | 7.18 | 7.68 | | 8.86 |
| - Geothermal | | | | | | | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 3.47 | 6.69 | 11.99 | 17.21 | 18.04 | 19.61 | 6.39 | 3.58 |
| - Thermal | 3.13 | 6.08 | 7.99 | 9.65 | 10.11 | 10.67 | 4.79 | 2.08 |
| - Hydro | 0.34 | 0.61 | 3.63 | 6.62 | 6.99 | 8.01 | 12.56 | 5.82 |
| - Nuclear | | | 0.37 | 0.94 | 0.94 | 0.94 | | 6.85 |
| - Geothermal | | | | | | | | |
| - Wind | | | | | | | | |

[1] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 33 | 52 | 63 | 63 | 70 | 72 |
| Electricity per capita (kW·h/capita) | 507 | 852 | 1,362 | 1,549 | 1,840 | 1,911 |
| Electricity production/Energy production (%) | 23 | 17 | 22 | 22 | 22 | 22 |
| Nuclear/Total electricity (%) | | | 6 | 13 | 12 | 12 |
| Ratio of external dependency (%)[1] | 37 | 10 | 8 | -5 | -8 | -15 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 34 | 37 | 38 | 34 | 40 | 39 |
| - Thermal | 35 | 38 | 32 | 31 | 35 | 33 |
| - Hydro | 31 | 29 | 48 | 31 | 39 | 39 |
| - Nuclear | | | 72 | 81 | 88 | 94 |

[1] *Total net import / Total energy consumption*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

A few years after the nuclear explosions of 1945 that brought world-wide awareness of nuclear energy, the first steps were taken to create the Comisión Nacional de Energía Atomica (CNEA), Argentina's Atomic Energy Commission in charge of all national nuclear activities.

Since the creation of CNEA several distinct periods of activity have occurred. The first period saw the organization of the first research and development teams; staff nuclear training primarily in more advanced countries; training of physicists through the creation of the Balseiro Institute of Physics; prospects for uranium exploration in Argentina; and, the construction of the first experimental 10 kW(t) Argonaut type reactor including its fuel elements.

During the second period, Argentina designed and constructed a 5 MW(t) irradiation and research reactor; promoted metal research and development; and, manufactured the fuel elements required by that reactor. The first uranium concentrate production plant was built in Malargüe (Province of Mendoza) and a battery leachate plant in Don Otto (Province of Salta). Radioisotope production and application techniques in the field of medicine, biology, industry and agriculture were developed.

In the third period, Argentina began nuclear energy activities. In 1964, CNEA was considering the construction of a nuclear power station for the Greater Buenos Aires-Litoral electrical system. A feasibility study was authorised by a national commission for the co-ordination of large electrical works. Within fourteen months, the Commission completed the study with the recommendation to build a 300- 500 MW(e) nuclear power station within the Greater Buenos Aires-Litoral electric power system. The study concluded that such a station could commence operation by 1971, and that the project would be technically feasible, economically convenient, and financially sound. Furthermore, Argentinean industry would be able to contribute an estimated 40 to 50 percent toward the construction and operation of the station. Sufficient deposits of indigenous uranium added to the appeal of nuclear power together with its expected stimulation to scientific and technological activities.

With the prospects of the nuclear energy generation in Argentina, CNEA had to first decide whether to purchase a light water or a heavy water reactor. British and the US suppliers offered enriched uranium reactors. Despite of the strong preference for independence CNEA entertained bids for these reactors for two reasons. First, light water reactors were less expensive than heavy water reactors, and were dominating the markets in the United States, Europe, and Japan. The second reason was tactical, for it was perceived that encouraging more bids would spike up the competition, and better terms would be offered by firms eager to gain foothold in a new market.

However, the Canadian and German offers were most attractive. The German offer was for a natural uranium reactor, with 100 percent financing, 35 percent local participation, and the shortest delivery time. The bid by the electrical giant, Siemens AG, of Germany was chosen for its superior financing terms, construction time, and local participation rate.

Nearly two years behind the schedule, the Atucha I nuclear power station was commissioned and began commercial operation in 1974.

Also in 1967 a feasibility study for a second station was undertaken by the provincial utility in Cordoba. CNEA was authorised to call for bids for a 600 MW(e) station, nearly double the size of the 317 MW(e) Atucha reactor in 1972. Natural uranium was selected as fuel and the contract was awarded to CANDU, a consortium of Atomic Energy of Canada Ltd (AECL) and the Italian construction company, Italimpianti.

The second nuclear power station was built in Embalse, on the Rio Tercero Reservoir in the province of Cordoba. It was commissioned in 1983 and went into commercial operation in January 1984. A prime attraction of the Canadian offer had been the Technology Transfer Agreement, which CNEA considered valuable for independent nuclear power production.

In late 1979 a third nuclear power station was scheduled to be built at the same site as Atucha I. Problems with the construction of the Embalse nuclear power plant (NPP) convinced the authorities to award the contract to ENACE, a joint venture of Kraftwerk Union (KWU) and CNEA, for a 700 MW(e) Siemens heavy water cooled and moderated pressurised reactor power station (same design as Atucha I). Construction started in 1981.

### 3.2. Current Policy Issues

### 3.3. Status and Trends of Nuclear Power

Less than 15 percent of electricity consumed in Argentina is produced by nuclear plants. In 1995 there were two nuclear power plants (Atucha I and Embalse) in operation with a total net capacity of 935 MW(e), see Table 7. Share of electricity produced by nuclear means is 13 percent of the total electricity supplied in the country. This is expected to increase with the construction of a third nuclear power plant, Atucha II of 692 MW(e) net capacity, whose completion, however, has been delayed due to economic uncertainties in and lack of funding.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| ATUCHA-1 | PHWR | 335 | CNEA | Operational | SIEMENS |
| EMBALSE | PHWR | 600 | CNEA | Operational | AECL |
| ATUCHA-2 | PHWR | 692 | CNEA | Under Construction | KWU |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| ATUCHA-1 | 01-Jun.-68 | 13-Jan-74 | 19-Mar-74 | 24-Jun.-74 | |
| EMBALSE | 01-Apr.-74 | 13-Mar-83 | 25-Apr.-83 | 20-Jan-84 | |
| ATUCHA-2 | 01-Jun.-81 | 01-Oct-00 | 01-May-01 | 01-Dec.-01 | |

Source: IAEA Power Reactor Information System, yearend 1996

## 4. NUCLEAR POWER INDUSTRY

On August 30, 1994, an Executive Decree was issued to restructure the nuclear sector and CNEA. As a result, the National Nuclear Regulatory Agency (Ente Nacional Regulador Nuclear - ENRE) was founded. The new Agency took over the regulatory responsibilities for nuclear activities that were previously carried out by CNEA. It establishes nuclear and radiological safety standards and formulates regulations related to physical protection and control of the use of nuclear materials. It is responsible for the licensing and regulations of nuclear installations and compliance with international safeguards. In addition, a shareholders company, Nucleoeléctrica Argentina S.A. (NASA) was established. NASA operates Atucha I and Embalse nuclear power stations and oversees the construction of Atucha II nuclear power station. The decree also directed NASA to pay annual royalties to CNEA and to ENRE as licensing fees. Ownership has been handed to the Ministry of Economy, as a pre-privatisation step.

### 4.1. Supply of Nuclear Power Plants

Not provided for this report.

### 4.2. Operation of Nuclear Power Plants

Not provided for this report.

### 4.3. Fuel Cycle and Waste Management Service Supply

Not provided for this report.

### 4.4. Research and Development Activities

The Atomic Energy Commission (CNEA) remains as an institute for research and development in the nuclear field. Production activities previously carried out by CNEA, are now handled by private interests.

### 4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

Not provided for this report.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the licensing Procedures

The licensing process for nuclear power stations involves interaction between the Operating Organization and the Regulatory Authority starting at the earliest steps of a projected installation. The role of the Regulatory Authority is to establish "Requirements", "Recommendations" and "Requests for Information" and to issue construction and operation licenses. "Requirements" must be carried out by the Operating Organization. "Recommendations" should be carried out unless it is shown by the Operating Organization that they are not necessary, or that the same objective can be achieved better by other means. The "Requests for Information" are issued by the Regulatory Authority in order to further evaluate or validate studies already presented by the Operating Organization. Standard AR 0.0.1 establishes general framework for the construction, operation and regulation of nuclear power stations.

Procedures to the Regulatory Authority for applying for a nuclear operating license is described in standard AR 3.7.1. These include:

- Preliminary Safety Report (PSR) nine months prior to requesting the construction license (does not include the work for site preparation).
- Systematic presentation of information, changes in design and other requirements as needed two months after presenting the PSR and up to one month before the reactor is loaded with the reacting combination of moderator and fuel.
- Monthly Progress reports on the construction of the nuclear power stations after the granting of the construction license.
- Quality Assurance (QA) program, QA manuals and QA information starting with the presentation of the PSR. The QA program must include organizations, system of documentation, verification of the design, purchase, materials, processes, inspections, tests, and corrective actions, as well as registry and its control.
- Organization chart for Operation, and the Staff Training Program in the beginning of the construction. It should be modified when changes are proposed.
- Progress reports during "non-nuclear" commissioning 24 months prior the predicted first criticality.
- Progress reports about the commissioning up to one week prior the first criticality.
- Final Safety Report (FSR) 12 months prior the first criticality.
- Additional information and modifications to the FSR up to one month prior the reactor is charged with moderator and fuel.
- Operating Manuals including the Radiological Code of Practice four months prior the first criticality.
- Final report of the QA program four months prior the first criticality.
- Request for individual operators' licenses four months prior the first criticality.
- Emergency Plan three months prior the first criticality.
- Constitution of an Ad-hoc Committee for "Nuclear" commissioning and operation three months prior the first criticality.
- Maintenance Manuals one month before requesting the licence of operation.
- Report of the Ad-hoc Committee at the end of the Nuclear commissioning.
- Final version of the Operating Manuals at the end of the commissioning.

Construction and operating license outlines the responsibilities of the director of the nuclear power station and the Operating Organization. License is given for an undefined period and may be cancelled, suspended or modified by the Regulatory Authority in case of non-compliance to the regulations. The license can include temporary requirements. Only licensed staff can operate Nuclear power stations.

The Operating Organization must have a Technical Review Committee (TRC) and an Internal Safety Committee (ISC) which should meet at least once a month in order to analyse nuclear operations; to asses the likelihood of failures and abnormal events; and, to carry out the evaluation of any modifications to the original design of the installation before these are presented to the Regulatory Authority. The director of operations must be advised by the Internal Safety Committee on any issues related to radiological and nuclear safety.

The "conditions and the limits of operation" are established in the license and require the pre-approval of the Regulatory Authority for any modifications. The license specifies the limits of radioactive effluents to the environment and states the requirements for annual exercise of the Emergency Plan. The license also defines procedures related to the "mandatory documentation", the operators retraining programme, the communication channels with the Regulatory Authority, and the relation with the "resident" inspectors.

### 5.2. Main National Laws and Regulations

Several Executive orders have identified CNEA as the Regulatory Authority on radiological and nuclear safety, including the protection of the workers, public and the environment against the effects of ionising radiation, and the safety of the installations. During the first years of nuclear activities in Argentina, there was no clear separation of the Regulatory Authority from the main operational safety group, since almost all NPPs operated in CNEA installations. In 1958, the regulations covered the whole country. At the same time research supporting regulatory framework was initiated to establish criteria to limit discharges of radioactive material to the environment and food pathways. The regulatory setting in that time included the licensing activities, the evaluation of design and the operation of nuclear power stations, the analysis of accidents and regulatory inspections.

At present, the regulatory system covers all CNEA nuclear activities and any or the third parties in the country, as well as all uses of radionuclides and radiation, except the use of X-rays, which are controlled by the Ministry of Health.

The standards for nuclear power stations established by the Regulatory Authority are the following:

AR.3.1.1. Occupational exposure (design).
AR.3.1.2. Limits to radioactive effluents (design).
AR.3.1.3. Radiological criteria related to accidents and risk assessment analyses.
AR.3.2.1. General safety criteria applied to design.
AR.3.3.1. Reactor core.
AR.3.3.2. Heat removal System.
AR.3.3.3. Primary pressure system.
AR.3.3.4. Behaviour of fuel in the reactor.
AR.3.4.1. Protection of the core and safety instrumentation.
AR.3.4.2. Shutdown systems.
AR.3.4.3. Containment system.
AR.3.5.1. Essential electric supply.
AR.3.6.1. Quality assurance.
AR.3.7.1. Documentation for the Regulatory Authority prior to the commercial operation.
AR.3.8.1. "Non-nuclear" commissioning
AR.3.8.2. "Nuclear" Commissioning.
AR.3.9.2. Communication of relevant events.
AR.3.10.1. Protection from earthquakes.

In Argentina, the Operating Organization is the Nuclear Power Directorate of CNEA, which is responsible for the radiological and nuclear safety in design, construction, commissioning, operation and decommissioning of nuclear power plants. It is responsible for making reasonable efforts toward the safety of the nuclear power stations with enforcing the minimum compliance of the standards, stipulations outlined in the Licence, and all the requirements established by the Authority.

The Operating Organization designates a "Person with Primary Responsibility" to each nuclear power station in operation who is directly responsible for the radiological and nuclear safety of the installation. The directors of Atucha I and Embalse nuclear power stations have the primary responsibility for these installations. The Operating Organization must give all the necessary support to the "Person with Primary Responsibility" and must carry out an adequate supervision in order to insure the correct and safe operation of the plant. The "Person with Primary Responsibility" must make a reasonable effort toward the safety of the plant in order to meet the minimum conditions and the specifications of the License.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT and/or Tlatelolco related agreement: | | |
| Sui generis full-scope safeguards agreement (Brazil, Argentina, | Signed on: | 13 December 1991 |
| ABACC, IAEA) Argentine Senate & Brazilian Parliament | Approved on | 5 August 1992<br>19 February 1994 |
| The Quadripartite Safeguards Agreement INFCIRC/435. | Entry into force: | 4 March 1994 |
| • Improved procedures for designation of safeguards inspectors | Prefers to apply the present procedures but is prepared to accept all inspectors approved by the Board with exceptions. Letter: | 19 June 1990 |
| • Project related safeguards agreement | | |
| INFCIRC No: 143 | Entry into force: | 13 March 1970 |
| 62 | | 2 December 1964 |
| • Bilateral safeguards agreement Argentina/USA | | |
| INFCIRC No: 130 | Entry into force: | 25 July 1969 |
| • Unilateral safeguards submission | | |
| INFCIRC No: 68 | Entry into force: | 3 October 1972 |
| 202 | | 23 October 1973 |
| 224 | | 6 December 1974 |
| 250 | | 22 July 1977 |
| 25 | | 22 July 1977 |
| 294 | | 15 July 1981 |
| 296 | | 14 October 1981 |
| 297 | | 14 October 1981 |
| 303 | | 8 July 1982 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 27 February 1991 |

| | | |
|---|---|---|
| • ARCAL | Entry into force: | September 1984 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 10 February 1995 |
| • Tlatelolco | Entry into force: | 18 January 1994 |
| • Agreement on privileges and immunities | Entry into force: | 15 October 1963 |
| • Convention on physical protection of nuclear material | Entry into force: | 6 May 1989 |
| • Convention on early notification of a nuclear accident | Entry into force: | 17 February 1990 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 17 February 1990 |
| • Convention on civil liability for nuclear damage | Entry into force of Vienna Convention: | 12 November 1977 |
| • Joint protocol | Signature: | 21 September 1988 |
| • Convention on nuclear safety | Signature: | 20 October 1994 |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines (INFCIRC/254) | Member | |
| • Acceptance of NUSS Codes | Summary: National authori ties can use codes as sugges ted, to complement their rules and regulations. Letter of: | 18 November 1988 |
| • Nuclear Suppliers Group | Member | |

## REFERENCES


[1] Country Profiles 1995 - 96.

[2] World Tables 1995 (Worldbank).

[3] IAEA Energy and Economic Data Base (EEDB).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Ente Nacional Regulador Nuclear (ENRE)<br>(National Agency for Nuclear Regulation)<br>Responsible for controlling utilisation of nuclear energy and granting construction and operating licenses.<br>Avenida del Libertador 8250<br>(1429) Buenos Aires, Argentina | Tel.: (541)7041348/ 7041218<br>Fax: (541)7031151 |
| Comisión Nacional de Energía Atómica (CNEA)<br>Avenida del Libertador 8250<br>(1429) Buenos Aires, Argentina | Tel.: (541)7041201<br>Fax: (541)7041170<br>Telex: 23458 CNEA or 25392 PREAT AR<br>Cable: PRESIATOM BAIRES |
| Nucleoeléctrica Argentina S.A.(NASA)<br>(Plantas Atucha I, Atucha II y Embalse)<br>Arribeños 3619-1429<br>Buenos Aires, Argentina | Tel.: (541) 7014651<br>Fax: (541) 7010407 |

# BELGIUM

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# 1. GENERAL INFORMATION

## 1.1. General Overview

Belgium is a small country of 30,514 square kilometres with 10.1 million inhabitants. It has a high population density of 331 persons per square kilometre (over 95 per cent of the population is classified as urban) and a high electricity consumption per capita (the third in Europe). Belgium's natural population increase during the 1980's was only about 0.1%. By the end of the decade the birth rate increased so that the population grew from 9.98 million in 1991 to the present 10.1 million (Table 1). It is situated in the heart of Western Europe, bounded on the north by the Netherlands and the North Sea, on the east by Germany and Luxembourg and on the south and south-west by France. The climate is temperate. The country has no gas, uranium, or oil and very limited hydraulic resources. The mining of coal ended in 1978 in the south of the country and in the early 1990's in the north. Coal mining was no longer economically viable.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 9.2 | 9.7 | 9.9 | 10.0 | 10.1 | 10.1 | 0.2 |
| Population density (inhabitants/km²) | 300.0 | 316.5 | 322.9 | 326.1 | 329.6 | 330.8 | |
| Predicted population growth rate (%) 1993 to 2000 | | 0.3 | | | | | |
| Area (1000 km²) | | 30.5 | | | | | |
| Urban population in 1994 as percent of total | | 97.0 | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

The historical Gross Domestic Product (GDP) statistics are shown in Table 2.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 25,153 | 118,016 | 191,925 | 206,313 | 227,938 | 4.8 |
| GDP (millions of constant 1990 US$) | 114,568 | 158,201 | 191,925 | 195,876 | 200,228 | 1.7 |
| GDP per capita (current US$/capita) | 2,605 | 11,979 | 19,287 | 20,516 | 22,584 | 4.6 |
| GDP by sector : (1990): | | | | | | |
| Agriculture 2% | | | | | | |
| Industry 30% | | | | | | |
| Services 68% | | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.3. Energy Situation

Belgium has no significant mining activities. The main domestic source used to be coal, but the final pits were closing in 1991, after the decision to withdraw subsidies from the industry (proved reserves of bituminous coal in 1993 were 715 million Mt., see Table 3). Hydraulic resources are estimated to be 2,873 Terajoules. In the early 1980's nuclear power replaced coal as the main indigenous energy source. Presently, nuclear power provides 18% of total primary energy consumed in Belgium, compared with only 7% in 1980. Over the same period, the share of oil declined from

50% to 39%, while coal fell from 25% to 19%. Gas raised from 20% to 22%. Missing 2% relates to import/export differences, alternatives, etc. (Table 4).

In 1993, per capita energy consumption in Belgium was 5.4 tons of oil equivalent (toe), which was significantly higher than the European Union average of 3.5 toe.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 12.87 | | | | 0.08 | 12.95 |

[1] This total represents essentially recoverable reserves.
[2] For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.
Source: IAEA Energy and Economic Data Base

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 1.05 | 1.69 | 1.93 | 1.90 | 2.02 | 2.09 | 3.09 | 0.56 |
| - Solids[2] | 0.75 | 0.55 | 0.46 | 0.43 | 0.35 | 0.39 | -2.38 | -1.26 |
| - Liquids | 0.30 | 0.97 | 0.96 | 0.74 | 0.82 | 0.83 | 6.01 | -0.98 |
| - Gases | | 0.16 | 0.41 | 0.38 | 0.43 | 0.45 | 33.39 | 0.60 |
| - Primary electricity[3] | | 0.01 | 0.10 | 0.36 | 0.41 | 0.42 | 21.42 | 10.87 |
| Energy production | | | | | | | | |
| - Total | 0.66 | 0.31 | 0.30 | 0.43 | 0.41 | 0.40 | -3.91 | 2.03 |
| - Solids | 0.66 | 0.31 | 0.17 | 0.03 | 0.02 | 0.02 | -6.47 | -15.91 |
| - Liquids | | | | | | | | |
| - Gases | | | | | | | -2.41 | -22.53 |
| - Primary electricity[3]) | | | 0.12 | 0.40 | 0.39 | 0.38 | 24.08 | 8.32 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.35 | 1.51 | 1.79 | 1.71 | 1.79 | 1.87 | 8.54 | 0.30 |
| - Solids | 0.02 | 0.23 | 0.29 | 0.40 | 0.33 | 0.36 | 13.16 | 1.49 |
| - Liquids | 0.33 | 1.12 | 1.09 | 0.92 | 1.02 | 1.06 | 6.23 | -0.21 |
| - Gases | | 0.16 | 0.41 | 0.38 | 0.44 | 0.45 | -33.97 | 0.68 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

Belgium is highly dependent on foreign countries for its energy supply and, therefore, has to integrate its energy policy into a larger frame on the international level. Working toward this goal implies finding a dependable energy supply on viable economic conditions that also sustains environmental quality (balancing of the three E's - energy, economy and environment).

Coal, the main energy source in the 1950's, was replaced by oil, which today represents about 40% of the total primary energy consumption. Gas, coal and nuclear energy each represent approximately 20% of the total primary energy. Keeping this in mind, special attention is now given to the rational use of energy both on the demand and supply side.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Legal and administrative context of the production, transmission and distribution of electrical power in Belgium is determined by the law of March 10, 1925, which stipulates:

i) that the production of electricity is completely free (each individual or company is free to produce its own electricity); and,

ii) that the distribution of electricity:

- is the exclusive right of the local municipality for all supplies that do not exceed 1000 kW (today 4000 kW and even 10 000 kW in several regions); and,
- that for larger customers, there is no monopolistic right for the municipality and the power can be supplied by the local municipality or by any private or public electric utility.

This legal and administrative context has lead to a situation where a large number of power generation companies developed across the country. In 1955, 47 generating companies existed in Belgium, most of them private. After World War II, a long chain of mergers reduced private suppliers to three companies (Ebes, Intercom and Unerg) by 1980. In 1979, public utilities regrouped into one public utility (S.P.E.). Finally, in 1990, the three private utilities merged to create Electrabel.

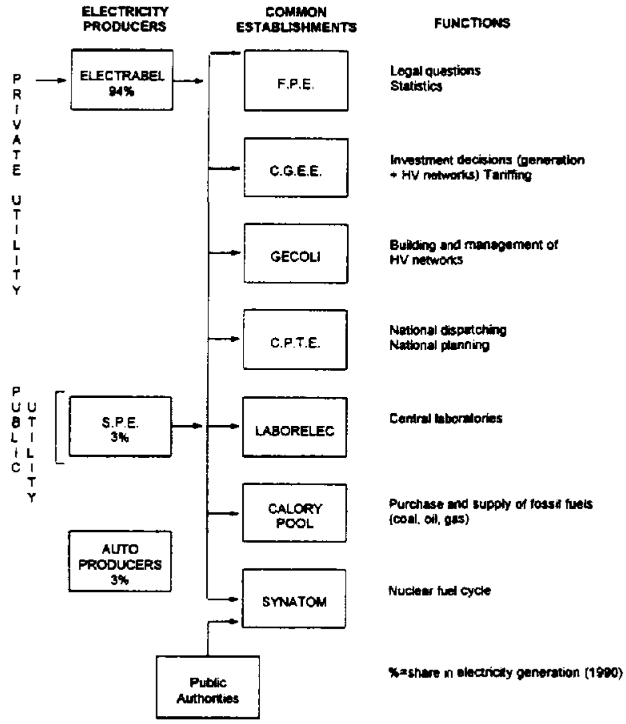
Electrabel accounts for 94% of electricity production. Self generation accounts for 3% and publicly owned generating facilities (S.P.E.) only about 3% of total electricity production. It is estimated that the public sector's installed capacity will increase from 6,3% in 1989 to 15% in 2005. The general structure of the Belgian generation and transmission system is given in Figure 1.

The agreement reached in 1994 between Electrabel and SPE will induce an important restructuring in the Belgian electricity sector. Following the agreement Electrabel and SPE will pool their electricity generating and transmission resources by transferring them to the co-operative company CPTE (Company for Co-ordination of Generation and Transmission of Electrical Energy), to be set up in 1995. This company will be formed by the merger of the limited liability company of the same name, which own the national dispatching centre, and the co-operative company Gecoli which own the national 380, 220 and 150 kV electricity grid (see Fig. 1).

CPTE will become the owner of all power production at its own power stations and those of Electrabel and SPE, together with imported power. It will sell this power to Electrabel and SPE, which in turn will supply to their own customers, trading under their own names. Electrabel and SPE will take over responsibility for operating CPTE's power stations, and Electrabel for electricity transmission, under management contracts.

On the distribution side, only a few municipalities have exercised their right to create "régies" (public, autonomous bodies). Many régies granted concessions or franchises to private companies, and later on regrouped to form "intercommunales" or grouping of municipalities. Intercommunales are either "pure", i.e., without collaboration of a private partners; or "mixed" ,i.e., joint ventures with the private company, Electrabel. Today, most Belgian distribution companies are mixed.

The electricity sector is fully integrated in the Belgian economy. Three of the companies in this sector (Société Générale de Belgique, Tractebel, Electrabel) rank among the four largest Belgian companies on the Brussels stock exchange.




Meaning of initials
F.P.E. = Professional Federation of Producers and Distributors of Electricity
C.G.E.E. = Managing committee of Electricity undertakings
C.P.T.E. = Coordination of electricity generation and transport

Note:
In 1994, Electrabel and SPE signed a project of Convention which contemplates the creation of an association charged with the production activities and the transport activities of the two partners in Belgium. This project of convention still needs to be approved by the Government

*FIG. 1. General Structure of the Belgian Generation and Transmission Electricity System*

## 2.2. Decision Making Process

### *2.2.1. Legal Framework*

Under the Act of 8 August 1988, Belgium became Federal state with significant delegation of responsibilities to three regional governments. However, the nuclear sector policy remains principally in the hands of the Federal (National) government.

Even though Belgian electricity generation is mainly in the hands of the private sector, both federal and regional governments have an influence on it. This influence is marked by partnership arrangements with shares held jointly by the government and the private sector; by the activities of semi-official bodies and by arrangements which enable the government to influence the main strategies of the energy industries. Management of the gas and electricity sectors is based on a continuing dialogue between the government and the Belgian federation of gas and electricity companies.

The agreements between government and the energy industries have enabled the government to set general strategies for the energy sector while standing back from detailed management. Supplies of oil and gas have been secured from diversified sources. A large nuclear programme has been implemented, and high cost coal production has been successfully eliminated.

Since 1955, the electricity sector's activities have been under the concerted control of labour organisations, the confederation of Belgian industry (VBO/FEB), and various Government entities. Two agreements signed in 1955 led to the establishment of two Committees.

The Management Committee composed of the representatives of the private utilities co-ordinates at management level the sector, particularly regarding investment choices in the development of the generating resources and in electricity pricing matters. The government supervised Control Committee composed of private utility, VBO/FEB and labour representatives makes recommendations regarding electricity costs, prices, depreciation and investment policies and the operation of the "inter-municipal" distribution companies.

In 1964, when the above two agreements expired, a new agreement was signed for another ten years, and again renewed in 1974. The new agreement extended the Control Committee to include the gas sector, and established a Management Committee for the public electric utility sector. A "Common Chamber" to cover private utilities and self-generators was added to the Management Committee to study the private sector's development plans regarding generation, interconnection and transmission facilities. The municipal directors of the mixed (i.e., private/public) intercommunales, and the municipalities in charge of electricity distribution within their territory, were represented in the Control Committee.

In 1980, by the law of 8 August, the Control Committee became a public establishment overseen by the federal Minister for Economic Affairs, and the national energy investment plant("National Equipment Plan") needs to be approved by the Minister, based on recommendations by the Control Committee and the National Committee for Energy.

In 1981, a new agreement was signed by the private electric utilities, the public electric utilities in the Belgian State, establishing a State representation in the decisional bodies of the private utilities and creating the Public Electric Company (SPE). SPE groups the public generating utilities and is entitled to participate in the co-ordination bodies of the electric sector. All parties to the agreement, the State included, committed themselves to guarantee utility companies' uninhibited access to the domestic and international capital markets, without public subsidies, for the financing of their investments.

Under the above described legal framework, investment decisions of the electricity sector, particularly those regarding the construction of nuclear units, are proposed by the Management Committee with the collaboration of the public electricity sector and under the supervision of the Belgian confederation of industry, labour organisations, municipal authorities and the Government (see Fig.2).

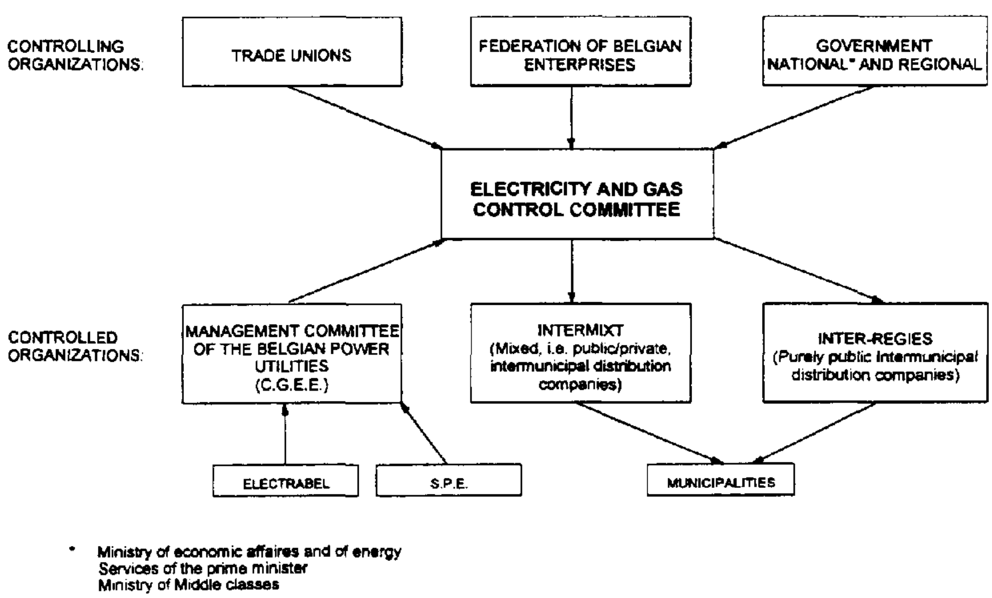



*FIG. 2. Control Committee*

*2.2.2. The Role of the Control Committee and Management Committee*

Control Committee oversees that the gas and electricity sector operates in agreement with the general interest of the nation and the national energy policy. Control Committee sets tariffs and assures electricity supply to customers; encourages rationalisation; establishes uniform bookkeeping scheme and examines annual accounts; examines technical and economic aspects of fuel supply to power plants; examines investment plans (ten-year plan for generating facilities, and five-year plan for high voltage transmission lines); acts as an advisory body to the Government.

Control Committee also formulates "Recommendations" to the controlled sectors; collects information, reports, and studies concerning the controlled sectors; audits their accounts, and appeals to external experts.

Thanks to the co-operation between the Government and the private utilities, the electricity prices billed in Belgium fall within the European average. Moreover, the shareholders of the private utilities enjoy satisfactory return on their investment.

Management Committee specialises in problems arising from the generation, interconnection, transmission, and distribution of electricity. Management Committee sets electricity rate structures and levels; establishes and updates accounting procedures; is in charge of the integrated operating account of the sector; and, standardises distribution voltages and distribution equipment.

## 2.3. Main Indicators

Since the 1980's nuclear overtake of coal, nuclear power now provides approximately 60% of Belgium's electricity, second only to France in relative importance. Of the total electricity produced, thermal energy sources account for 38%, hydro 1.5%, and geothermal 0.01%. Total net installed capacity of electricity generating plants in 1993 was 14,053 MW, of which thermal accounted for 7,161 MW, hydro 1,402 MW, nuclear 5,500 MW, and geothermal 5 MW. In 1993, total electricity consumption in Belgium was 72 TW·h with per capita consumption of 7,175 kWh. Table 5 lists the historical electricity production and installed capacity up to 1993 and Table 6 gives the main indicators.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 15.15 | 30.52 | 53.13 | 70.85 | 69.85 | 72.24 | 6.47 | 2.22 |
| - Thermal | 14.98 | 30.22 | 40.26 | 29.54 | 29.32 | 32.84 | 5.07 | -1.44 |
| - Hydro | 0.17 | 0.25 | 0.32 | 0.90 | 1.02 | 1.18 | 3.09 | 9.89 |
| - Nuclear | | 0.06 | 12.55 | 40.40 | 39.50 | 38.20 | | 8.28 |
| - Geothermal | | | | | | | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 4.52 | 6.26 | 11.01 | 14.14 | 14.05 | 14.90 | 4.55 | 2.19 |
| - Thermal | 4.47 | 6.18 | 8.21 | 7.02 | 6.93 | 7.78 | 3.09 | -0.38 |
| - Hydro | 0.05 | 0.06 | 1.13 | 1.40 | 1.40 | 1.40 | 16.41 | 1.57 |
| - Nuclear | | 0.01 | 1.67 | 5.71 | 5.71 | 5.71 | | 9.20 |
| - Geothermal | | | | | | | | |
| - Wind | | | | | 0.01 | 0.01 | | |

[(1)] *Electricity losses are not deducted.*

Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 115 | 175 | 196 | 191 | 200 | 207 |
| Electricity per capita (kW·h/capita) | 1,660 | 3,038 | 4,859 | 6,375 | 6,796 | 7,188 |
| Electricity production/Energy production (%) | 22 | 90 | 163 | 150 | 156 | 167 |
| Nuclear/Total electricity (%) | | | 25 | 60 | 60 | 56 |
| Ratio of external dependency (%)[1] | 33 | 89 | 93 | 90 | 89 | 89 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 38 | 56 | 55 | 57 | 57 | 55 |
| - Thermal | 38 | 56 | 56 | 48 | 48 | 48 |
| - Hydro | 36 | 45 | 3 | 7 | 8 | 10 |
| - Nuclear | | 59 | 86 | 81 | 79 | 76 |

[1] *Total net import / Total energy consumption*

Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

First nuclear power development began during World War II, when Belgium started uranium production in its mines in Africa and signed a nuclear technical co-operation agreement with the US Nuclear power development was accelerated after the 1970's oil crisis. The main milestones are:

1949 Government of Belgium grants purchasing priority to Uranium resources in Congo to the governments of the UK and the US.

1957 Belgian engineers take part at the commissioning of the first commercial nuclear plant in the United States.

1960 Franco-Belgian convention and creation of SENA (Société Nucléaire franco-belge des Ardennes): the principle was that everything from funding to studies and energy production should be shared equally.

1962 Commissioning of the BR3 PWR prototype plant (11 MW) in Mol. This reactor was the first imported from the United States.

1965 Creation of Synatom (Syndicate for the design of large capacity nuclear power plants).

1966 Commissioning of the Franco-Belgian (Chooz A) power plant (305 MW).

1973 Oil crisis and decision to build Doel 3, Doel 4, Tihange 2 and Tihange 3.

1974 - 1975 Commissioning of Doel 1, 2 and Tihange 1.

1977 Synatom becomes a nuclear fuel management company (Belgian company for Nuclear Fuel).

1980 Creation of the National organisation for radioactive waste and fissile materials (Ondraf/Niras).

1982 - 1983 Commissioning of Doel 3 and Tihange 2.

1985 Commissioning of Doel 4 and Tihange 3.

1985 Exhaustive backfitting process for Doel 1, 2 and Tihange 1.

1986 Architect-engineering companies Electrobel and Tractionel merge to create Tractebel.

1988 The construction of an 8th unit (N8) of 1400 MW (50 per cent Electrabel - 50 per cent EDF) is postponed by the Government.

1990 Private electricity producers Intercom, Ebes and Unerg merge to create Electrabel.

1991 Decommissioning of CHOOZ A.

1995 Creation of the co-operative company CPTE (Company for co-ordination and Transmission of Electrical Energy) by Electrabel and SPE.

### 3.2. Current Policy Issues

The Government:

i) postponed the construction of a new nuclear power plant after the Chernobyl accident, since then, no new plants are planned for construction;

ii) authorises power upgrading following steam generators replacement and turbine refurbishment;

iii) authorises the use of MOX fuel in the Belgian nuclear power plants;

iv) has requested a study of the different options related to the back end fuel cycle (open or closed cycle);

v) has created a Federal Nuclear Regulatory Agency responsible for the licensing of nuclear activities (this unifies the former specialised sections of the Ministries of Labour and of Health).

### 3.3. Status and Trends of Nuclear Power

Belgium has seven NPPs in operation, which provide approximately 60% of the country's electricity production (see Table 7 for the status of the NPPs). Belgium nuclear power plants have satisfactory operation record with an average load factor of about 80%.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| DOEL-1 | PWR | 392 | ELECTRAB | Operational | ACECOWEN |
| DOEL-2 | PWR | 392 | ELECTRAB | Operational | ACECOWEN |
| DOEL-3 | PWR | 1006 | ELECTRAB | Operational | FRAMACEC |
| DOEL-4 | PWR | 985 | ELECTRAB | Operational | ACECOWEN |
| TIHANGE-1 | PWR | 962 | ELECTRAB | Operational | ACLF |
| TIHANGE-2 | PWR | 960 | ELECTRAB | Operational | FRAMACEC |
| TIHANGE-3 | PWR | 1015 | ELECTRAB | Operational | ACECOWEN |
| BR-3 | PWR | 11 | CEN/SCK | Shut Down | WEST |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| DOEL-1 | 01-Jul-69 | 18-Jul-74 | 28-Aug-74 | 15-Feb-75 | |
| DOEL-2 | 01-Sep-71 | 04-Aug-75 | 21-Aug-75 | 01-Dec-75 | |
| DOEL-3 | 01-Jan-75 | 14-Jun-82 | 23-Jun-82 | 11-Oct-82 | |
| DOEL-4 | 01-Dec-78 | 31-Mar-85 | 08-Apr-85 | 01-Jul-85 | |
| TIHANGE-1 | 01-Jun-70 | 21-Feb-75 | 07-Mar-75 | 01-Oct-75 | |
| TIHANGE-2 | 01-Apr-76 | 05-Oct-82 | 13-Oct-82 | 06-Jun-83 | |
| TIHANGE-3 | 01-Nov-78 | 05-Jun-85 | 15-Jun-85 | 01-Sep-85 | |
| BR-3 | 01-Nov-57 | 29-Aug-62 | 10-Oct-62 | 10-Oct-62 | 30-Jun-87 |

Source: IAEA Power Reactor Information System, yearend 1996

Although governmental decision of December 1988 has brought about a moratorium on the construction of new NPPs, Electrabel is allowed to upgrade the capacity of its NPPs. The upgrades will increase total Belgian nuclear generation capacity with about 250 MW. Moreover, Belgian utilities have a 25% share in two 1,400 MW PWR French units under construction at Chooz, close to the Belgian border, scheduled to be commissioned in 1996. By the end of the century, the share of nuclear power in the total electricity generation is expected to decrease to 50% while the share of fossil fuelled power plants, especially through the commissioning of new combined-cycle gas turbine units, is estimated to increase.

### 3.4. Organisational Charts

Figure 3 shows the nuclear sector organisation and its shareholdings among the main companies, research centres and the Belgian state. Electricity supply is carried out by Electrabel with Tractebel as an controlling shareholder (42 per cent of the shares).

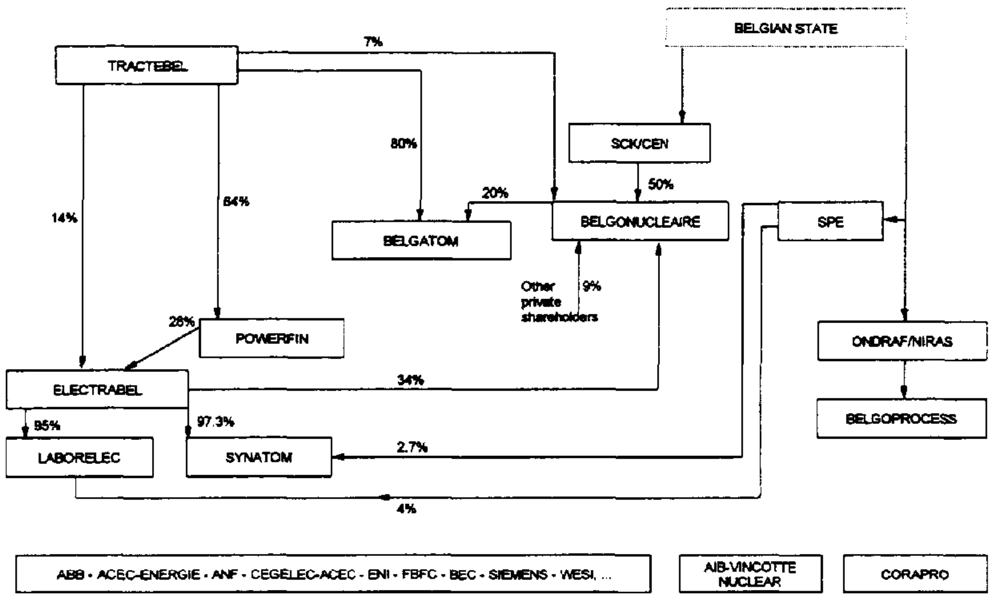



***FIG. 3. Belgian Nuclear Sector Organization***

Tractebel, a Belgian industrial group with international scope provides public utility services; community services; engineering and industrial construction and services. It is organised into seven operating units including the "electricity in Belgium" unit (Electrabel), the "Electricity and Gas International" unit (Powerfin), and the "engineering" unit (Tractebel Engineering).

In 1991, Electrabel generated 94% of Belgian electricity, the balance was produced by the public utility company SPE (Société coopérative de Production d'Electricité) and small self-producers. Electrabel provided, either directly or through the local inter-municipal organisations, about 85% of the electricity supply to the end-users. Electrabel operates the Tihange and Doel nuclear power plants.

The Belgian NPPs require over 700,000 man-hours of nuclear engineering services. Nuclear Engineering services are provided by the engineering division of Tractebel for the Belgian NPPs and by the engineering division of Belgonucléaire for the fabrication of MOX fuel. The nuclear technical know-how of both Tractebel and Belgonucléaire is commercialized for other custormers by Belgatom, a joint subsidiary.

Fuel fabrication plants are at Mol-Dessel; the uranium-plutonium mixed-oxide fuel (MOX) fuel factory is owned and operated by Belgonucléaire (35 tHM/yr), the uranium fuel factory by FBFC (400 tU/yr).

Synatom, a subsidiary of Electrabel and SPE, is responsible for the enriched uranium procurement and spent fuel management for all Belgian nuclear power plants.

Ondraf/Niras (National Agency for Radioactive Wastes and Fissile Materials Management) is entrusted by law with the safe transportation, treatment, conditioning, storage and disposal management of all radioactive waste produced in the country. Belgoprocess, a subsidiary of Ondraf/Niras, operates the radwaste treatment plants, conditioning and storage facilities of the Mol-Dessel site, and manages the former Eurochemic site. Nuclear waste management underwent a significant development in 1991 with the construction of a facility for temporary storage of high level nuclear waste to be returned to Belgium after reprocessing of spent fuel at Cogema in France, and of a centralized facility to treat all solid low-level nuclear waste not conditioned by the producers.

Belgian companies supplied about 80% of the systems and equipment for the country's nuclear facilities. The nuclear steam supply systems (NSSS) were provided by the Westinghouse Group and Framatome associated with Ahlstom Acec Energie and Cockerill Mechanical Industry (CMI).

The reactor vessels, reactor internals, primary pumps, steam generators, pressurises, piping, and the instrumentation and control systems were made in Belgium. The manufacturers and contractors participate in servicing the operating nuclear power plants in Belgium.

AIB-Vinçotte Nuclear is a non-profit organisation that is licensed by the Belgian Government to carry out safety assessments and inspections of nuclear power plants. Another non-profit organisation, Corapro, was responsible for the licensing of the fuel cycle and research and development facilities. It has been taken over by AIB-Vinçotte Nuclear. The main organisations in the nuclear sector are listed in Table 8 (status 1994).

TABLE 8. MAIN NUCLEAR ORGANIZATIONS

| | Turnover (million BEF) | Number of people | Status | Activity |
|---|---|---|---|---|
| ELECTRABEL | 200,000 | 17,000 | private | owner/operator |
| SPE | 10,000 | 280 | public utility | owner |
| TRACTEBEL ENGINEERING* | 12,000 | 2,500 | private | architect engineer |
| BELGONUCLÉAIRE | 2,300 | 350 | 50 % public<br>50 % private | fuel manufacture/ architect-engineer |
| SYNATOM | 13,000 | 30 | private (with public golden share) | fuel supplier |
| FBFC | 935 | 350 | private | fuel manufacturer |
| ONDRAF | 900 | 70 | public | radioact. waste management |
| BELGOPROCESS | 1,200 | 300 | public | radioact. waste facilities |
| CEN/SCK | 2,500 | 565 | public | R & D |
| LABORELEC | 1,400 | 260 | co-operative | R & D |
| AIB-VINCOTTE<br>GROUP NUCLEAR | 3,300 | 1,400<br>50 | non profit | licensing/ inspection |

* Division of TRACTEBEL Group, which has a total turnover of 298,000 million BEF and employees 36,000 people.

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

Architect engineering is performed by three firms:

- Tractebel Engineering (among the 12 leading design firms in the world) provides Architect/Engineer services, including pre-project studies, site selection and qualification, feasibility and optimisation studies, basic and detailed engineering, construction - supervision, and start-up. Power systems engineering represents about 50% of the activities, half of which accounts for nuclear engineering services for NPPs.
- Belgonucléaire, a subsidiary of Tractebel and CEN/SCK has engineering expertise in nuclear fuel, core design, engineering of uranium-plutonium mixed-oxide fuel (MOX) fabrication plants and radwaste treatment, storage and disposal facilities.
- Belgatom, jointly owned by Tractebel (80%) and Belgonucléaire (20%), provides world-wide nuclear engineering services for clients other than Electrabel.

There are no Belgian companies supplying Nuclear Steam Supply Systems (NSSS).

Most of the companies involved in nuclear component manufacturing or supply are grouped in Fabrimetal, a professional federation covering 100 industrial companies in metal working, mechanical engineering, electrical engineering and electronics, transport equipment and plastic conversion. Among the main nuclear component suppliers and contractors are:

| | |
|---|---|
| ABB | Mechanical and electrical systems |
| ABAY-TS | Electrical and instrumentation systems |
| ALSTHOM[1] | Generators, primary pumps |
| ALSTHOM[2] | Pumps, valves, turbines |
| CEGELEC ACEC | Specific instrumentation and control systems (reactor protection, rod position indication and control, thermodynamics instrumentation, neutron flux instrumentation) |
| CEGELEC COMSIP | Instrumentation for site security systems |
| CMI | Main mechanical NSSS components (such as steam and diesel generators) |
| ENI | Electrical components |
| FABRICOM | Piping, electrical equipment, ventilation |
| G.C.C.N[3] | Structural systems |
| IMOP | Piping, electrical, insulation |
| KABELWERK EUPEN | Electrical cables |
| LEPAGE EURONUCLEAIR | Mechanical equipment |
| PAULVANDERSCHUEREN[4] | Precision machined and mechanically welded assemblies |
| PAUWELS | Transformers |
| SIEMENS | Mechanical and electrical supply systems |
| SOBELCO | Thermal engineering and construction |
| STORCK MEC NV | Piping |
| TCM[5] | Piping |
| WESTINGHOUSE | Mechanical and electrical supply systems |

[1] GEC Alsthom Acec Energie
[2] GEC Alsthom Rateau Services
[3] Groupe Genie civil des centrales Nucléaires
[4] Mecanique de Precision Paul Vanderschueren
[5] Tuyauteries et Constructions mosanes

### 4.2. Operation of Nuclear Power Plants

Electricity supply (nuclear and non-nuclear) is mainly carried out by Electrabel. Electrabel provides about 85% of the electricity supply to end users, 75% of natural gas distribution and 50% of cable television in Belgium. Electrabel operates the Tihange and Doel nuclear power plants with the total capacity of 5630 Mw(e) (11% of the European Union's nuclear generation as of end 1995). As a nuclear operator, Electrabel ranks 12th world-wide in installed nuclear capacity. It owns Doel 1 and Doel 2, 50% of Tihange 1 (the other 50% is owned by EDF, France) and 96% of Doel 3, Doel 4, Tihange 2 and Tihange 3. The other 4% of Doel 3, Doel 4, Tihange 2 and Tihange 3 is owned by the public utility SPE.

Engineering support to operation is provided by Tractebel Engineering, a division of Tractebel, which is responsible for plant modifications, upgrading and backfitting, fuel fabrication procurement, core management and fuel handling and inspection services, Quality Assurance, In-Service Inspection, A/E services, project management, and technical assistance in case of a nuclear accident.

Maintenance service suppliers: Most of the Component Suppliers and Contractors listed under 4.1 assure maintenance service. The list hereunder is not exhaustive, as Belgium is an open market and most contracts are concluded after competitive tender procedures.

| | |
|---|---|
| ABB | Maintenance and inspection of steam generators, reactor vessels |
| ALSTHOM[1] | Maintenance of generators, quality control and training in the field of primary components (reactor vessels, internals, primary pumps) and fuel handling equipment and systems |
| ALSTHOM[2] | Maintenance of valves, pumps, fans |
| CEGELEC ACEC | Instrumentation and control systems |
| MITSUBISHI HEAVY INDUSTRIES | Replacement steam generators |
| TECNUBEL | Maintenance and cleaning, decontamination, radiomonitoring |
| WESTINGHOUSE[3] | Design, training, quality control, maintenance, inspection and repair work of primary components (reactor vessel and internals, steam generators), fuel, control rod, fuel handling equipment and systems |

[1] GEC Alsthom Acec Energie
[2] GEC Alsthom Rateau Services
[3] Westinghouse Energy Systems Europe

### 4.3. Fuel Cycle and Waste Management Service Supply

Fuel cycle and waste management engineering services are provided by Tractebel and Belgonucléaire for the Belgian Market, and worldwide by Belgatom.

Two fuel fabrication plants are located at Mol-Dessel; the MOX fuel factory, is owned and operated by Belgonucléaire. The uranium fuel factory is owned and operated by FBFC, a subsidiary of Framatome (51%) and Cogema (49%) of France. FBFC manufactures uranium fuel assemblies and pressurised water reactor control rods and provides the final assembly of MOX fuel (all BWR and PWR types).

Synatom, a joint subsidiary of Electrabel and SPE, is responsible for the enriched uranium procurement and the spent fuel management for all Belgian nuclear power plants. It maintains ownership of the nuclear materials, at all times; prior, during and after use in nuclear reactors until final disposal.

Interfaces regarding the nuclear fuel cycle are shown in Figure 4.

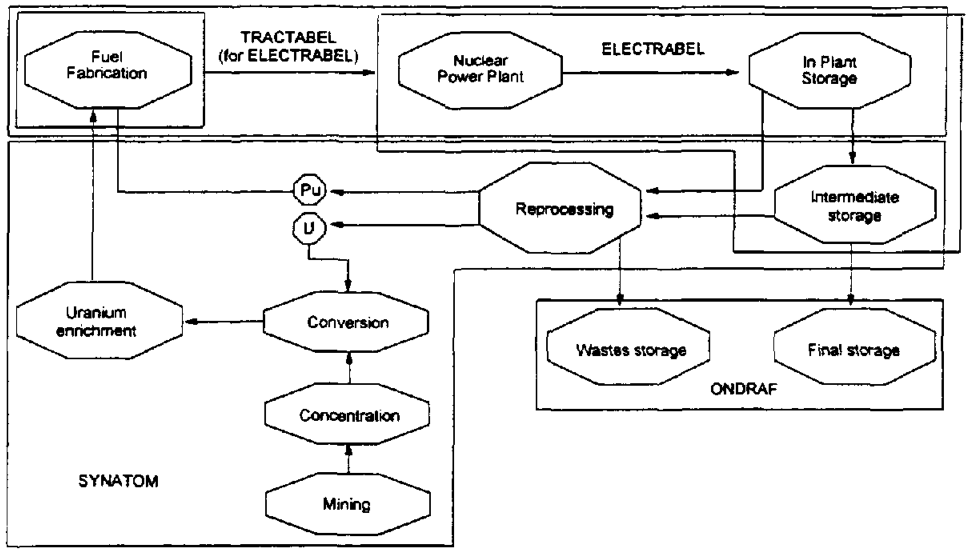



*FIG. 4. Organizations covering the nuclear fuel cycle: Interfaces*

Transportation services are provided by:

- TRANSNUBEL: Fresh and spent fuel (uranium and MOX) transportation; design of handling systems for fuel containers.
- TRANSRAD: Radioactive waste transportation ; uranium transportation

Ondraf/Niras, National Agency for Radioactive Waste and Fissile Materials Management is entrusted by the law with the safe management of all radioactive wastes produced in the country, including their transport, treatment, conditioning, storage and disposal.

Belgoprocess, a subsidiary of Ondraf/Niras, operates the radwaste treatment plant, conditioning and storage facilities of the Mol-Dessel site, as well as managing the Eurochemic site.

### 4.4. Research and Development Activities

Nuclear research and development in Belgium is co-ordinated by the Ministry of Economic Affairs of the Federal Government and carried out mostly by the SCK/CEN (Belgian Nuclear Research Centre) at Mol. Nuclear research done by SCK/CEN is mainly confined to reactor safety experiments, reactor fuel and reactor materials examinations, radioactive waste disposal, decommissioning, radiation protection and health physics.

Research and development for the support of both nuclear and non-nuclear power plant operations is carried out by Laborelec, a central research laboratory of the utilities, Electrabel and SPE; and, also by Tractebel.

### 4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

Belgium works in a number of international nuclear organisations including the International Atomic Energy Agency (IAEA), Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) as well as other bilateral and multilateral organisations such as WANO.

Belgium is also involved in a number of European organisations set up to improve safety of nuclear power plants in countries of the former Soviet Union and Eastern Europe:

- TPEG (Twining Programme Engineering Group) is a European Economic Interest Group (EEIG) created by EU electric utilities to meet the initiatives of the CEC (Commission of European Communities) for helping utilities of Central and Eastern Europe in safety matters. [Tractebel]
- ENAC (European Nuclear Assistance Consortium) is a EEIG created by EU NPP design and construction companies to perform generic studies on VVER reactors. [Belgatom]
- RAMG (Regulatory Assistance Management Group) is formed of Western Safety Authorities to assist for setting up of Eastern Safety Authorities. [AVN]
- TSOG (Technical Safety Organisation Group) is an association of technical support organisations in EU member countries to advise the Eastern European Safety Authorities. [AVN]
- CASSIOPEE (Consortium d'Assistance Operationnelle aux Pays d'Europe de l'Est) is an EEIG of the EU agencies responsible for radioactive waste management and storage. [Ondraf/Niras]
- EFCC (European Fuel Cycle Consortium)is a consortium grouping European reprocessing companies and fuel fabricators for improving the operation of nuclear fuel cycle facilities in Eastern Europe. [Belgonucléairie]
- Joint EC-RF (joint EU/Federation of Russia) analysis of European Challenges and solutions in nuclear safety aims to improve the LWR in Europe and Russia. [Tractebel]

Belgium participates in programmes and projects for developing and promoting new advanced NPP technology:

- EUR (European Utility Requirements) common requirements for building future LWRs in Europe, written by European Electricity producers. [Tractebel]
- EPRI programme for ALWR Certification in the US [Tractebel]
- EPP (European Passive Plant) programme for developing Westinghouse type passive nuclear plants in Europe. [Tractebel]

Belgium participates in several international R&D programmes:

- Pressure Vessel Steel Projects (materials behaviour in the frame of Plant Lifetime extension) with IAEA, "Kurchatov Institute" of Russia, and VTT of Finland.[Tractebel]
- Halden Reactor Project (Norway) project runs under the auspices of OECD/NEA. [SCK/CEN, Belgonucléaire, Tractebel, AVN]
- Benchmarking of the RELAP (thermohydraulic) code in the frame of the international user's group (member of the Code Assessment and Maintenance Programme - CAMP).
- ITER proto-type reactor under the umbrella of the EFET consortium (European fusion programme). [Belgatom]
- VIP (Venus International Programme) - with Tractebel participation - to assess neutronics codes for MOX fuel by performing experimental tests in the VENUS reactor with UK and Japan as scientific partners. VENUS is operated by the Belgian nuclear research center SCK/CEN. [SCK/CEN, Belgonucléaire]
- RASPLAV project to study melt core cooling inside the reactor vessel, a joint research programme with the Federation of Russia and 14 other countries. RASPLAV is sponsored by the Nuclear Energy Agency (NEA) of the OECD. [Tractebel]

- FIGARO: Irradiation and examination of two high burnup MOX fuel rods for fission gas release analysis. [Belgonucléaire, Tractebel]
- ARIANE: Evolution of isotopic composition of MOX fuel during irradiation. [Belgonucléaire, Tractebel]

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

Licensing takes place under the authority of the Minister of the Interior (Royal decree of August 7, 1995) which has the guardianship over the Federal Agency for Nuclear Control. This Minister and the Agency are responsible for promulgating and enforcing regulations designed to protect the employees of the nuclear plants and the general population against the hazards of ionising radiation. The Agency is assisted in technical matters by a Scientific Council of experts and representatives from various authorities responsible for nuclear safety who have only an advisory role. The Commission gives recommendations by absolute majority. State approved agencies, such as AIB-Vinçotte company carry out official acceptance procedures for installations prior to commissioning and exercise supervision over installations during operation. Final authorisation for nuclear plant commissioning rests with the King.

The main steps in the Belgian licensing procedure are:

- Filing of an application: The request for the licence is first sent to the Director General of the Federal Agency for Nuclear Control, together with the relevant information (characteristics of the installation, planned safety measures, an Environmental Impact Assessment, and a study of the premises and the demographic, geological, meteorological, etc. characteristics of the area of the installation). The request has to contain a preliminary safety report and a report describing the incidences of the environment;
- The Scientific Council is consulted a first time. After the Council has given its preliminary advice it is sent to the applicant. Then the European Commission is also consulted (if necessary) according to article 37 of the Euratom Treaty, as well as all the municipalities in a radius of 5 km around the installation (who inform their population) and the Permanent Deputation of the Province involved. After the advice of the municipalities, of the Province and of the European Commission the file is again submitted to the Scientific Council, which then gives its definitive advice;
- The Minister of the Interior then decides by submitting a Royal Decree to the King. This Royal Decree gives the erection and operation licence. It contains the conditions to be respected. These stipulate, among other things, the content of the safety report;
- After the erection of the installation, before the start of the operation, the Agency or the state approved agency designated by her, proceeds to the reception of the installation. This reception must establish the conformity of the installation with the general regulation, the stipulations of the erection and operation licence and the safety report. When the reception is favourable the Minister of the Interior proposes to the King to confirm the erection and operation licence, which are granted for an unlimited period.

### 5.2. Main National Laws and Regulations

Act of March 10, 1925:

Electricity generation is not regulated. Each individual or corporation is free to generate electricity.

Act of March 29, 1958 (Royal decrees of February 28, 1963 and of March 12, 1987):

General Regulations for the protection of the Population and Workers against the Hazards of Ionising Radiation. Nuclear installations are divided into four classes, in descending order of hazards involved. Class I includes nuclear reactors and large nuclear installations (criticality hazard). Installations in Classes II, III and IV are divided according to the quantity of radioactive materials. Installations in Classes I, II and III require prior licensing, whereas those in Class IV do not.

Royal decree of October 15, 1979:

Founding of the Inter-ministerial Commission for Nuclear Safety and State Security in the Nuclear Field against hazards arising from the use of radioactive substances.

Royal decree of May 16, 1986:

This order determines the financial security certificate for the transport of nuclear substances.

Act of August 8, 1980:

Founding of Ondraf/Niras for treating, conditioning, storing and disposal of radioactive waste and for handling some aspects of fissile materials and decommissioning. The Act of January 11, 1991 has replaced the Act of August 8,1980.

Act of July 22, 1985:

Defining third party liability pertaining to nuclear energy generation as outlined in the Paris Convention of 29 July 1960, and the additional Convention of Brussels of 30 January 1963:

- Liability of the power plant operator in the event of a nuclear accident: victims are not required to supply proof of the nuclear power plant operator's fault in order to be compensated for damages arising from a nuclear accident.
- Three-tiered compensation system:
  - by the power plant operator up to a maximum amount of BEF 4 billion. Under Belgian law, the nuclear plant operator must supply proof of an insurance policy or have adequate security deposits to cover potential civil liability suits before the operating license is granted;
  - by the Belgian State for the amount between BEF 4 billion and BEF 9 billion;
  - by the signatories of the Paris and Brussels Conventions for the amount between BEF 9 billion and BEF 15 billion.

Act of April 15, 1994 (replaces the Act of March 29, 1958):

Founding of a Federal Agency for Nuclear regulation.

Agreements concluded between the Belgian state and the electric utilities:

- The decommissioning Agreement with the State in 1985 regulates the setting up of a provision to cover the dismantling costs of nuclear installations and the decontamination costs of the nuclear sites to be implemented within 30-years. This provision amounts to 12 per cent of the adjusted initial capital investment. The agreement is updated every five years at the request of the Control Committee.

- The agreement in 1990 with the Belgium State defines the contribution of each party of the agreement in the financing of the decommissioning and the cleanup cost of the state owned nuclear facilities at the MOL-DESSEL site. Parties to the agreement are the State of Belgium, Ondraf/Niras, Synatom and Electrabel and SPE.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA (As of June 1996)*

| | | |
|---|---|---|
| • NPT related safeguards agreement INFCIRC No: 193 | Entry into force: | 21 February 1977 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc. (As of June 1996)*

| | | |
|---|---|---|
| • NPT | Entry into force: | 2 May 1975 |
| • EURATOM | Member | |
| • Agreement on privileges and immunities | Entry into force: | 26 October 1965 |
| • Convention on physical protection of nuclear material | Entry into force: | 6 October 1991 |
| • Convention on early notification of a nuclear accident | Signature: | 26 September 1986 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Signature: | 26 September 1986 |
| • Convention on civil liability for nuclear damage and joint protocol | Entry into force :<br>Paris Convention:<br>Signature: | <br>3 August 1966<br>21 September 1988 |
| • Third party liability in the field of nuclear energy | Paris Convention: | July 1960 |
| • Supplementary convention to the Convention of third party liability | Brussels Convention: | January 1963. |
| • Additional protocol to the convention of third party liability | | January 1964. |
| • Amendment on third party liability in the field of nuclear energy | | November 1982. |
| • Convention on nuclear safety | Signature: | 20 September 1994 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | Summary: Codes can be used as guidelines when formulating national regulations. Belgium often goes beyond Code requirements.<br>Letter of: | <br>8 November 1988 |
| • Nuclear Suppliers Group | Member | |

*BILATERAL AGREEMENTS*

Belgium has nuclear bilateral agreements with Luxembourg (1970), Romania (1974), USA-USNRC (1978), Korea (1981), France (1981 and 1984), Egypt (1984), The Netherlands (1984 and 1990) and China (1985).

Belgium (or the Belgian-Luxemburgian economic union) has scientific, industrial and technological agreements with France (1950), USA (1950, 1951), Kuwait (1974), Democratic Republic of Germany (1974), Poland (1974), Bulgaria (1975), Czechoslovakia (1975), Hungary (1975 and 1986), Romania (1976), Cuba (1976), Egypt (1979), China (1979), Algeria (1982 and 1983), Tunisia (1983), Germany (1980), United Arab Republics (1984); USSR (1984), Mexico (1984), Brazil (1985), Kenya (1985), Venezuela (1986), and India (1990).

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## ANNEX I. DIRECTORY OF THE MAIN ORGANISATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITIES*

| | |
|---|---|
| Ministère des Affaires Économiques<br>Administration de l'Énergie<br>Service de l'Énergie Nucléaire<br>North Gate III<br>Boulevard E. Jacqmain 154<br>B-1000 Bruxelles, Belgique | Tel.: +32-2-206 41 11<br>Fax: +32-2-206 57 11 |
| Services Fédéraux des Affaires<br>Scientifiques, Techniques<br>et Culturelles (SSTC)<br>Rue de la Science 8<br>B-1040 Bruxelles, Belgique | Tel.: +32-2-238 34 11<br>Fax: +32-2-230 59 12 |
| Ministère de la Santé Publique et<br>de l'Environnement<br>Service de Protection Contre les<br>Radiations Ionisantes<br>(Minstry of Public Health)<br>Cité Administrative de l'Etat<br>Quartier Vésale 2/3-27<br>B-1010 Bruxelles, Belgique | Tel.: +32-2-210 49 66<br>Telex: 65396 radist b<br>Fax: +32-2-210 49 67 |
| Ministère des Affaires Étangères<br>Service Scientifique<br>Rue Beillard 65, 7Éme Étage<br>B-1040 Bruxelles, Belgique | Tel.: +32-2-238 25 11<br>Fax: +32-2-230 02 80 |
| Ministère de l'Emploi et du Travail<br>Service de la Sécurité Technique<br>des Installations Nucléaires<br>Rue Belliard 53<br>B-1040 Bruxelles, Belgique | Tel.: +32-2-233 45 28<br>Fax: +32-2-233 45 31 |

*OTHER NUCLEAR ORGANIZATIONS*[1]

| | |
|---|---|
| Tractebel Engineering (Architect/Engineer)<br>Avenue Ariane, 7<br>1200 Brussels | Tel.: +32-2-773 81 11<br>Fax: +32-2-773 89 00 |
| Belgonucleaire, S.A. (Architect/Engineer)<br>Avenue Ariane, 4<br>1200 Brussels | Tel.: +32-2-774 0511<br>Fax: +32-2-774 0547 |
| Belgatom (Architect/Engineer)<br>Avenue Ariane, 7<br>1200 Brussels | Tel.: +32-2-773 81 11<br>Fax: +32-2-773 98 20 |

[1] according to the "Forum Nucléaire Belge" report

Electrabel (Utility)
Boulevard du Regent, 8 — Tel.: +32-2-518 61 11
1000 Brussels — Fax: +32-2-511 50 20

Spe-Societe Cooperative de Production
d'Électricité (Utility)
Rue Royale, 55 (BTE 10) — Tel.: +32-2-217 81 17
1000 Brussels — Fax: +32-2-218 61 34

Asea Brown Boveri Energie (ABB) (Fuel Fabrication)
Hoge Wei, 27 — Tel.: +32-2-718 63 11
1930 Zaventem — Fax: +32-2-718 66 73

Abay-TS (Contractor)
Rue de Geneve 4, BTE 30 — Tel.: +32-2-729 61 11
1140 Brussels — Fax: +32-2-729 61 61

Cegelec Acec (I & C Systems)
BP 4208 — Tel.: +32 71 44 65 11
6000 Charleroi — Fax: 32 71 44 65 15

Cegelec Comsip (Instrumentation)
Avenue de la Couronne, 311 — Tel.: +32-2627 82 11
1050 Brussels — Fax: +32-2-627 82 00

CMI (NSSS Components Manufacturer)
Avenue a. Greiner, 1 — Tel.: +32-41-30 21 11
4100 Seraing — Fax: +32-41-30 22 00

ENI (Electrical Contractor)
Kontichsesteenweg, 25 — Tel.: +32-3-870 12 11
2630 Aartselaar — Fax: +32-3-887 12 98

Fabricom (Electrical and Mechanical Contractor)
Rue Gatti de Gamond, 254 — Tel.: +32-2-370 31 11
1180 Brussels — Fax: +32-2-370 35 33

Gec Alsthom Acec Energie (Generator Supplier)
Rue Chapelle Beaussart, 80 — Tel.: +32-71-44 31 11
6030 Charleroi — Fax: +32-71-36 56 30

Gec Alsthom Rateau Services
(Mechanical Equipment Supplier)
Leuvensesteenweg, 474 — Tel.: +32-15-41 29 81
2812 Muizen — Fax: +32-15-42 33 37

Imop (Mechanical Contractor)
Noorderlaan 119 — Tel.: +32-3-541 21 70
2030 Antwerpen — Fax: +32-3-541 72 52

Kabelwerk Eupen AG (Cable Supplier)
Malmedyerstrasse, 9 — Tel.: +32-87-55 47 71
4700 Eupen — Fax: +32-87-74 32 09

Lepage Euronucleair (Mechanical Contractor)
Rue Chausteur, 6 — Tel.: +32-71-41 00 30
6042 Lodelinsart — Fax: +32-71-42 24 65

Pauwels Trafo Belgium (Transformers Supplier)
Antwerpsesteenweg 167 — Tel.: +32-15-29 92 11
2800 Mechelen — Fax: +32-15-29 92 08

Siemens S.A. (Electrical Contractor)
Chaussee de Charleroi, 116 — Tel.: +32-2-536 21 11
1060 Brussels — Fax: +32-2-536 24 92

G.C.C.N. C/O S.B.B.M. - Six Construct
(Civil Works Contractors)
Boulevard Louis Mettewie, 74-76
1080 Brussels

Sobelco (Thermal Construction)
Rue Capouillet 50-58 — Tel.: +32-2-535 13 11
1060 Brussels — Fax: +32-2-535 13 46

Storck Mec (Mechanical Contractor)
Haven 269
Oosterweelsteenweg 57 - PB 54 — Tel.: +32-3-540 15 11
2030 Antwerpen — Fax: +32-3-540 15 00

TCM (Mechanical Contractor)
Quai d'Arone, 31 — Tel.: +32-85-23 31 52
4500 Huy — Fax: +32-85-23 51 78

Mecanique de Precision Paul Vanderschueren
(Mechanical Equipment Supplier)
Avenue de Tyras, 51 — Tel.: 32 2 262 1010
1120 Brussels — Fax: +32-2-262 0241

Westinghouse Energy Systems Europe, S.A.
(NSSS Supplier)
Boulevard Paepsem, 20 — Tel.: +32 2 556 81 11
1070 Brussels — Fax: +32-2-556 89 26

Tecnubel S.A. (Decontamination)
Avenue Ariane, 4 — Tel.: +32-2-774 05 00
1200 Brussels — Fax: +32-2-774 05 70

FBFC International, S.A. (Fuel Manufacturer)
Europalaan, 20 — Tel.: +32-14-33 12 11
2480 Dessel — Fax: +32-14-31 58 45

Synatom, S.A. (Fuel Management)
Rue de la Pepiniere, 20 — Tel.: +32-2-505 07 11
1000 Brussels — Fax: +32-2-505 07 90

Transnubel, D.A. (Fuel Transportation)
Gravenstraat, 73 — Tel.: +32-14-31 38 56
2480 Dessel — Fax: +32-14-31 89 48

Transrad, S.A. (Waste Transportation)
Avenue du Port, 94 — Tel.: +32-2-424 00 57
1020 Brussels — Fax: +32-2-424 31 91

ONDRAF/NIRAS (Waste Management)
Place Madou, 1 (btes 24-25) — Tel.: +32-2-212 10 11
1030 Brussels — Fax: 32 2 218 51 65

Belgoprocess (Waste Treatment)
Gravenstraat, 73 — Tel.: +32-14-33 41 11
2480 Dessel — Fax: +32-14-31 30 12

CEN/SCK (Research Center)
Boeretang, 200 — Tel.: +32-14-33 32 07
2400 Mol — Fax: +32-14-32 03 13

Laborelec (Utility's Laboratory)
Rue de Rhode, 125 — Tel.: +32-2-382 02 11
1630 Linkebeek — Fax: +32-2-382 02 41

Groupe AIB-Vincotte (Authorised Inspection Agency)
Avenue du Roi, 157 — Tel.: +32-2-536 82 11
1060 Brussels — Fax: +32-2-536 85 85

# BRAZIL

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# BRAZIL

## 1. GENERAL INFORMATION

### 1.1. General Overview

Brazil is a federal republic in South America, bounded on the north, west and south by every country of the continent except Chile and Ecuador, and on the east by the Atlantic ocean, along 7,400 km (4,600 miles) of coast line. The country covers an area of 8,511,965 square kilometers (3,286,487 square miles), about half of all South America, and is the world's fifth largest country in area. Stretching for approximately 2,700 miles from north to south and from east to west, it contains no desert, high mountains, or Arctic environments that limit the extent of human occupancy.

The population of Brazil, as of 1993, was about 157 million - with a density of 18.4 persons per $km^2$ (about 46 people per $mile^2$). Table 1 shows the historical statistics concerning population information. Most Brazilians live in high density areas of eastern Brazil, or along the coast or the major rivers. Although urbanisation has not produced actual decline in rural population, internal migration has caused cities to grow much faster than rural areas. Today, about 77% of the people live in urban areas. Many migrants to the cities take up residence in favelas, or shantytowns, on the edge of urban areas. The urban poverty and unemployment that accompany swift urbanisation are aggravated by a fast population growth rate. Prevailing the growth rate at the end of the 1980's, the population of Brazil was expected to double in 34 years.

The capital, Brasilia, whose construction started in 1957, was built in the highlands, in order to encourage development of the interior. According to the 1991 estimate, the largest cities of Brazil are: São Paulo (9,626,894 inhabitants), Rio de Janeiro (5,473,909 inhabitants), Belo Horizonte (2,017,127 inhabitants), Salvador (2,072,058 inhabitants), Recife (1,296,995 inhabitants), Brasilia (1,598,415 inhabitants) and Porto Alegre (1,263,329 inhabitants).

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 72.6 | 95.8 | 121.3 | 148.5 | 156.5 | 159.1 | 2.0 |
| Population density (inhabitants/$km^2$) | 8.5 | 11.3 | 14.2 | 17.4 | 18.4 | 18.7 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 1.6 |
| Area (1000 $km^2$) | 8512.0 |
| Urban population in 1993 as percent of total | 71.0 |

Source: IAEA Energy and Economic Data Base

The single most important influence on Brazil's climate is its location on the equator. Temperatures seldom exceed 35°C in the tropics owing to the moderating effects of high atmospheric humidity. Most of Brazil receives a moderate rainfall of 1,000-1,500 mm (40-60 in.), although the Amazon lowlands and several other areas receive more than 2,030 mm (80 in.) of rainfall annually. The semi-arid north-eastern interior, or 'Sertao', frequently suffers from very long droughts. Tropical rain forest, or 'Selva', is found in the wettest part of the Amazon Basin. Much of the south and south-west of Brazil is covered by savanna, or tropical grassland, and in the interior of the north-east, caatinga, a low and bushy scrub and thorn forest is characteristic.

Brazil's three major river systems are: the Parana-Paraguay-Plata in the south, the Sao Francisco in the east, and the Amazon in the north. The Amazon, the major river of South America, is the world's second longest river (6,440 km/4,000 miles), and most of its basin lies within Brazil. The Amazon river's major tributaries are the Tocantins-Araguaia, the Madeira, the Negro, the Xingu and the Tapajos. Brazil's mineral resources are superlative with many still unexplored. Sizable deposits of iron and manganese ores have been discovered, but Brazil lacks the high-grade cooking coal needed to transform them into steel. Brazil is a leading exporter of iron. Discoveries of metals and minerals, including phosphates, uranium, manganese, titanium, copper, coal, and gemstones, are regularly made, particularly in the state of Minas Gerais and the Amazon area.

### 1.2. Economic Indicators

Table 2 provides the Brazilian Gross Domestic Product (GDP) statistics during the last two decades. Economy's average growth rate was only 1.4% during the period 1980 to 1992, too low for a developing country, whose average population growth rate was 2.0% during the same period.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 43,235 | 234,890 | 327,129 | 564,798 | 556,182 | 6.4 |
| GDP (millions of constant 1990 US$) | 119,340 | 273,079 | 327,129 | 341,145 | 360,487 | 2.0 |
| GDP per capita (current US$/capita) | 451 | 1,937 | 2,203 | 3,609 | 3,495 | 4.3 |

| GDP by sector | |
|---|---|
| Agriculture | 10% |
| Industry | 37% |
| Services | 53% |

Source: IAEA Energy and Economic Data Base

### 1.3. Energy Situation

Brazil has modest fossil energy resource and one of the largest hydroelectric potential in the world (Table 3). However, most of this potential has not yet been tapped. The hydro resources located in the north-east, south-east and south of the country have already been thoroughly surveyed. The hydroelectric potential of north and central west regions, which cover practically Brazil's Amazon area, is beginning to be tapped to partially meet both regional and national electric needs.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 35.39 | 16.59 | 4.45 | 25.55 | 291.17 | 373.14 |

[1] This total represents essentially recoverable reserves.
[2] For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.
Source: IAEA Energy and Economic Data Base

Historically, the expansion of the energy sector represented a dynamic aspect on the process of industrialisation and modernisation of economic and social structures in Brazil. This expansion has provided the energy needed for this process and has stimulated the development of productive sectors. During the last decades, Brazilian development was mainly induced by the State's direct action. The two large centralised energy systems, electricity and petroleum (state-owned) were consolidated. The consolidation bolstered the development of the country's main industries and engineering service infrastructure. Table 4 shows the historical energy statistics.

Since the 1940's, anhydrous alcohol extracted from the sugar cane has been added to gasoline, at first only in small quantities. During the first oil crisis in 1973, the percentage of anhydrous alcohol was increased, reaching approximately 14% in 1992. In order to carry out a National Alcohol Programme (1975), Brazil developed a technology for direct use of hydrous alcohol (containing about

4% water) in automobile engines. Since 1977, alcohol production and consumption have been rising rapidly. In 1991, about 43 per cent of the Brazilian cars were alcohol fuelled.

During the 1960's and 1970's the total energy production experienced a high average annual growth rate of 12%; however, during the 1980's and early 1990's energy production growth rate decreased considerably (3.3% per year). Primary electricity production had also a similar pattern; the annual growth rate decreased from 10% from 1960 to 1980 to 5% during 1980 to 1992.

Final energy consumption in Brazil reached 7.3 Exajoules in 1993, a nearly nine-fold increase from the 1960 figure of 0.78 Exajoule. The share of liquid fuels in primary energy consumption decreased from 69% in the 1960's to 41% in 1992. Solid fuels, primary electricity (hydro and nuclear) and gas provided 22%, 34% and 2.4%, respectively, of primary energy consumption in 1993.

TABLE 4. BASIC ENERGY SITUATION

Exajoule

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Energy consumption | | | | | | | | |
| - Total[1] | 0.78 | 2.88 | 5.51 | 6.82 | 7.17 | 7.65 | 10.28 | 2.38 |
| - Solids[2] | 0.05 | 1.40 | 1.89 | 1.69 | 1.59 | 1.60 | 19.36 | -1.18 |
| - Liquids | 0.54 | 1.09 | 2.34 | 2.73 | 2.84 | 3.22 | 7.56 | 2.32 |
| - Gases | | | 0.04 | 0.15 | 0.17 | 0.18 | 15.03 | 11.67 |
| - Primary electricity[3] | 0.18 | 0.38 | 1.24 | 2.25 | 2.57 | 2.65 | 10.22 | 5.56 |
| Energy production | | | | | | | | |
| - Total | 0.37 | 2.09 | 3.56 | 5.27 | 5.46 | 5.60 | 12.02 | 3.28 |
| - Solids | 0.03 | 1.35 | 1.78 | 1.38 | 1.23 | 1.23 | 23.35 | -2.58 |
| - Liquids | 0.16 | 0.36 | 0.51 | 1.72 | 1.75 | 1.84 | 5.86 | 9.67 |
| - Gases | | | 0.04 | 0.15 | 0.17 | 0.18 | 15.03 | 11.67 |
| - Primary electricity[3]) | 0.18 | 0.38 | 1.24 | 2.01 | 2.30 | 2.34 | 10.23 | 4.63 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.41 | 0.84 | 1.95 | 1.50 | 1.78 | 1.80 | 8.06 | -0.56 |
| - Solids | 0.03 | 0.05 | 0.13 | 0.31 | 0.35 | 0.37 | 7.86 | 7.98 |
| - Liquids | 0.39 | 0.78 | 1.82 | 1.19 | 1.43 | 1.42 | 8.07 | -1.73 |
| - Gases | | | | | | | | |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

In the last few years, a price and tariff policy not consistent with production costs and an inadequate return on investments led to higher energy costs and decreased reliability of supply. The effects were exacerbated by construction delays and rising construction costs in the 1980's. Currently, the Government and the National Congress are enacting constitutional changes in order to encourage privatisation (privatisation programme), stimulate competition, and attract new investments to the energy sector. The main objectives of the national energy policy are orientated to: (i) conservation and efficient use of energy, (ii) expansion of oil production and electric power supply, (iii) realistic pricing policy, (iv) efficiency of energy production systems, (v) private enterprise participation, (vi) use of renewable energy resources; and (vii) technical innovation.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Up until early 1960's, the Brazilian electric utilities had no central co-ordination. Operation and planning activities were limited to independent utility requirements, resulting in isolated or poorly integrated systems. Rapid growth in industrialization created expansion of inter-regional integration opportunities for the electric companies outside their geographical areas. This integration gave rise to increased supply reliability and provided economies of scale.

In 1962, the federal government established a holding company, ELETROBRAS, with the objective of organizing, co-ordinating and planning all activities of the sector at the national level. ELETROBRAS is part of the Ministry of Mining and Energy - MME. As of December 1996, the Brazilian electricity sector comprises 62 organizations: four companies of the ELETROBRAS System (ELETRONORTE, CHESF, FURNAS and ELETROSUL), 27 state utilities associated to ELETROBRAS and 31 public and private utilities (see Table 5). The federal government is responsible for electricity generation in the north and north-east regions through two federal monopolies: ELETRONORTE and CHESF. In the remaining regions, the ELETROBRAS System competes in the generation activities with state-owned utilities. The most important of these state-owned companies are CEMIG, in the Minas Gerais State; CESP, in São Paulo; COPEL in Paraná; and, CEEE in Rio Grande do Sul.

ELETROBRAS is an open corporation with shares negotiated in the capital market. It co-ordinates the whole electricity sector concerning the technical, financial and administrative aspects. ELETROBRAS is the major share holder of the federal companies and is a minor share holder in the state-owned companies. Electricity generation and transmission is run by ELETROBRAS subsidiaries and some of the state-owned utilities within the geographical limits of the states. The states have a mix of state and privately owned companies for the distribution of electricity. The exception is the state of Tocantins, recently founded, where electricity is supplied by a private utility. The national electrical transmission grid has 59,000 km of 230 kV lines and 91,000 km of lines lower than 230 and higher than 34 kV.

A large utility company, Itaipu Binational, was founded in 1973 by the Brazilian and Paraguayan Governments. The Itaipu power station has an installed capacity of 12,600 MW. Due to the difference in the frequencies used in both countries, the energy share sent to Brazil has to be transformed in direct current, transmitted to a conversion centre and then reconverted to alternate current in 60 Hz. According to the treaty that gave rise to Itaipu Binational, Brazil has to buy the excess energy produced and not consumed by Paraguay (27,560 GW·h in 1993).

TABLE 5. PARTICIPATION OF PRIVATE AND STATE-OWNED COMPANIES IN THE ELECTRICITY GENERATION

| COMPANY TYPE | PARTICIPATION (%) |
|---|---|
| ELETROBRAS system | 40.0 |
| State-owned Utilities | 36.0 |
| ITAIPU - Brazil's share | 9.5 |
| ITAIPU - Brazil's import | 9.5 |
| Auto-Producers | 4.7 |
| Private/Municipal | 0.3 |

Source: ELECTROBRAS

### 2.2. Policy and Decision Making Process

The institutional organization of the Brazilian electricity sector includes the Ministry of Mining and Energy (MME) as the highest political instance, the National Department of Water and Electrical Energy (DNAEE) as a normative body, and ELETROBRAS as a planning and system expansion co-ordinator. Policy and decision making tasks are accomplished by ELETROBRAS mainly through three commissions: GCOI - Network Operation Co-ordination Group, GCPS - Electrical Systems' Planning Co-ordination Group, and SINTREL - National Electric Energy Transmission System.

GCOI, created in 1969, is a co-ordinating group formed by ELETROBRAS and the utilities, that optimises the operation of the hydro-thermal system by using to a maximum extent water resources and providing for fossil and nuclear fuel economy.

GCPS, created in 1992, is a committee integrated by utilities, under the co-ordination of ELETROBRAS. GCPS develops and updates the system's ten-year expansion plan. This Decennial Plan is the main instrument used by the Ministry of Mining and Energy for planning the expansion of the electric sector.

SINTREL was created in 1993, as a result of deregulation, for improving competitiveness and increasing the participation of private capital in the sector. The utilities are in charge of the expansion, operation and maintenance of the SINTREL's network.

In order to adapt the Government structure to the new market trends of deregulation, competitiveness and privatization, in December 1996 it was created the National Electric Energy Agency (ANEEL) replacing DNAEE as the normative body for electricity sector of Brazil..

### 2.3. Main Indicators

Brazil's electricity output in 1992 amounted to 241.7 TW·h, of which 92.6% originated from hydroelectric sources, 6.7% from fossil fuelled plants, and 0.7% from nuclear plants (Table 6). In 1992, the electricity/energy production rate was about 44%. Per capita electricity consumption increased from 1,128 kW·h in 1980 to 1,707 kW·h in 1992 (Table 7).

TABLE 6. ELECTRICITY PRODUCTION AND CAPACITY OF ELECTRICAL PLANTS

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 22.87 | 45.46 | 139.49 | 222.82 | 255.34 | 260.68 | 9.46 | 4.57 |
| - Thermal | 4.48 | 5.60 | 10.58 | 14.06 | 16.50 | 17.72 | 4.39 | 3.75 |
| - Hydro | 18.38 | 39.86 | 128.91 | 206.71 | 238.44 | 242.92 | 10.23 | 4.63 |
| - Nuclear | | | | 2.06 | 0.40 | 0.04 | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 4.80 | 11.23 | 33.37 | 53.05 | 56.23 | 57.64 | 10.18 | 3.98 |
| - Thermal | 1.16 | 2.41 | 5.87 | 6.87 | 7.01 | 7.09 | 8.45 | 1.36 |
| - Hydro | 3.64 | 8.83 | 27.50 | 45.56 | 48.60 | 49.93 | 10.64 | 4.35 |
| - Nuclear | | | | 0.63 | 0.63 | 0.63 | | |

[1] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 7. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 11 | 30 | 45 | 46 | 46 | 48 |
| Electricity per capita (kW·h/capita) | 315 | 458 | 1,128 | 1,647 | 1,788 | 1,817 |
| Electricity production/Energy production (%) | 60 | 20 | 37 | 40 | 45 | 44 |
| Nuclear/Total electricity (%) | | | | 1 | | |
| Ratio of external dependency (%)[1] | 53 | 29 | 35 | 22 | 25 | 24 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 54 | 46 | 48 | 48 | 52 | 52 |
| - Thermal | 44 | 27 | 21 | 23 | 27 | 29 |
| - Hydro | 58 | 52 | 54 | 52 | 56 | 56 |
| - Nuclear | | | | 37 | 7 | 1 |

[1] *Total net import / Total energy consumption.*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

In 1970, a decision was made to build Brazil's first nuclear power station through an international bid. The contract of a turn-key project for a 626 MW(e) PWR reactor (ANGRA 1) was awarded to Westinghouse Electric Corporation of the United States of America. ANGRA 1 construction started in 1971, and the first criticality was achieved ten years later.

In 1975, in an effort to become self-sufficient in nuclear power generation, Brazil signed an agreement with the Federal Republic of Germany to build eight 1,300 MW(e) reactors (PWR Biblis B type) over the period of 15 years. Under this agreement, two of these units (ANGRA 2 and ANGRA 3) were scheduled for construction on the following year with most of their components imported from Kraftwerk Union's (KWU) shops in Germany. According to this agreement, the rest of the plants were to contain 90% Brazilian-made components. The Brazil-Germany agreement created the Empresas Nucleares Brasileiras, NUCLEBRAS, a Brazilian stated-owned nuclear holding company. Additionally, several subsidiaries (joint companies) were established to achieve nuclear technology transfer from Germany (see Table 8).

TABLE 8. NUCLEBRAS SUBSIDIARIES

| COMPANY | ACTIVITY |
|---|---|
| NUCLEP* | Heavy Components Manufacture |
| NUCLEI* | Enrichment by Jet-Nozzle Process |
| NUCLEN* | Nuclear Power Plant Architect and Engineering |
| NUCLAM* | Uranium Prospection |
| FEC | Fuel Elements Manufacture |
| CDTN | Nuclear Technology R&D Centre |
| NUCON | Nuclear Power Plant Construction |
| NUCLEMON | Rare Earth's Production |
| CIPC | Mining and Yellow Cake Production |

*Joint Brazilian-German Companies

The Brazilian nuclear regulatory body is the National Nuclear Energy Commission (CNEN), responsible for conducting the national research programme; licensing nuclear power plants and nuclear facilities; performing regulatory activities; and training and organizing personnel, according to the Law 4,118 of 1962. In the early 1980's, the Brazilian Navy started a nuclear propulsion programme. Backed by CNEN, the Navy's main activity was the development of uranium enrichment by using ultracentrifuge process. Relatively good success was achieved by the end of the decade which has continued through the 1990's.

Due to several factors (especially financial problems) the Brazilian-German technology transfer programme was forestalled. ANGRA 2 and ANGRA 3 construction was interrupted several times, resulting in further delay in Brazilian nuclear programme. Due to Brazil's foreign debt and high inflation with added pressures from privatisation programme and budget cuts, the Brazilian nuclear programme was reorganized at the end of the 1980's.

In 1988, NUCLEBRAS and its subsidiaries were replaced by a new company, Industrias Nucleares Brasileiras SA (INB), with limited authority. INB became responsible for rare earth's, mining of nuclear minerals and yellow cake and nuclear fuel production assuming FEC, NUCLEMON and CIPC activities. FEC, renamed as Nuclear Complex of Rezende, was transformed in an INB Directorate. Both INB and NUCLEP, responsible for heavy equipment fabrication, became CNEN's subsidiaries. Responsibility for the construction of nuclear power stations was transferred to the state-owned utility, FRUNAS/ELECTROBRAS, incorporating NUCON activities. NUCLEN was maintained responsible for nuclear power plant architect and engineering. NUCLEI and NUCLAM were disbanded.

### 3.2. Status and Trends of Nuclear Power

The status of the Brazilian NPP is shown in Table 9. The ANGRA 1 nuclear power plant located between Sao Paulo and Rio de Janeiro, has a net capacity of 626 MW(e). It started commercial operation in December 1984. During the period of 1985-1989, the plant experienced two long unscheduled outages due to problems on the main condenser and emergency diesel electric generator. From 1990 on, the plant operated with a limited capacity factor of 55% due to preference given to hydroelectric generation. Nevertheless, ANGRA 1 has operated at full capacity, in several occasions, when it was necessary. In March 1993, the plant experienced problems with some fuel rods. It resumed energy production in December 1994. ANGRA 1 plays an important role in the reliability of the south-east electric system (predominantly of hydro origin) assuring continuous electric power supply to the states of Rio de Janeiro and Espírito Santo where local water resources are virtually exhausted and power supply depends on long transmission lines. The operating experience is given in Table 10.

TABLE 9. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| ANGRA-1 | PWR | 626 | FURNAS | Operational | WEST |
| ANGRA-2 | PWR | 1245 | FURNAS | Under Construction | KWU |
| ANGRA-3 | PWR | 1245 | FURNAS | Planned | KWU |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| ANGRA-1 | 01-May-71 | 13-Mar-82 | 02-Apr.-82 | 01-Dec.-84 | |
| ANGRA-2 | 01-Jan-76 | 01-Mar-99 | 01-Apr.-99 | 01-Jul.-99 | |
| ANGRA-3 | | | | | |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 10. OPERATING EXPERIENCE OF ANGRA 1

| Year | Energy GW·h | Average Load Factor (%) |
|---|---|---|
| 1982 | 51.7 | |
| 1983 | 162.5 | |
| 1984 | 1545.5 | |
| 1985 | 3169.4 | 57.8 |
| 1986 | 132.4 | 2.4 |
| 1987 | 910.6 | 16.6 |
| 1988 | 566.6 | 10.3 |
| 1989 | 1695.1 | 30.9 |
| 1990 | 2055.3 | 37.5 |
| 1991 | 1306.4 | 23.8 |
| 1992 | 1506.4 | 27.4 |
| 1993 | 402.7 | 7.3 |

Source: IAEA Power Reactor Information System

Construction of ANGRA 2 began in January 1976, but due to financial problems the construction of the unit has slowed down and experienced several stoppages. ANGRA 2 is about 75 per cent complete, the remaining work to be done is mostly related to electro-mechanical assembly and plant commissioning. Effective electro-mechanical assembling work of ANGRA 2 was resumed during the second half of 1996. Its completion and commissioning will be concluded late 1999.

The third nuclear station (ANGRA 3), a 1,245 MW(e) PWR reactor, similar to ANGRA 2, was initiated in 1983. ANGRA 3 has about 59 per cent of the design and engineering work completed. Main components have been supplied (imported). Civil works and electro-mechanical assembling activities have not yet commenced.

### 3.3. Current Policy Issues

Hydroelectric power plays a paramount role in the Brazilian electricity system while thermal power plants (conventional and nuclear) are meager contributors to electricity supply. Considering the country's huge hydroelectric potential along with social and economical uncertainties, it is very difficult to forecast further nuclear power development in Brazil. However, according to the Plan 2015 (ELETROBRAS National Plan for Electrical Sector Expansion), nuclear capacity equivalent to 2,490 MW(e) (ANGRA 2 and ANGRA 3) is foreseen to be installed by the year 2004. ANGRA 3 power station will start construction during the second semester of 1999 and it is expected to be completed 4 or 5 years later.

### 3.4. Organizational Chart

The organizational structure of Brazil's nuclear sector and the relationships among different organizations are shown in Figure 1. The National Nuclear Energy Commission (CNEN), is the regulatory body, which reports to the Secretary for Strategic Affairs (SAE). The Brazilian Electricity Company (ELETROBRAS), responsible for planning and co-ordinating all activities of the electrical sector at national level, is under the Ministry of Mining and Energy. The remaining organizations are discussed in the following sections.

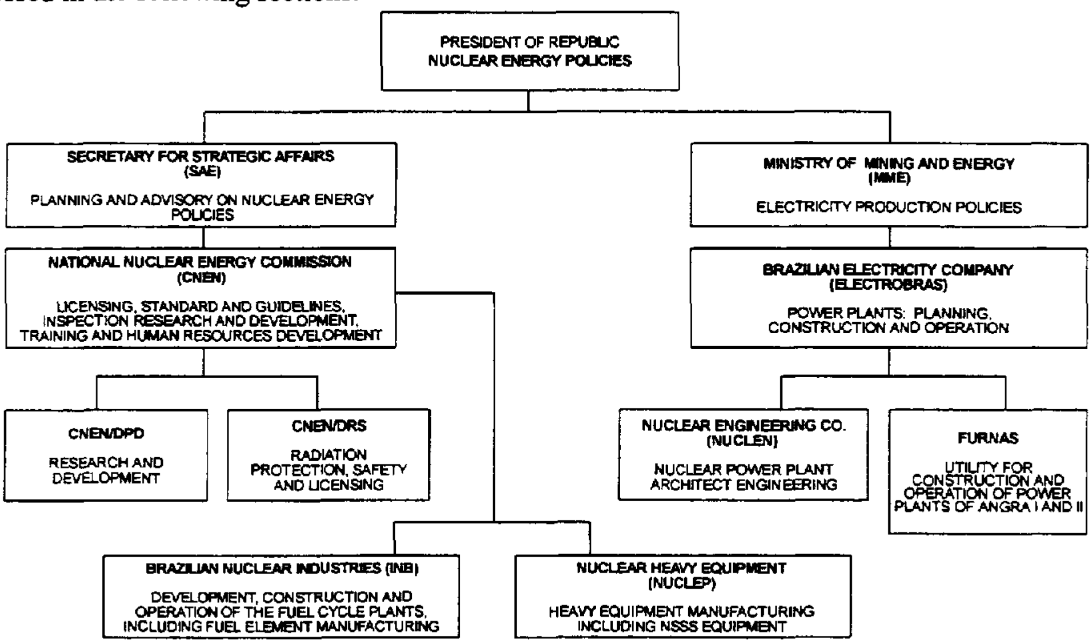


*FIG. 1. Organization Structure for Nuclear Energy Development in Brazil*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

Two companies related to nuclear power plant engineering and component supply remained active after the reorganisation of the nuclear sector in 1988: NUCLEP (Nuclear Heavy Equipment) as a subsidiary of CNEN and NUCLEN (Nuclear Engineering Company) as a subsidiary of ELETROBRAS. NUCLEN is responsible for nuclear power plant architect engineering; subcontracting engineering services and ordering of equipment; quality assurance; and, technical assistance to engineering and industrial companies. NUCLEP was established to design and fabricate heavy nuclear power plant components, specially those used in the reactor primary circuit. NUCLEP specialises in fabrication of large components made from alloy steels, nickel alloys and titanium alloys. It maintains modern quality control laboratories, outfitted with precision instruments, qualified and certified according to international standards, for mechanical, chemical and metallurgical testing.

NUCLEP has technological partnerships with KWU/SIEMENS, MAN-GHH and Voest-Alpine to assure appropriate technology transfer for nuclear components and fabrication. In November 1994, NUCLEP obtained the ISO 9001 Certificate from ABS-American Bureau of Shipping Quality Evaluations by virtue of its capability to fulfill the most rigid quality requirements, in compliance with world-wide quality standards.

### 4.2. Operation of Nuclear Power Plants

FURNAS is the utility responsible for construction and operation of Brazilian nuclear power plants ANGRA 1 and 2. The ANGRA site has a PWR/ANGRA 2 type simulator in operation since 1985. The simulator has provided operator training services for utilities from countries such as Spain, Switzerland, Germany and Argentina, which operate nuclear power plants supplied by KWU.

### 4.3. Fuel Cycle and Waste Management Service Supply

Industrias Nucleares do Brazil - INB, CNEN's subsidiary, is responsible for the industrial nuclear fuel cycle activities in Brazil, from mining and uranium concentrate production to fuel elements fabrication. A uranium mine and mill located in Pocos de Caldas (Figure 2), State of Minas Gerais, has been in operation since 1982 with an annual nominal production capacity of 400 tons $U_3O_8$. This mine will operate until 1997 when high-grade ore will be exhausted and the mine will be shut-down.

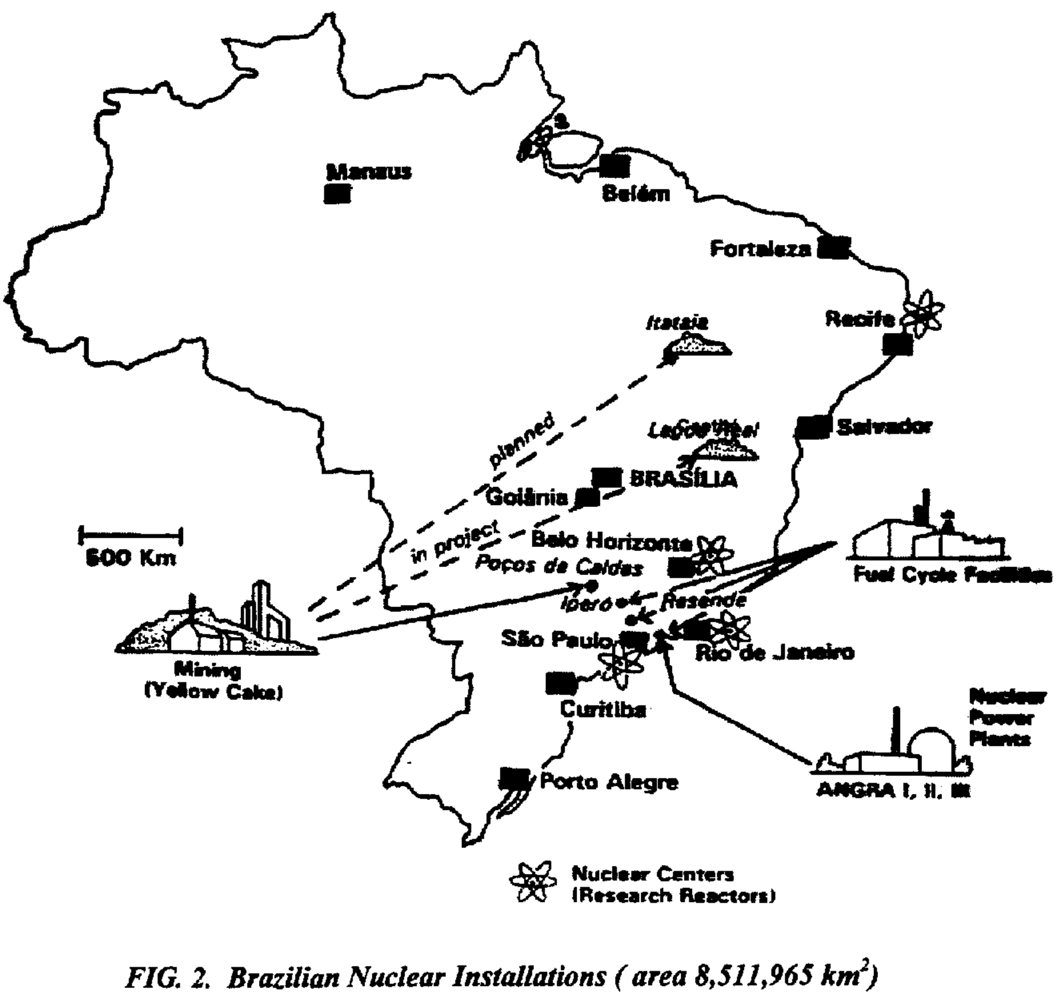


*FIG. 2. Brazilian Nuclear Installations ( area 8,511,965 km²)*

Additional uranium deposits in Caetité, State of Bahia, and Itataia, State of Ceará have been prospected. The Caetité deposit, whose preparatory works for its exploitation will be initiated in 1997, has reserves of 61,840 tons $U_3O_8$ and a planned production capacity of 300 tons $U_3O_8$ per year. The Itataia deposit has 91,200 tons of uranium reserves associated with phosphates with the annual scheduled production of about 700 tons.

The Fuel Fabrication Plant (FEC) is in Resende, State of Rio de Janeiro, and has a production capacity of 100 tons of uranium per year. At present, fuel rods are manufactured and fuel elements assembled using $UO_2$ pellets received from external suppliers. The $UO_2$ powder production line, using the AUC process, and pellets fabrication will be in operation in 1997, with a capacity of 120 tons uranium per year. The Fuel Fabrication Plant also produces other fuel element components, such as top and bottom nozzles, spacer grids, and end plugs. INB also has a demonstration plant operating to produce rare earth oxides of very high purity (99.9%). It is capable of producing the complete spectrum of rare earth components, from chlorides, obtained from the monazite sands, to high purity oxides. These projects will be also developed jointly with private companies.

As part of its nuclear propulsion programme, Brazilian Navy installed in Iperó (60 km from São Paulo), a demonstration enrichment centrifuge pilot plant.

The major sources of radioactive waste in Brazil are the ANGRA 1 Nuclear Power Plant and the Monazite processing industry. The waste generated by the uranium mining and milling industrial complex, although significant in volume, is kept at the site, in a dam specially built for this purpose. The waste management policy takes into account both the accumulated and projected waste generated by the above mentioned facilities and the existing 3,500 cubic meters of Caesium-137 waste produced as a result of the decontamination work performed in Goiânia, following the 1987 accident that involved a 1,375 Curie teletherapy source.

The National Nuclear Energy Commission, CNEN, is responsible for regulation and final disposition of radioactive waste. Political and psycho-social aspects related to the subject of radioactive waste disposal, specially the "not-in-my-back-yard syndrome", contribute to the difficulties faced by the Brazilian Government when decisions concerning radioactive waste management are to be taken.

The waste generated by the uranium mining and milling industrial complex, located at the Poços de Cladas plateau in the Brazilian state of Minas Gerais, is kept in a 29.2 hectares dam system, specially built for this purpose with an actual volume of one million cubic metres. It is estimated that 4.8 Tbq (130 Ci) of $U^{238}$ and 15 Tbq (405 Ci) of $Ra^{226}$ have been deposited at this site. The chemical processing of monazite sands to extract rare earth elements, is a significant source of thorium, a nuclear material with no planned short term application, and a complex compound of $Ra^{228}$ with barium sulphate, called "mesothorium", with no foreseeable use. There are, presently, about 300 metric tons of "mesothorium" with an estimated $Ra^{228}$ activity of 1.85 Tbq (50 Ci) in a provisional storage facility waiting for final disposal. The material containing thorium hydroxide, separated from the rare earth elements during monazite processing, although not formally classified as waste, is also stored. It amounts, approximately, to 17,000 metric tons. Since the reprocessing option has not been ruled out by the Brazilian authorities, spent fuel is not classified as high level radioactive waste.

Since the Brazilian reprocessing programme has not been clearly defined, the ANGRA 1 spent fuel is temporally stored on-síte, in the reactor basin. As of December 1994, 67.5 metric tons of spent fuel (164 fuel elements) were stored in racks at the on-site reactor basin of ANGRA 1 nuclear power plant and 0.06 metric tons of spent fuel from one of the research reactors under storage conditions. The utility, FURNAS, is conducting studies related to the design of super compact racks with a planned capacity of 1,252 fuel assemblies to increase the storage capacity of the on-site reactor basin. Presently, there are no firm plans concerning the management of high level nuclear waste.

### 4.4. Research and Development Activities

The National Nuclear Energy Commission (CNEN), created in 1956, has a twofold mission: to regulate, license and inspect the uses of nuclear energy for peaceful purposes; and, to promote, orient and co-ordinate research and development in all areas related to nuclear energy. CNEN comprises three directorates whose responsibilities are:

i) Directorate of Administration and Infrastructure (DAL): human resources, administration and information management, financial reporting and control;

ii) Directorate of Research and Development (DPD): fuel cycle and materials, reactor technology, radiation utilisation, radioisotopes application and production, instrumentation and control, safety, nuclear physics and chemistry, etc.;

iii) Directorate of Radiation Protection and Safety (DRS): Radiation protection, safety, control and licensing of nuclear power plants and other nuclear installations.

During the last decades, four large research nuclear centres were established for carrying out R&D in nuclear sciences and engineering. Research reactors, accelerators and various R&D laboratories, including pilot plant facilities, were progressively set up in these centres. These four research centres are:

IPEN (São Paulo) - Institute for Energy and Nuclear Research

- Research Reactors: 2 (one 2 MW/pool type and one zero power reactor/tank type)
- Cyclotron
- Radioisotopes Production ($^{99m}$Tc; $^{131}$I; $^{121}$I; etc.)
- Research on fuel cycle and materials; reactor technology; safety; fundamentals; radiation and radioisotope applications; etc.

IEN (Rio de Janeiro) - Institute for Nuclear Engineering

- Research Reactor: 1 (100 kW, ARGONAUTA)
- Cyclotron
- Research on fast reactor; instrumentation and control; fundamentals.

CDTN (Belo Horizonte) - Centre for Nuclear Technology Development

- Research Reactor: 1 (100 kW, TRIGA)
- Research on mining; reactor technology; materials, safety; chemistry; environment technology.

IRD (Rio de Janeiro) - Institute for Radiation Protection and Dosimetry

- Research on radiation protection and safety; environmental technology.

Within CNEN organizational chart IPEN, IEN and CDTN institutes report to the Directorate of Research and Development white IRD institute reports to the Directorate of Radiation Protection and Safety.

### 4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

The agreement signed with the Federal Republic of Germany in 1975 included clauses for technology and know-how transfer in all areas of the nuclear technology including enrichment process, called "jet-nozzle", then in a development stage. The agreement included training of Brazilian personnel in German industries, laboratories and universities.

Under the sponsorship of International Atomic Energy Agency, Brazil has been participating in many technical assistance programmes, advisory groups and symposium meetings. Brazil has technical co-operation agreements with other countries, like the United States of America, France, Argentina and China in exchange of information on nuclear safety and radiological protection, computer codes development and assessment, training, radioactive waste management and radioactive materials transportation.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

The governmental organization responsible for the licensing of Nuclear Power Plants (NPP's) and other nuclear installations in Brazil is the National Nuclear Energy Commission (CNEN). In August 1962, with the enactment of law No. 4,118, a National Policy on Nuclear Energy was established with the Government monopoly of nuclear materials and minerals.

In the early 1970's, due to the needs of the Brazilian Nuclear Power Programme, three experimental standards were issued by CNEN on Site Selection, Licensing Process and Radiological Protection, the Resolução CNEN 09/72, CNEN 06/72 and CNEN 06/73. An extensive set of rules and standards, as listed under section 5.2, regulate the nuclear activities in Brazil. CNEN licenses nuclear installations. The process involves the issuance of five licenses or authorisations as listed below:

Site Approval;
Construction Permit;
Nuclear Material Utilisation Authorisation;
Initial Operation Authorisation; and,
Permanent Operation Authorisation.

Standard CNEN-NE-1.04 establishes the requirements for the licensing process. The Initial Operation Authorisation is issued with some temporary conditions and the Permanent Operation Authorisation (POA) is limited to 40 years. A Periodic Safety Reassessment is conducted every ten years of operation, when the conditions of authorisation can be modified or extended.

In 1981, the Environmental Policy Law was promulgated and, from 1983 to 1989, CNEN was also responsible for conducting the environmental licensing of nuclear installations. In 1989, the Brazilian Institute of Environment (IBAMA) was created and designated to conduct the environmental licensing of all installations, including nuclear facilities.

During the operational phase of nuclear facilities periodic safety reports are required. Regulatory safety assessment is conducted by CNEN through the review of the licensee's reports as well as through periodic inspections. On-site resident inspectors are assigned for permanent supervision of operational safety.

### 5.2. Main National Laws and Regulations

Main legislation is approved by the National Congress. CNEN's regulations and standards are based on IAEA standards, commonly used by many nations. The main laws and standards used in Brazil are:

- Law No. 4,118: National Policy on Nuclear Energy, 1962.
- Law No. 6,189: CNEN's Set-up as Regulatory and Licensing Federal Authority, 1974.

CNEN's Main Standards:

- CNEN-NE.1.04: Licensing of Nuclear Installations, 1984.

- CNEN-NE.1.16: Quality Assurance for Nuclear Power Plants, 1984.
- CNEN-NE.1.01: Licensing of Nuclear Reactors Operators, 1979.
- CNEN-NN.1.12: Qualification of Independent Technical Supervisory Organization, 1981.
- CNEN-NE.1.14: Operating Reports of Nuclear Power Plants, 1983.
- CNEN-NN.1.15: Independent Technical Supervisory in Quality Assurance Activities for Nuclear Power Plant, 1983.
- CNEN.NE.2.01: Physical Protection of Operational Units of Nuclear Installations, 1981.
- CNEN-NE.2.02: Nuclear Material Control and Safeguards, 1982.
- CNEN-NE.2.03: Fire Protection in Nuclear Power Plants, 1988.
- CNEN-NE.3.01: Basic Limits, for Radiological Protection, 1988.
- CNEN-NE.5.02: Transport Storage and Handling of Nuclear Fuels, 1989.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • IAEA Statute | Signature: | 26 October 1956 |
| • Agreement for the application of safeguards between Brazil, | Signature: | 10 March 1967 |
| USA and IAEA. INFCIRC/110 | Entry into force: | 31 October 1968 |
| • Amendment to the Article VI of the IAEA Statute | Signature: | 8 September 1971 |
| • Amendment to the safeguards agreement between Brazil, USA and IAEA. | Signature: | 27 July 1972 |
| • Agreement for application of safeguards between Brazil, Germany | Signature: | 26 February 1976 |
| and IAEA. INFCIRC/237 | Entry into force: | 26 February 1976 |
| • ARCAL | Entry into force: | September 1984 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 27 February 1991 |
| • NPT and/or Tlatelolco related agreement: | | |
| Sui generis full-scope safeguards | Signed on: | 13 December 1991 |
| agreement (Argentina, Brazil, ABACC, and IAEA). INFCIRC/435 | Entry into force: | 4 March 1994 |
| Argentina Senate: | Approved on: | 5 August 1992 |
| Brazilian Parliament: | Approved on: | 19 February 1994 |

*OTHER RELEVANT INTERNATIONAL TREATIES*

| | | |
|---|---|---|
| • Treaty for prohibition of experiences with nuclear weapons in the atmosphere, cosmic space and under water | Signature: | 5 August 1963 |
| • ILO Convention | Signature: | 7 April 1964 |

| | | |
|---|---|---|
| • Partial test ban treaty | Entry into force: | 15 December 1964 |
| • Technical assistance agreement between UN, its specialised agencies and the IAEA | Signature: | 29 December 1964 |
| • Agreement on privileges and immunities | Signature:<br>Entry into force: | 13 June 1966<br>13 June 1968 |
| • NPT/Tlatelolco Treaty<br>Amendment of the Treaty | Ratified<br>Ratified: | 29 January 1968<br>30 May 1994 |
| • Treaty on the prohibition of the installation of nuclear weapons and other lethal weapons in the seabed, deep ocean floor and sub-seabed. | Signature: | 3 September 1971 |
| • Convention on civil liability in the field of maritime carriage of nuclear material | Signature: | 17 December 1971 |
| • Convention on prevention of marine pollution by dumping of wastes and other materials | Signature: | 29 December 1972 |
| • Convention on the physical protection of nuclear material | Signature:<br>Entry into force: | 15 May 1981<br>8 February 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Signature:<br>Entry into force: | 26 September 1986<br>4 January 1991 |
| • Convention on early notification of a nuclear accident | Signature:<br>Entry into force: | 26 September 1986<br>4 January 1991 |
| • Convention on the control of movement of dangerous wastes and their deposits | Signature: | 16 June 1992 |
| • Vienna convention on civil liability for nuclear damage | Signature:<br>Entry into force: | 23 December 1992<br>26 June 1993 |
| • Nuclear safety convention | Signature: | 20 September 1994 |
| • ZANGGER Committee | Non-member | |
| • Nuclear export guidelines | | |
| • Acceptance of NUSS Codes | | |

*MULTILATERAL AGREEMENTS*

| | | |
|---|---|---|
| • Antarctica Treaty | Signature: | 1 December 1959 |

| | | |
|---|---|---|
| • Treaty for prohibition of nuclear weapons in Latin America | Signature: | 9 May 1967 |

*BILATERAL AGREEMENTS:*

| | | |
|---|---|---|
| • Co-operation agreement concerning peaceful uses of nuclear energy | Paraguay | 18 August 1961 |
| • Co-operation agreement concerning peaceful uses of nuclear energy | Bolivia | 11 January 1966 |
| • Co-operation agreement in the field of peaceful uses of nuclear energy | Ecuador | 11 June 1970 |
| • Agreement concerning nuclear ships in Brazilian waters | Germany | 7 June 1972 |
| • Co-operation agreement concerning peaceful uses of nuclear energy | Germany | 27 June 1975 |
| • Co-operation agreement concerning peaceful uses of nuclear energy between CNEN and the Nuclear Research Centre in Karlsruhe | Germany | 8 March 1978 |
| • Special agreement between CNEN and the Research Centre in Julich | Germany | 8 March 1978 |
| • Assistance in establishing the conditions of the application of uranion hexafluoride | France | 6 January 1981 |
| • Agreement for the co-operation on the peaceful uses of nuclear energy | Colombia | 12 March 1981 |
| • Co-operation agreement concerning peaceful uses of nuclear energy | Peru | 26 June 1981 |
| • Co-operation agreement in the field of peaceful uses of nuclear energy | Italy | 29 July 1981 |
| • Memorandum of understanding | Great Britain | 2 December 1981 |
| • Co-operation agreement in the field of peaceful uses of nuclear energy | Spain | 12 May 1983 |
| • Co-operation agreement concerning peaceful uses of nuclear energy | Venezuela | 30 November 1983 |
| • Technical co-operation agreement | USA | 6 February 1984 |

| | | |
|---|---|---|
| • Memorandum of understanding on co-operation in the field of peaceful uses of nuclear energy | China | 29 May 1984 |
| • Co-operation agreement concerning peaceful uses of nuclear energy | China | 11 October 1984 |
| • Agreement concerning early notification and mutual assistance in case of nuclear accident or radiological emergency | Argentina | 18 July 1986 |
| • Agreement concerning peaceful uses of nuclear energy | Argentina | 18 July 1991 |
| • Application of safeguards | Argentina | 13 December 1991 |
| • Agreement on the privileges and immunities | ABACC | 27 March 1992 |
| • Co-operation agreement in the field of peaceful uses of nuclear energy | Russian Federation | 15 September 1994 |

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[1] Statistical Data from IAEA Energy and Economic Data Bank, (EEDB) (1995).

[2] PLAN 2015: Energy Supply and Demand Study - System Expansion Strategy, ELETROBRAS, (May 1993).

[3] PLAN 2015: Electric Energy Sector and Brazilian Economy: Perspectives, ELETROBRAS, (May 1993).

[4] National Energy Balance (BEN), Mining and Energy Ministry, DNGE/SEN/MME, (1994).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| National Nuclear Energy Commission | |
| Rua General Severiano 90, BOTAFOGO | |
| 222290-040 - Rio de Janeiro-RJ | Tel: (5521) 2959596 |
| Brazil | Fax: (5521) 295 8696 |

NATIONAL NUCLEAR ENERGY COMMISSION INSTITUTES

| | |
|---|---|
| Centro de Desenvolvimento de Tecnologia Nuclear, CDTN | |
| Prof. Mário Werneck, S/N°, Cidade Universitária | |
| 30161-970 - Belo Horizonte-MB | Tel.: (5531) 499 3261 |
| BRAZIL | Fax: (5531) 499 3444 |
| | |
| Instituto de Engenharia Nuclear, IEN | |
| Cidade Universitaria Ilha do Fundão | |
| 21945-970 - Rio de Janeiro-RJ | Tel.: (5521) 280 6830 |
| BRAZIL | Fax: (5521) 590 2692 |
| | |
| Instituto de Pesquisas Enérgeticas e Nucleares, (IPEN) | |
| Travessa "R", 400 | |
| Cidade Univesitaria | |
| 05508-900 - São Paulo - SP | Tel.: (5511) 816 9000 |
| BRAZIL | Fax: (5511) 212 3546 |
| | |
| Instituto de Radioproteção e Dosimetria, IRD | |
| Av. Salvador Allende, S/N°, Barra da Tijuca | |
| 22780-160 - Rio de Janeiro - RJ | Tel.: (5521) 442 1927 |
| BRAZIL | Fax: (5521) 442 1950 |

OTHER NUCLEAR ORGANIZATIONS

| | |
|---|---|
| Furnas Centrais Eléctricas S/A, FURNAS | |
| R. Real Grandeza, 219, | |
| Bloco A, 16° Andar, Botafogo | |
| 22283-900 - Rio de Janeiro-RJ | Tel.: (5521) 528 5300 |
| BRAZIL | Fax: (5521) 286 8895 |
| | |
| Indústrias Nucleares Brasileiras, INB | |
| R. Mena Barreto, 161 | |
| 22271-100 - Rio de Janeiro-RJ | Tel.: (5521) 552 1845 |
| BRAZIL | Fax: (5521) 286 8261 |
| | |
| Nuclen Engenharia e Servviços S/A. NUCLEN | |
| R. Visconde de Ouro Preto, 5, 12° Andar | |
| 20000-000 - Rio de Janeiro - RJ | Tel.: (5521) 552 1845 |
| BRAZIL | Fax: (5521) 552 1745 |
| | |
| Nuclebrás Equipamentos Pesados S/A, NUCLEP | |
| Av. Gal, Euclides de Oliveira Figueiredo, 200, Itaguaí | |
| 23825-410 - Rio de Janeiro-RJ | Tel.: (5521) 688 2056 |
| BRAZIL | Fax: (5521) 688 3011 |

# BULGARIA

# 1. GENERAL INFORMATION

## 1.1. General Overview

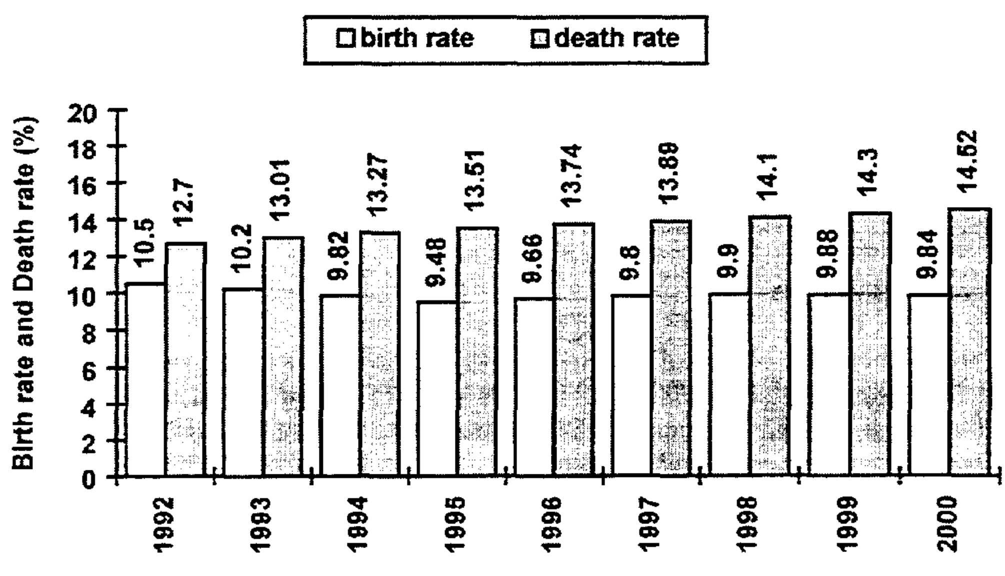
Bulgaria is a country situated in the south-eastern Europe and it occupies the biggest part of the Balkan peninsula. The northern border of Bulgaria continues for 470 km on the Danube river and later on in south-eastern direction to the Black Sea for about 139 km on land. In eastern direction Bulgaria borders the Black Sea while to the south there is a 752 km long border with Turkey and Greece. To the west the country has a border with the Former Yugoslav Republic of Macedonia and Yugoslavia. Within these borders Bulgaria has 110,990 $km^2$ surface, including an altitude correction.

The demographic situation in the country is characterised with a clear tendency of decrease in the population (Table 1). For the period between 1985 and 1996 the population has decreased by 476,000 people ( 5.3%). At the end of 1994, the population of the country numbered 8.43 million people and the population density was 76 persons per square kilometre. There exists a negative trend in the change of the population, which was for 1990 -0.4%; for 1991 -1.7%; for 1992 -2.2%; and for 1993 -2.8%; see Figure 1, which shows the birth and death rates from 1992 to 2000. According to the National Institute of Statistics, the total number of the population is expected to decrease by another 230,000 people around the year 2000, compared to 1993 (Table 2 and Figure 2).

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 7.9 | 8.5 | 8.9 | 8.7 | 8.6 | 8.5 | -0.3 |
| Population density (inhabitants/$km^2$) | 70.9 | 76.5 | 79.9 | 78.6 | 77.4 | 77.1 | |
| Predicted population growth rate (%) 1993 to 2000 | -0.5 | | | | | | |
| Area (1000 $km^2$) | 110.9 | | | | | | |
| Urban population in 1994 as percent of total | 70.0 | | | | | | |

Source: IAEA Energy and Economic Database




Source: Statistics of the National Economic development 1992/2000, Institute of Statistics, 1993, Sofia

***FIG. 1. Birth and Death Rate of the Bulgarian Population***

TABLE 2. PROJECTED POPULATION OF BULGARIA (1993-2000)

| Year | Inhabitants | | |
|---|---|---|---|
| | Total | Men | Women |
| 1993 | 8,459,000 | | |
| 1994 | 8,427,418 | 4,829,966 | 4,297,452 |
| 1995 | 8,402,258 | 4,114,159 | 4,288,100 |
| 1996 | 8,369,498 | 4,093,459 | 4,276,040 |
| 1997 | 8,335,562 | 4,072,789 | 4,262,773 |
| 1998 | 8,301,308 | 4,051,899 | 4,249,409 |
| 1999 | 8,266,256 | 4,030,968 | 4,235,288 |
| 2000 | 8,230,465 | 4,009,606 | 4,220,859 |

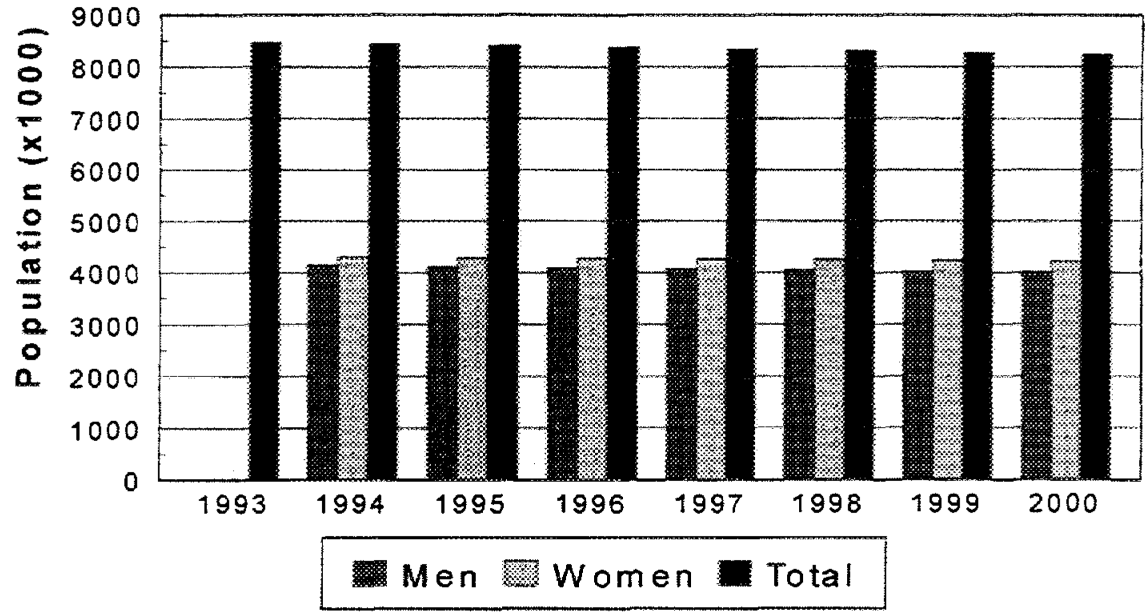



*FIG. 2. Projected Population of Bulgaria (1993 - 2000)*

Bulgaria has four distinct seasons which create changes in the demand for energy and in particular for electricity. The annual fluctuation of Bulgarian's electric power demand has one peak period in winter, which has been identified to be the result from using electricity for heating the houses. During 1995 and 1996 there has been a tendency of flattening of the winter peaks and summer drops in the consumption of electricity, due to certain changes in the structure of the demand and to higher usage of air conditioning in the service sector in the summer and heating in the winter.

## 1.2. Economic Indicators

Table 3 shows the historical Gross Domestic Product (GDP) data from the IAEA Energy and Economic Database (EEDB) in US$. GDP in 1995 was 871 billion levs in current prices. The GDP, expressed in prices of 1992, amounts to 187.7 billion levs. During the period 1990 - 1993 the GDP has been constantly declining though the decline is slowing down from 9.1 and 11.7 in 1990 and 1991 to 5.7 and 4.2 in 1992 and 1993. In 1994 and 1995 the decline was still lower and there has been some growth estimated at some 0.5% in 1995. Table 4 and Figure 3 show the structure of the GDP and Table 5 the changes of the gross added value by sector for the years 1990 to 1993. Table 6 and Figure 4 show the projected indexes of GDP. Table 7 shows the projected energy consumption per GDP by sector until 2015 expressed in 1992 prices.

TABLE 3. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 6,619 | 19,993 | 18,543 | | | |
| GDP (millions of constant 1990 US$) | 8,435 | 16,571 | 18,543 | 15,455 | 15,223 | -0.6 |
| GDP per capita (current US$/capita) | 780 | 2,256 | 2,127 | | | |
| GDP by sector: | | | | | | |
| Agriculture | 10% | | | | | |
| Industry | 37% | | | | | |
| Services | 53% | | | | | |

Source: IAEA Energy and Economic Database

TABLE 4. STRUCTURE OF THE GROSS DOMESTIC PRODUCT

%

| Economic Sector | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|
| Agriculture and Forest Industry | 18.3 | 15.5 | 11.5 | 9.2 |
| Industry | 51.0 | 48.1 | 44.6 | 41.7 |
| Services | 30.9 | 45.7 | 45.8 | 47.6 |
| Gross Added value in prices at the producer | 100.2 | 109.3 | 101.9 | 98.5 |
| Correction | -0.2 | -9.3 | -1.9 | +1.5 |
| Total GDP | 100.0 | 100.0 | 100.0 | 100.0 |

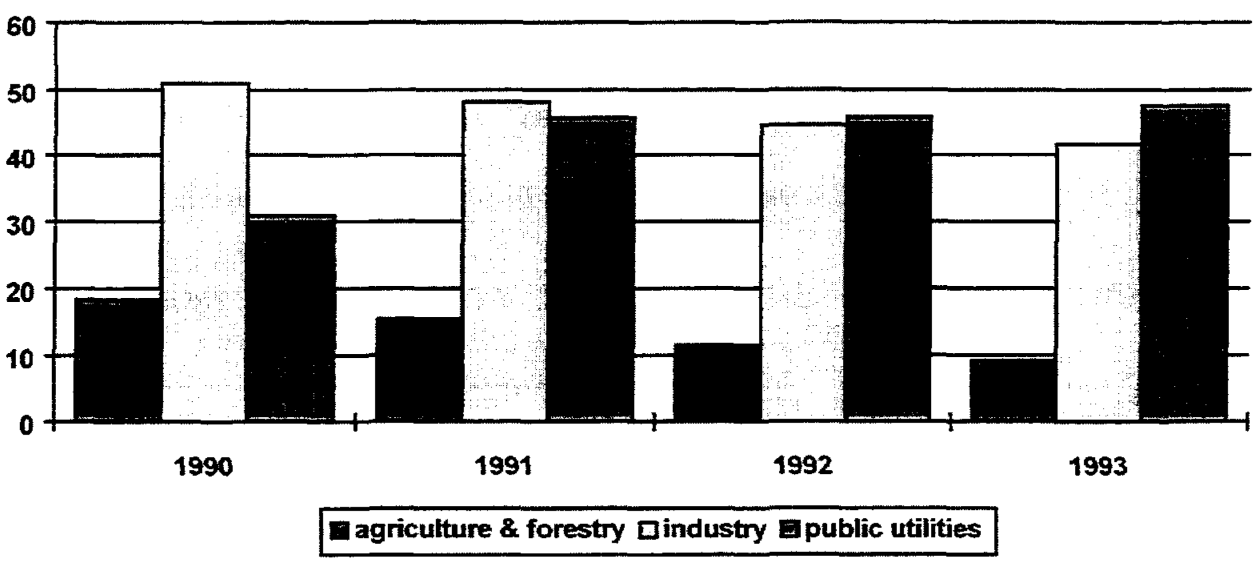



*FIG. 3. Structure of the Gross Domestic Product*

TABLE 5. CHANGE OF THE GROSS ADDED VALUE IN THE DIFFERENT ECONOMIC SECTORS COMPARED TO THE PREVIOUS YEAR

%

| Economic Sector | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|
| Agriculture and Forest Industry | 96.3 | 107.7 | 86.2 | 83.7 |
| Industry | 87.5 | 81.4 | 88.8 | 96.1 |
| Services | 95.7 | 88.7 | 89.9 | 94.0 |
| Gross added value in prices at the producer | 90.9 | 92.9 | 88.9 | 93.8 |
| Total GDP | 90.9 | 88.3 | 94.3 | 95.8 |

TABLE 6. INDEXES OF THE GDP COMPARED TO 1992 PRICES.

| Sector | 1992 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Industry | 100 | 90.2 | 91.0 | 94.0 | 97.7 | 101.7 | 106.8 | 140.5 | 183.2 | 231.0 | 284.5 |
| Metallurgy | 100 | 85.7 | 84.8 | 85.9 | 87.6 | 89.4 | 92.1 | 110.0 | 130.2 | 149.1 | 166.7 |
| Chemistry | 100 | 91.1 | 91.7 | 94.5 | 98.1 | 101.9 | 106.8 | 139.2 | 179.8 | 224.7 | 274.2 |
| Building &.Construction | 100 | 98.1 | 99.4 | 103.1 | 107.7 | 112.6 | 118.8 | 160.0 | 213.5 | 275.5 | 347.3 |
| Transport | 100 | 115.0 | 118.5 | 125.0 | 132.8 | 141.1 | 151.4 | 221.6 | 321.3 | 450.7 | 617.4 |
| Agriculture | 100 | 81.1 | 82.3 | 85.5 | 89.4 | 93.5 | 98.8 | 133.8 | 179.4 | 232.8 | 295.0 |
| Services | 100 | 101.2 | 103.7 | 108.7 | 114.7 | 121.2 | 129.2 | 182.3 | 253.7 | 340.0 | 443.0 |
| Total | 100 | 95.9 | 97.6 | 101.7 | 106.7 | 112.0 | 118.7 | 163.4 | 222.8 | 294.0 | 378.8 |

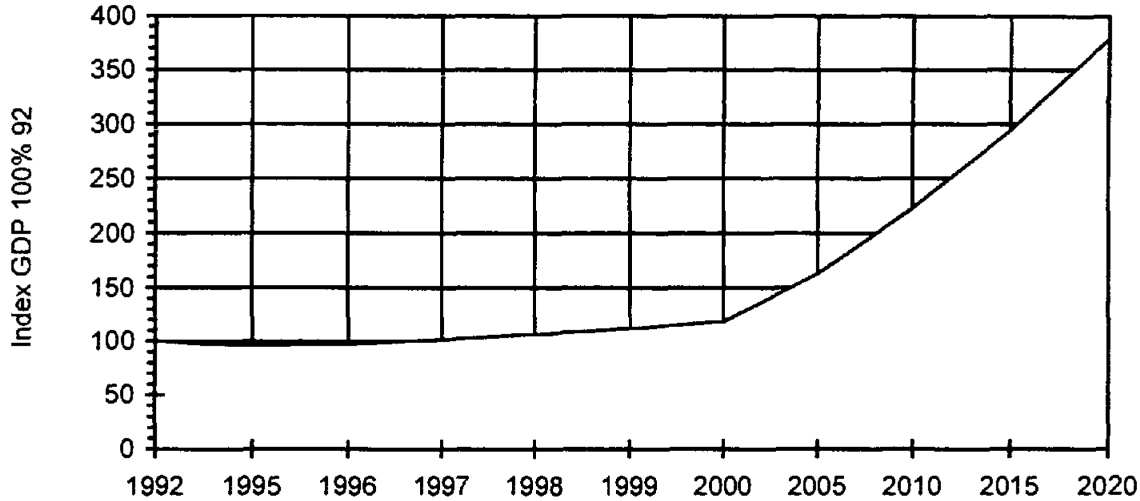



*FIG. 4. Indexes of the Gross Domestic Product of Bulgaria*

TABLE 7. ENERGY CONSUMPTION PER UNIT OF GROSS DOMESTIC PRODUCT (GDP) IN PRICES OF 1992

| Sector | 1992 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Industry | 0.102 | 0.103 | 0.104 | 0.104 | 0.103 | 0.102 | 0.100 | 0.088 | 0.077 | 0.069 | 0.063 |
| Transport | 0.099 | 0.085 | 0.084 | 0.083 | 0.082 | 0.081 | 0.079 | 0.075 | 0.070 | 0.066 | 0.062 |
| Agriculture | 0.044 | 0.052 | 0.054 | 0.054 | 0.055 | 0.056 | 0.054 | 0.048 | 0.043 | 0.039 | 0.036 |
| Services | 0.077 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.005 | 0.005 | 0.005 | 0.005 |
| Total | 0.088 | 0.087 | 0.087 | 0.086 | 0.085 | 0.083 | 0.082 | 0.072 | 0.063 | 0.056 | 0.051 |

Source: Energy Production Development in Bulgaria till 2020, Forecast of the Committee of Energy , 1995, p.17

### 1.3. Energy Situation

Bulgaria has very few domestic energy resources (Table 8). Proven oil and gas reserves for the country, have declined for a number or years and are only about 3 million tonnes of oil equivalent, which is very small. In fact it is less than three months normal hydrocarbon consumption for Bulgaria. Hydropower potential is also limited since most of Bulgaria's rivers are small and the only really large river, the Danube, has a fairly small drop in altitude where it forms Bulgaria's northern border with Romania. Largely because of this constraint, hydrocapacity accounts for about 16% of the country's total installed generating capacity and an even smaller percentage of generation. The country has significant but very low grade coal reserves (Table 9). The mineable reserves amount to around 2.6 billion tonnes including lignite, of which 2.2 billion tonnes are situated in the Maritza East deposit. The present production amounts to 33 million ton per year (Figure 5). About 90% of these reserves have a heating value of only 1,200-1,500 kcal/kg, which is 20-25% of the heating value of internationally traded steam coal. In addition these lignite reserves have a very high sulphur content. Consumption of coal in Bulgaria reached its historically highest level in 1987. In that year, 40.5 million tonnes of coal were consumed. Thereafter, consumption has declined.

TABLE 8. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 19.26 | 0.03 | 0.08 | | 0.36 | 35.53 |

[1] *This total represents essentially recoverable reserves.*

[2] *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1992) by a factor of 10.*

Source: IAEA Energy and Economic Database

TABLE 9. BULGARIA COAL RESERVES

| | Mineable Reserves (million tons) | Present Production (million tons/year) | Lifetime (years) |
|---|---|---|---|
| Lignite | 2350 | 28 | 85 |
| Sub-bituminous coal | 210 | 5 | 40 |
| Bituminous | 10 | <1 | 40 |
| Anthracite | 1 | <1 | 20 |

**Present production (million t/year)**

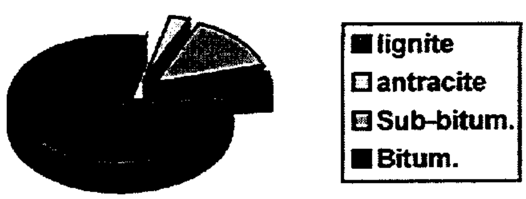



***FIG. 5. Structure of the coal production in Bulgaria.***

Bulgaria imports almost all of its petroleum since domestic production is negligible, for example in 1990 domestic production was 64,000 tons of oil and 13 million cubic meters of gas. Imported petroleum is in the form of crude oil and is being refined in Bulgaria or directly imported as products. Typically, about 90% of petroleum is imported as crude and most of the rest is imported as heavy fuel oil. Bulgaria has three refineries located respectively at Burgas, on the Black Sea Coast, and at Pleven and Ruse on the Danube plain in the northern part of the country. The Burgas refinery accounts for about 85% of the country's refining capacity with the other two refineries being very small with insertion economics.

Bulgaria on average consumes about 6.5 billion cubic meters of gas per year. This represents 16-19% of its energy requirements. Almost all of the gas is used by industry. The largest gas user in 1990 was the COE which uses it to generate steam for district heating and to produce electricity. Virtually all of the gas used in Bulgaria is imported from the Russia. Domestic production currently has been less than 1% of Bulgaria's supply. Alternatives to Russian supplies are very limited. The actually utilised hydropower potential of the country is only 33% of the technically utilizable (15 TW·h/y).

Uranium has been mined in Bulgaria by Rare Earth Metals Company. The total production has always been sold to the Soviet Union through barter trade arrangements. The last uranium sales were made in 1990, when the Soviet Union stopped purchases. Since then, stocks in Bulgaria have accumulated to about 650 tonnes.

The Bulgarian uranium occurrences contain ore of low grade and mining is extremely scattered. There are three mining areas of about equal size and about equal output; around Sofia, in the Southwest (Pirin district), and in central/eastern Bulgaria (Stara Zagora district). These three areas have a total of 17 slamming operations consisting of 6 underground mines, which contributed about two thirds of production. The produced concentrate (yellow cake) is of relatively low grade. All local operations are presently in competitive in the international uranium market since there is a surplus of yellow cake world-wide and prices are depressed.

TABLE 10. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[(1)] | 0.26 | 0.75 | 1.10 | 1.23 | 1.04 | 0.89 | 7.52 | -1.54 |
| - Solids[(2)] | 0.20 | 0.37 | 0.40 | 0.39 | 0.36 | 0.32 | 3.61 | -1.57 |
| - Liquids | 0.04 | 0.35 | 0.42 | 0.43 | 0.37 | 0.24 | 12.19 | -3.83 |
| - Gases | | 0.02 | 0.15 | 0.22 | 0.16 | 0.16 | | 0.59 |
| - Primary electricity[(3)] | 0.02 | 0.02 | 0.13 | 0.18 | 0.15 | 0.16 | 10.37 | 1.40 |
| Energy production | | | | | | | | |
| - Total | 0.22 | 0.28 | 0.35 | 0.40 | 0.39 | 0.39 | 2.34 | 0.94 |
| - Solids | 0.19 | 0.23 | 0.23 | 0.25 | 0.23 | 0.23 | 0.99 | -0.13 |
| - Liquids | 0.01 | 0.01 | 0.01 | | | | 1.61 | -13.52 |
| - Gases | | 0.02 | 0.01 | | | | | -8.02 |
| - Primary electricity[(3)]) | 0.02 | 0.02 | 0.10 | 0.15 | 0.15 | 0.16 | 8.63 | 3.87 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.04 | 0.47 | 0.74 | 0.73 | 0.67 | 0.49 | 15.47 | -2.87 |
| - Solids | 0.01 | 0.14 | 0.18 | 0.15 | 0.10 | 0.08 | 16.98 | -5.22 |
| - Liquids | 0.03 | 0.33 | 0.42 | 0.35 | 0.41 | 0.25 | 13.40 | -3.61 |
| - Gases | | | 0.14 | 0.23 | 0.16 | 0.16 | | 0.74 |

[(1)] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy*
[(2)] *Solid fuels include coal, lignite and commercial wood*
[(3)] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Database

The energy intensity of Bulgarian Gross Domestic Product (GDP) does not appear to have decreased, with energy consumption and output roughly at the same rate. However, this pattern should start to change as the economic restructuring occurs and as relative energy prices continue to increase. Reduction of energy consumption and, therefore, of net energy imports is likely to be an important component of any improvement of Bulgaria's balance of trade. Table 10 shows the IAEA Energy and Economic Database (EEDB) energy statistics in exajoules and Tables 11 to 13 show the primary energy production, primary energy consumption and the energy structure in their typical units. The pattern of energy use in Bulgaria is significantly different from the West. The main area of difference is in the direct use of gas. In most western industrial countries gas is used in industry, in power generation and by households and the service sector. In Bulgaria, gas is almost entirely used in the industrial sector and in power generation, including district heating plants (many plants being combined heat and power or CHP plants), with a negligible amount being used in services and households. Furthermore, this lopsided pattern of usage will not change rapidly since Bulgaria lacks a distribution network for gas so that it cannot currently be supplied to most households and commercial establishments. Indirectly, of course, the household and service sectors use some gas since a small part of the electricity they consume and most of the heat supplied by district heating plants, comes from gas. Even taking this indirect use into account, however, the use of natural gas in Bulgaria is still heavily skewed towards the industrial sector. Table 14 shows the electricity and heat produced by NEK during 1992 to 1994 and Fig. 6 the electricity and heat production structure.

TABLE 11. PRIMARY ENERGY PRODUCTION

| Source | Unit | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|
| Hard Coal | Mt | 0.19 | 0.14 | 0.17 | 0.25 | 0.26 |
| Lignite | Mt | 29.51 | 27.83 | 25.23 | 26.74 | 25.35 |
| Brown Coal | Mt | 4.60 | 3.70 | 3.09 | 3.35 | 3.42 |
| Oil | Mt | 0.07 | 0.06 | 0.06 | 0.05 | 0.05 |
| Natural Gas | $Gm^3$ | 0.01 | 0.01 | 0.01 | 0.04 | 0.07 |
| Hydro | TW·h | 2.69 | 1.85 | 2.44 | 2.06 | 1.94 |
| Wood | Mt | 1.71 | 1.83 | 1.46 | 1.85 | 1.85 |
| Dung | Mt | 0.25 | 0.13 | 0.11 | 0.00 | 0.00 |
| Total | | 39.03 | 35.55 | 32.57 | 34.34 | 32.94 |

TABLE 12. PRIMARY ENERGY CONSUMPTION

Mtoe

| | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|
| Production | 6.99 | 6.21 | 5.64 | 6.15 | 5.33 |
| Import | 27.50 | 22.46 | 17.59 | 14.04 | 12.87 |
| Export | 2.64 | 0.89 | 0.16 | 0.25 | 0.20 |
| Bunkers | 0.06 | 0.44 | 0.00 | 0.00 | 0.00 |
| Stock Changes(+/-) | 0.77 | 1.41 | 0.43 | 0.95 | 0.90 |
| Total | 32.68 | 29.63 | 23.50 | 20.89 | 18.90 |

TABLE 13. ENERGY STRUCTURE

| Energy Source | Unit | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|
| Hard Coal | GMt | 6.75 | 6.05 | 4.57 | 3.93 | 3.25 |
| Lignite | Mt | 29.91 | 29.82 | 25.31 | 26.50 | 25.75 |
| Brown Coal | Mt | 4.65 | 3.78 | 3.16 | 3.19 | 3.42 |
| Oil | Mt | 14.98 | 9.94 | 6.84 | 5.54 | 4.40 |
| Natural Gas | $Gm^3$ | 6.59 | 6.79 | 5.81 | 5.12 | 5.18 |
| Hydro | TW·h | 2.69 | 1.85 | 2.44 | 2.06 | 1.63 |
| Nuclear Fuel | Mtoe | 3.90 | 3.93 | 3.53 | 3.10 | 3.73 |
| Net Electricity Import | TW·h | 4.39 | 3.79 | 2.07 | 2.71 | 0.13 |
| Wood | Mt | 1.71 | 1.76 | 1.47 | 1.81 | 1.81 |
| Dung | Mt | 0.28 | 0.13 | 0.11 | 0.00 | 0.00 |

TABLE 14. ELECTRICITY AND HEAT PRODUCTION BIJ NEK DURING 1992 TO 1994

| | Unit | 1992 | 1993 | 1994 |
|---|---|---|---|---|
| Electricity Production | | | | |
| Thermal Power Plants | GW·h | 17,271 | 17,303 | 16,762 |
| Hydro Power Plants | GW·h | 2,063 | 1,941 | 1,509 |
| Nuclear Power Plants | GW·h | 11,552 | 13,896 | 15,334 |
| Total electricity production | GW·h | 30,887 | 33,141 | 33,605 |
| Heat Production | | | | |
| HGC-Kozloduy | thGcal | 84 | 77 | 72 |
| Thermal Power Plants | thGcal | 2,332 | 2,095 | 1,560 |
| Total heat production | thGcal | 2,416 | 2,172 | 1,632 |

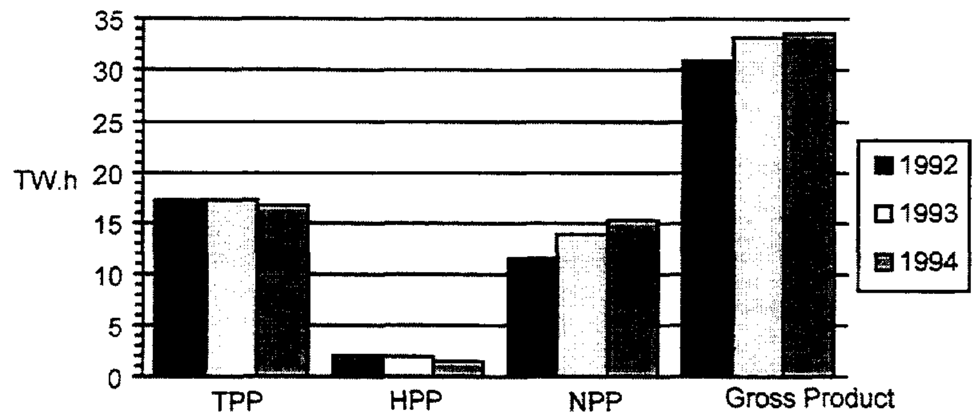



*FIG. 6. Electricity and Heat Production Structure*

### 1.4. Energy policy

Bulgaria struggles to meet the country's demand for electricity. Bulgaria has traditionally imported electricity and coal from Ukraine, both of which were disrupted during the winter of 1991-1992. In February 1993, Bulgaria signed a new contract with Ukraine for the supply of electricity and coal, but in November of that year Ukraine halted power deliveries. During the winter of 1994-1995, disruption of coal supplies from Ukraine, which provided the fuel for 1,250 megawatts of Bulgaria's thermal capacity, forced the country to increase its reliance on nuclear energy and hydropower.

Bulgaria will attempt to resolve its electricity supply problems in the near term through a combination of government expenditures and foreign assistance. The country will focus on upgrading its thermal and hydroelectric generating plants, improving the safety of Kozloduy and building new coal-fired power plants. Bulgaria also intends to increase its sale of electricity abroad, exporting power to Turkey and Greece.

The Bulgarian Ministry of Energy, which formerly had some policy-making duties, is now charged with developing a national energy policy. In the early 1990s, the responsible Committee advised the government to backfit the Kozloduy units to permit continued operation, warning that the country could not afford the level of energy imports that would be necessitated by a shutdown of the plant.

Between 1991 and 1993, the National Electric Company (NEK) undertook a comprehensive programme for upgrading Kozloduy units 1-4. The programme focused first on units 1 and 2, with the aim of restoring them to their original operating condition and improving their reliability and safety. Subsequently, units 3 and 4 were subject to a short-term upgrading effort.

In July 1995, the National Assembly's Committee on Power Supply accepted a new energy strategy. Under the strategy, which addressed electricity supply to the year 2020, a new nuclear plant, probably the one at Belene, would go into service after 2010. Kozloduy units 1-4 would operate until 2003, and units 5 and 6 until 2010. The strategy also called for the construction of 1,500 Megawatts of coal-fired generating capacity, the modernisation of 1,200 Megawatts of hydropower, and the completion of the construction of the pumped storage plant. The parliamentary committee's projection called for nuclear energy to supply 30-40 percent of the country's electricity, coal to supply 30 percent, natural gas, 12 percent, and hydropower, 7 percent. Bulgaria would import the rest of the electricity if needed.

In October 1995, the Committee on Power Supply announced a revised version of its energy strategy. Under this version, a decision on completing the construction of the Beeline nuclear power plant would be postponed until feasibility studies were undertaken.

In November 1995, the Bulgarian government approved the energy strategy, which includes a study of licensing the Belene plant, an evaluation of the condition of equipment already on-site, and an investigation of the possible completion of Unit 1 or the construction of an advanced design reactor. Under the strategy, construction at Belene would be dependent on decommissioning plans for Kozloduy units 1 and 2. The strategy must now be debated in Parliament.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

The structure of the energy sector is shown in Figure 7.

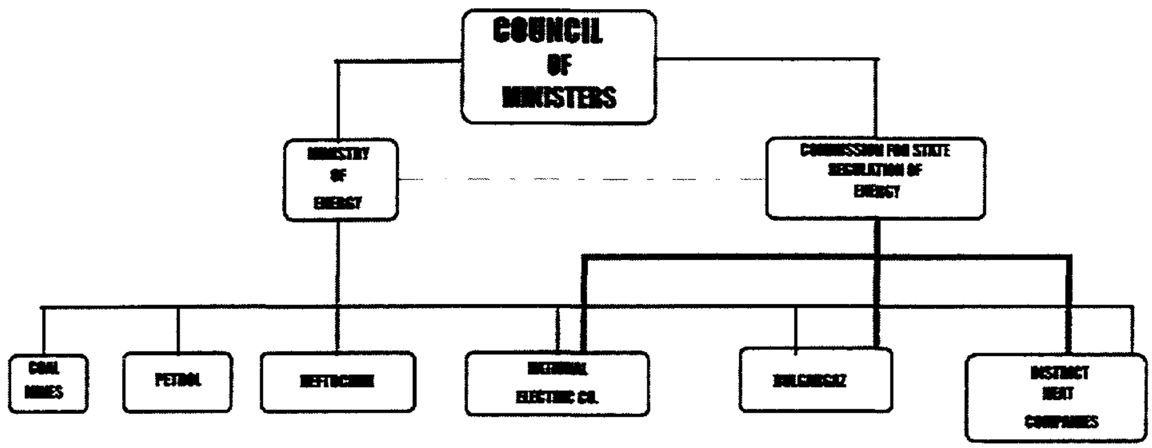



*FIG. 7. Organisation of the Energy Sector*

### 2.2. Decision Making Process

Until the end of 1989 decision making was fully centralised, largely in Sofia. Top operating management was given a limited authority and even less incentive to improve performance. Over the past several years, the top management of most energy sector organisations has been given increased responsibility though this should be further expanded. The government is in the process of developing performance contracts which should provide incentives for improved performance. A restructuring programme is under development which will delegate authority to lower level organisation within the energy sector. This process has been reflected in the new energy strategy study, accepted by the Council of Ministers in December 1995.

### 2.3. Main Indicators

Table 15 shows the historical electricity balance from IAEA Energy and Economic Database. The 1992 electricity demand - 38,239 GW·h - is met mainly by domestic sources. The domestic production amounted to 35,547 GW·h, or 93% of the total demand in that year. The remaining 2,692 GW·h or 7% were the balance of imports and exports. The main producer of electricity is the utility NEK, who owns the power plants, accounting for 30,879 GW·h or 86.9% of total electricity generation in the country. The nuclear power plants produced 32.5% of total electricity and 37.4% of the electricity produced by NEK. The figures for the hydropower are 5.8% and 6.7%, and for the thermal power plants 48.6% and 55.9%, respectively. The non-utility producers have generated a total of 4,667 GW·h and net consumption has been 29,333 GW·h.

The total electrical installed capacity of NEK in 1995 amounts to 11,070 MW of which 4,940 are thermal, 3,760 MW nuclear, 1,970 hydro and 400 pumped storage (Table 16). To this 578 MW must be added from district heating plants and 1,060 MW from industrial power producers (Figure 8). Table 16 shows also the generated electricity in 1994 and 1995 and the 1994 plant load factors. Table 17 shows the energy related ratios derived from EEDB.

TABLE 15. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 4.66 | 19.51 | 34.84 | 42.14 | 38.00 | 38.13 | 10.58 | 0.65 |
| - Thermal | 2.77 | 17.36 | 24.96 | 26.77 | 22.07 | 21.33 | 11.62 | -1.12 |
| - Hydro | 1.89 | 2.15 | 3.71 | 1.88 | 1.94 | 1.47 | 3.44 | -6.41 |
| - Nuclear | | | 6.17 | 13.50 | 13.99 | 15.33 | | 6.72 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 0.93 | 4.12 | 8.81 | 11.13 | 12.09 | 12.09 | 11.93 | 2.28 |
| - Thermal | 0.47 | 3.30 | 5.62 | 6.57 | 7.15 | 7.15 | 13.27 | 1.73 |
| - Hydro | 0.46 | 0.82 | 1.87 | 1.97 | 1.40 | 1.40 | 7.26 | -2.03 |
| - Nuclear | | | 1.32 | 2.59 | 3.54 | 3.54 | | 7.30 |

[(1)] *Electricity losses are not deducted*

Source: IAEA Energy and Economic Database

TABLE 16. 1995 INSTALLED CAPACITY AND 1994 GENERATED ELECTRICITY

| Source | Abbr. | 1994 Plant Load Factor | 1994 Generated Electricity | | 1995 Generated Electricity | | 1995 Installed Capacity | |
|---|---|---|---|---|---|---|---|---|
| | | % | GW·h | % | GW·h | % | MW | % |
| Thermal Power Plant | TPP | 40 | 16,762 | 44 | 16,750 | 42 | 4,940 | 39 |
| Nuclear Power Plant | NPP | 47 | 15,334 | 40 | 17,240 | 43 | 3,760 | 30 |
| Hydro Power Plant | HPP | 9 | 1,509 | 4 | 2,300 | 6 | 1,970 | 16 |
| Chaira Pumped Storage | CPS | | | | | | 400 | 3 |
| TOTAL (NEK) | | | 33,605 | | 36,290 | | 11,070 | 88 |
| District Heating | DH | 36 | 1,805 | 5 | 1,700 | 4 | 578 | 4 |
| Industrial Power Producers | IPP | 31 | 2,908 | 8 | 2,000 | 5 | 1,060 | 8 |
| Imports | | | 1,173 | 3 | | | | |
| Exports | | | (1,245) | (3) | 740 | | | |
| Overall Total | | | 38,246 | 100 | 40,250 | 100 | 18,843 | 100 |

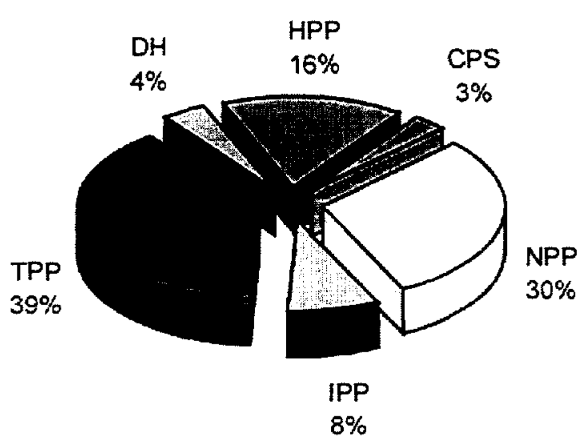



*FIG. 8. 1995 Installed Capacities*

The 87 hydropower plants, built between 1912 and 1984, have an installed capacity of around 2,000 MW but the available capacity in all hydropower plants is estimated at 1,600 MW. Since 1991 several small hydropower plants have been returned to their previous private owners. Most or the power plants (58) are of the run-of-river type with total capacity 177 MW. There are 12 power plants with total capacity 237 MW connected to seasonal storage reservoirs and 17 power plants with total capacity 1,560 MW connected to multi-annual storage reservoirs. The majority of hydropower plants (89%) have been in operation for more than 30 years now. (NEK, published by the Information and Advertisement Centre, Energoproekt, Sofia 1993).

Since 1975 on, nuclear power has been constantly increasing its share in the overall production of electricity in the country. This has been especially visible after the commercial start up of the two 1000 MW units at Kozloduy in 1987 and 1992 respectively. It can be seen that in 1995 the Kozloduy nuclear power plant represented 30% of total installed capacity, or 34% of NEK capacity. Table 16 shows that in 1994 and 1995 the Kozloduy nuclear power station contributed respectively 40% and 43% of the total electricity energy demand of Bulgaria.

TABLE 17. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 33 | 89 | 125 | 141 | 122 | 104 |
| Electricity per capita (kW·h/capita) | 596 | 2,045 | 3,961 | 4,897 | 3,957 | 3,965 |
| Electricity production/Energy production (%) | 21 | 60 | 87 | 94 | 84 | 83 |
| Nuclear/Total electricity (%) | | | 20 | 35 | 41 | 45 |
| Ratio of external dependency (%)[(1)] | 16 | 63 | 67 | 59 | 65 | 55 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 57 | 54 | 45 | 43 | 36 | 36 |
| - Thermal | 68 | 60 | 51 | 47 | 35 | 34 |
| - Hydro | 47 | 30 | 23 | 11 | 16 | 12 |
| - Nuclear | | | 53 | 60 | 45 | 49 |

[(1)] *Net import / Total energy consumption*

Source: IAEA Energy and Economic Database

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical development

The nuclear development of Bulgaria started after the Geneva conference "Atoms for peace" in 1956 and was the favoured strategy of the political leadership ever since. The first step was the construction and the start of operation of IRT-2000 research reactor and a large programme of isotope applications and scientific research. Later on, in 1966, an agreement was signed with the Soviet Union to deliver commercial reactors for electricity production. This agreement laid down the foundations of the Bulgarian nuclear power programme. The main articles of this agreement described the role of the reactor manufacturer and designer as well as the participation of the Bulgarian organisations and industry.

The Soviet nuclear industry was designing and supplying the nuclear island as well as the conventional part of the plants, while the architect engineer of the conventional plant and the auxiliary systems was the Bulgarian company "Energoprojekt". The Soviet safety rules and norms were supposed to be used as long as there was no special Bulgarian legislation available. Unfortunately, there was no nuclear law adopted and no provisions for a regulatory authority. During the construction and start up period the role of supervisors was adopted by the Russian representatives at the site, but, later on, they have only taken the position of manufacturer and supplier representatives. A number of Russian organisations also carried out all of the important assembly operations.

The first two units, which are a typical WWER 440 /230 model, were built and put into operation for a period of less than 5 years and, even if a parity of the rouble to the dollar is assumed, the investment cost was less than 500 $ per kW installed. The second pair of reactors was completed and connected to the grid in 1980 and 1982 accordingly. By that time, the model 230 developed towards model 213, which is the reason why Units 3 and 4 incorporate some of the safety characteristics of the 213's. The further increase in the demand for electricity resulted in the construction of additional two units of 1,000 MW each from the model known as WWER - 1000 /320. A second site was chosen in the early eighties near the city of Belene. The cite was prepared with all the necessary infrastructure to host six 1000 MW units and completion of the first one reached about 40% in 1990, when due to lack of financial resources and some opposition from the near by communities the construction was frozen.

### 3.2. Current Policy Issues

Considering the importance of the Kozloduy NPP to the electricity supply of the country (for 1994 the share of Kozloduy NPP in the total electricity generation was 46.5%) on one side and the important safety concerns raised by the IAEA in 1990 and 1991 on the other side, the regulatory authority took urgent steps and requested emergency maintenance and safety upgrading. This was done on the basis of the IAEA recommendations as well as the requirements of the regulator - CUAEPP (Committee on the Use of Atomic Energy for Peaceful Purposes). A detailed programme for safety improvement had been set and its implementation has been underway since 1991. The main goals of the programme are in a stage by stage manner to upgrade the operational reliability and safety of Kozloduy units 1 to 4 by means of :

- i) Restoring the design functional availability of the units' systems and equipment, especially those related to nuclear safety and radiation protection;
- ii) Improving the reliability and performance of the safety systems for single and common cause failures, including human errors;
- iii) Upgrading the reliability of the three main barriers (fuel cladding, primary circuit and confinement);
- iv) Upgrading the safety culture in the operation of the plant;
- v) Improving the " man- machine" interface;
- vi) Improving the personnel training;
- vii) Developing a quality assurance programme;
- viii) Improving radiation protection practices and emergency planning.

The financial resources for the implementation of the programme are secured mainly by the National Electric Company while a substantial portion of the "soft" assistance in performing some of the additional safety assessments, studies as well as training, upgrading safety culture etc. are coming through the assistance programmes of the European community, the IAEA and through bilateral programmes with USA, France, Germany and others. One of the important features of this programme is the acceptance methodology and the interaction of the different participating parties: NPP Kozloduy, CUAEPP, WANO assistance team and the CONSORTIUM of European safety organisations.

Nuclear power has been widely accepted in Bulgaria. In 1994 upon the request of the Committee on the Use of Atomic Energy for Peaceful Purposes a special study was conducted which showed that between 59.2 and 64 % of the population in principle supports the operation of Kozloduy NPP. Concerning the construction of the new nuclear unit in Belene the polls have been changing from major refusal of support in 1990 to some 43 to 46 % in support in 1995. The Western pressure to close Kozloduy 1 to 4 has resulted in a wide support from the population to improve the safety of the plant and to continue to operate till the end of the designed life but in general, people are still hesitating regarding the construction of the new plant in Belene.

According to Article 18 of the Constitution of Bulgaria and the Law on the Use of Atomic Energy for Peaceful Purposes the Nuclear power plants are owned by the state. At present there are no plans for privatisation but there has been some attempts to create a BOO or BOT scheme for the new nuclear power plant at Belene. In the new Law on the Use of Atomic Energy for Peaceful Purposes, there are laid down the basic principles creating the necessary resources for the management of radioactive waste, as well as for the future decommissioning of the nuclear units. Special funds are mandated and have to be legally established by the Council of Ministers. A proposal for financial input in the funds is also expected to be approved.

### 3.3. Status and Trends in Nuclear Power

Bulgaria has six nuclear power units in operation at Kozloduy, of which operation started between 1974 and 1991, comprising four 408 MW(e) WWER-440/230 units and two 953 MW(e) WWER-1,000 units, all imported from the former USSR (Table 18). The nuclear electricity share in the total production amounts on average to about 45% but in different periods of the year it can be up to 50%. The load factor of the 440 MW units has been reasonably high (up to 80 % or more for unit 4) in the eighties. After 1991 because of the requirement for long outages for upgrading and modernisation these factors have lowered to 60% or less. The 1,000 MW units operate with a load factor which is determined by the specific requirements of the grid which at present is synchronised only with Ukraine.

TABLE 18. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| KOZLODUY-1 | WWER | 408 | NEC | Operational | AEE |
| KOZLODUY-2 | WWER | 408 | NEC | Operational | AEE |
| KOZLODUY-3 | WWER | 408 | NEC | Operational | AEE |
| KOZLODUY-4 | WWER | 408 | NEC | Operational | AEE |
| KOZLODUY-5 | WWER | 953 | NEC | Operational | AEE |
| KOZLODUY-6 | WWER | 953 | NEC | Operational | AEE |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date |
|---|---|---|---|---|
| KOZLODUY-1 | 01-Apr.-70 | 30-Jun.-74 | 24-Jul.-74 | 24-Jul.-74 |
| KOZLODUY-2 | 01-Apr.-70 | 22-Aug.-75 | 01-Oct.-75 | 01-Nov.-75 |
| KOZLODUY-3 | 01-Oct.-73 | 04-Dec.-80 | 04-Dec.-80 | 01-Jan-81 |
| KOZLODUY-4 | 01-Oct.-73 | 25-Apr.-82 | 01-May-82 | 01-Jun.-82 |
| KOZLODUY-5 | 01-Jul.-80 | 05-Nov.-87 | 29-Nov.-87 | 01-Sept.-88 |
| KOZLODUY-6 | 01-Jul.-84 | 01-Feb.-91 | 02-Aug.-91 | 01-Dec.-93 |

Source: IAEA Energy and Economic Database, year end 1996

The Belene project on the River Danube, near the Rumanian border, originally included the construction of four to six 1000 MW(e) units imported from the former USSR. Construction started in 1986 but stopped in 1990 mainly owing to public opposition, at which time the first unit (WWER-1000) was 65% complete. After the approval of the National Energy Strategy plan in December 1995, feasibility studies for completion of the first unit of the Belene plant have been initiated. Russian organisations and ENERGOPROJEKT are preparing the studies. No decision for the restart of the construction has been taken yet.

### 3.4. Organizational Chart

The only utility in Bulgaria which produces, distributes and sells electricity is the National Electricity Company. Its organisational chart is given in Figure 9. Preparations are under way for restructuring of the company aimed at future privatisation of different branches like : distribution, maintenance etc. The nuclear branch of the company, the Kozloduy NPP, according to the Law of Atomic Energy will stay under state ownership.

## 4. NUCLEAR POWER INDUSTRY

Bulgaria has not developed its own nuclear industry, since it uses a "once through" fuel cycle and all fuel cycle services and the nuclear steam supply systems have been delivered from the Former Soviet Union (now Russia). The country has been a member of the co-operative effort of the former COMECON countries and the RADOMIR METAL company near Sofia has been selected to produce some equipment for the 1,000 MW reactors containment buildings (heavy isolation doors, penetrations, seals etc.).

A number of companies from Bulgaria, Russia and other countries participate in the regular maintenance of the different systems of the plants. From Bulgaria the most important are:

i) Energoprojekt for design, engineering, safety assessment etc.;
ii) RISK ENGINEERING for safety assessment, design, etc.;

iii) Energoremont, the largest maintenance company of the energy sector;
iv) ATOMENERGOREMONT, specialised company for maintaining the NPP.

A number of the services are delivered by several smaller local companies, specialised in different aspects of the plant operations.

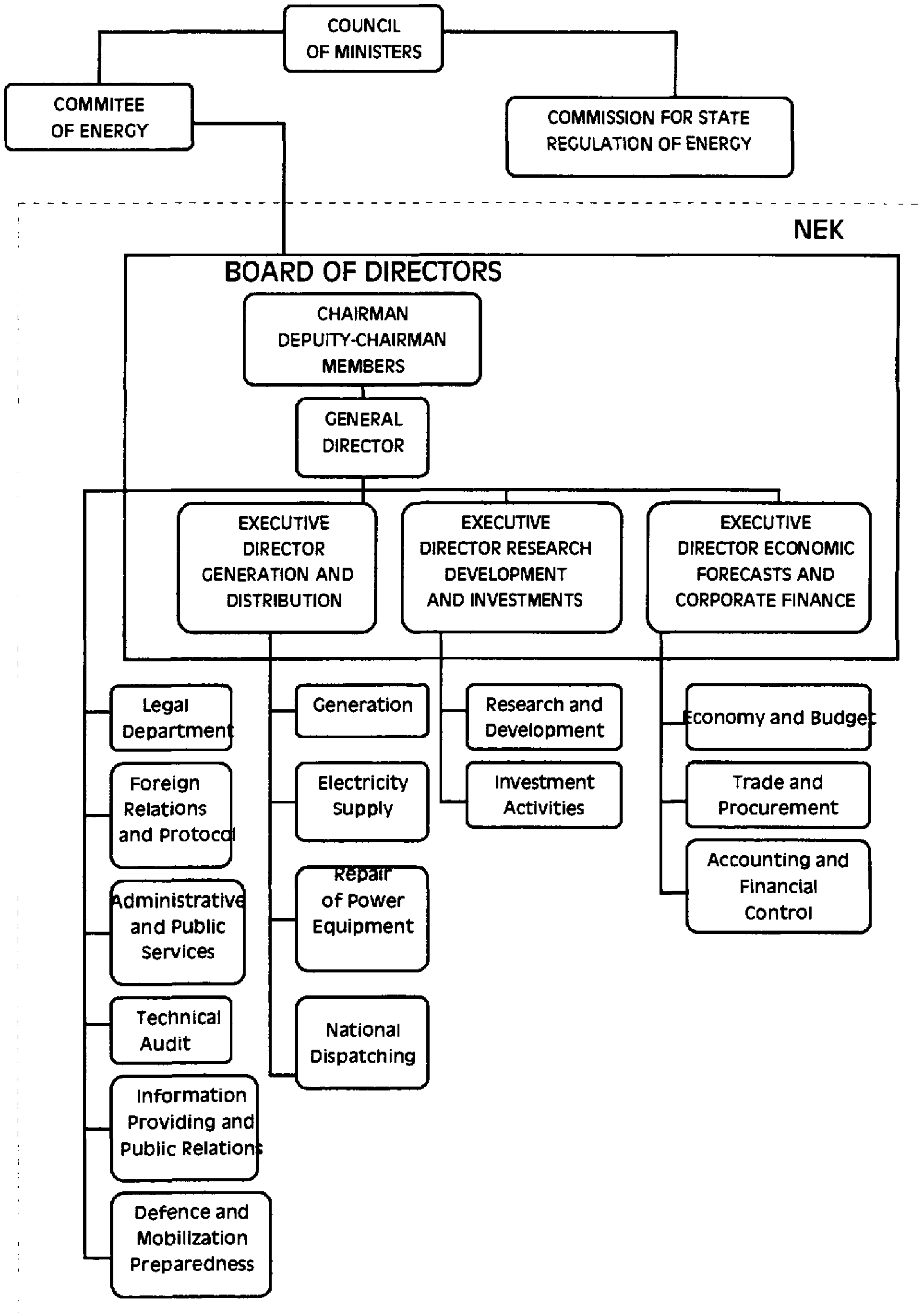



*FIG. 9. Organisational Structure of the Central Management of NEK.*

The important Russian organisations are :

- GIDROPRESS.
- IZORA JOINT STOCK COMP.
- VNIIAES INST.
- KURCHATOV NATIONAL RESEARCH CENTRE
- PODOLSK METALLURGICAL WORKS

Western companies also participate in the maintenance and support of the NPP Kozloduy.

- INETEC-Zagreb is the main contractor for performing ISI of the SG , Pressure vessel and other important components.
- WESTINGHOUSE is supplying the Radwaste reprocessing and packaging plant.
- SIEMENS have been important supplier of safety equipment.

### 4.1. Supply of Nuclear Power Plants.

Bulgaria does not supply nuclear power plants and/or equipment for nuclear power plants. The equipment for the existing plants have been purchased from Russia, but some parts and systems have been supplied from western suppliers like Siemens, Westinghouse, Sempel, Sebim, Framatome and others.

### 4.2. Operation of Nuclear Power Plants

The nuclear power plant Kozloduy is operated by the National Electric Company. The obligations of the nuclear operator as described in the Vienna convention on Civil liability for Nuclear Damage are transferred to the Kozloduy branch.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management Service Supply

Bulgaria utilises a "once through" fuel cycle. Nuclear fuel is supplied from Russia. At present, the TENEX company is the only foreign supplier of nuclear fuel licensed by the CUAEPP. NEK is the sole Bulgarian organisation which has been given the authority to purchase, use and handle special nuclear material. Until 1990, the spent fuel was being returned to the Soviet Union for reprocessing after a 5 year cooling period in the fuel ponds in the reactor building.

### 4.4. Research and Development Activities

Nuclear research and development activities in Bulgaria are co-ordinated by the CUAEPP, according to Article 13 para. 1 of the Law on the Use of Atomic Energy for Peaceful Purposes. Research and development activities are carried out in several institutes, the most important of which are:

i) The Institute of Nuclear Research and Nuclear Energy at the Bulgarian Academy of Sciences;
ii) The University of Sofia Dept. of Nuclear Physics, Dept of Nuclear Technology and Nuclear Power Engineering and the Radiochemical laboratory;
iii) ENERGOPROEKT engineering company;
iv) Institute of Radiation Protection - at the Ministry of Public Health;
v) Plovdiv University ( Dept. of Nuclear Physics) and other smaller Institutes and research organisations.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

An important part of the Research and Development activities is being carried out through co-operation with International organisations like: Institute of Nuclear Research in Dubna, Russia; Institute of Theoretical Physics, Trieste; CERN and other foreign Institutes.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and Licensing Process

The National Regulatory Authority in the field of safe utilisation of atomic energy for peaceful purposes is the Committee on the Use of Atomic Energy for Peaceful Purposes (CUAEPP). The legal framework in respect of the CUAEPP is provided for in the Peaceful Utilisation of the Atomic Energy Act (Promulgated in the Official State Gazette issue No. 79 of 1985, amended SG No. 80 of 1985, amended and supplemented SG No. 69 of 1995).

#### 5.1.1. Safety Authority

Present to Article 13, paragraph 1 of the Peaceful Utilisation of the Atomic Energy Act, the Committee on the Use of Atomic Energy for Peaceful Purposes shall have the following powers:

- i) Participate in the elaboration of concepts and programmes, co-ordinate research and studies in the field of atomic energy utilisation;
- ii) Establish the requirements for safe utilisation of atomic energy and the procedure codes of accountancy, storing and shipping of nuclear material;
- iii) Establish criteria and requirements with regard to training, qualifications and capacities of human resources employed in atomic power utilisation;
- iv) Collect, process and provide information to relevant bodies and organisation on circumstances and events related to nuclear and radiation safety;
- v) Co-ordinate controls over safe utilisation of atomic energy;
- vi) Implement measures and be in charge of redemption action in respect of contaminated environment;
- vii) Carry out the international co-operation activities of the Republic of Bulgaria in the field of atomic energy utilisation and participate in the activities of international organisations in the field.

Government/state control over the sage use of atomic energy is exercised by the CUAEPP through its Safe Utilisation of Atomic Energy Inspectorate (ISUAE). Pursuant to Article 18 of the Peaceful Utilisation of the Atomic Energy Act, the following specific powers shall be vested with the CUAEPP:

- i) exertion of control over all natural and legal persons in the matter of compliance with the established requirements for safe utilisation of atomic energy and the procedure for accountancy, storage and shipping of nuclear material and radioactive substances;
- ii) granting and issuance of licences for conduct of activities in the province of atomic energy utilisation. Atomic energy utilisation activities shall only be carried out following the grant of license. Carrying out of such activities without a license or prior to the issuance thereof, or in deviation from the license constitutes a criminal act under Article 356.g (1) of the Penal Code. Such license shall be requested for all activities relating to atomic energy utilisation and more specifically (pursuant to Article 23 (1) of the Peaceful Utilisation of the Atomic Energy Act) for:
  - decommissioning and any modifications of designs and constructions, procurement, provision of supplies and services of significance to the safety of nuclear installations and sites designated for extraction, operation or storage of radioactive substances or intended for operations with other ionising irradiation sources; obtaining, production, import, selection of site, design, construction,

fabrication of equipment, commissioning, operation, export, trade, storing and shipping of nuclear material, radioactive substances and other ionising irradiation sources;

iii) Exercise of extended control in concomitance with specialised controlling bodies in respect of the safe utilisation of atomic energy;

iv) Registration of ionising radiation sources;

v) Assignment of studies, surveys, expertise and other activities in connection with exercise of controls.

vi) The Committee on the Use of Atomic Energy for Peaceful Purposes in its capacity as a governmental agency is made-up by the top executives and their deputies of all Bulgarian ministries and other administrations within the structure whereof atomic energy is utilised as well as the chief executive officers of all organisations which utilise atomic energy.

Structure-wise the Committee on the Use of Atomic Energy for Peaceful Purposes in its capacity as a central governmental administration consists of:

i) Chief Secretary and Administrative Services Unit.

ii) Safety Utilisation of Atomic Energy Inspectorate (ISUAE) Unit.. There are two directorates within the ISUAE — the Nuclear Facilities & Installations Safety Directorate and the Safety of Ionising Radiation Sources Directorate. Each directorate comprises of departments. The power of the ISUAE are herein above described in the Law on the Use of Atomic Energy for Peaceful Purposes ( Chapter III).

iii) Co-ordination and Development Department which is tasked with the organisation and co-ordination of the activities of the Nuclear Research and Nuclear and Radiation Safety Fund, the organisation of the preparation and implementation of international technical assistance projects, ensuring of access to the information publications and data-base of the International Nuclear Information Centre (INIC) of IAEA.

iv) International Co-operation Department tasked with the international co-operation and collaboration of the Republic of Bulgaria in the field of atomic energy utilisation.

v) Information and Public Relations Department in charge of the collection of information in the CUAEPP and dissemination of information from the CUAEPP via the media to the public on nuclear safety and radiation protection.

The Committee for the Use of Atomic Energy for Peaceful Purposes implements the state/government policy in the matter of safe utilisation of atomic energy, Article 12 (1) of the CUAEPP. The functions of the CUAEPP are in effect separated from the ones of the bodies and organisations involved in atomic energy utilisation issues. The Committee is a state body/governmental agency reporting to the Council of Ministers.

**5.1.2. Licensing Process**

The main legal provisions for the licensing of nuclear installations in Bulgaria are outlined in ordinance No 5 of the CUAEPP. This Ordinance regulates the requisite documentation, the conditions, the order, terms and time-limits for issuance of licences and permits for atomic energy utilisation (atomic energy in the Republic of Bulgaria shall be used for peaceful purposes alone). Said licences and permits for utilisation of atomic energy shall be issued by the Safe Utilisation of Atomic Energy Inspectorate with the Committee for the Use of Atomic Energy for Peaceful Purposes based on an application in writing filed by the Applicant wherein the specific activity involving atomic energy utilisation for which the grant of a permission is requested shall be identified. Attached thereto shall be the documentation required for the issuance of the requested licence/permit as prescribed by this Ordinance in question (inclusive of a Quality Assurance Plan for the respective activity or business) and by other relevant regulations in the matter of atomic energy utilisation. All documentation submitted in respect of requested license issuance shall be in the Bulgarian language. Submission of the original documents in a foreign language shall be admissible provided that a notarised translation in the Bulgarian language shall be thereto attached.

Ordinance No. 6, governs the criteria and requirements in respect of training, qualifications and capacities of human resources employed in the field of atomic energy utilisation to the end of acquiring, sustaining and advancement of their professional qualifications and assurance of the requisite capacity for safe utilisation of atomic energy.

### 5.2. Main National Laws and Regulations

The following fundamental acts of legislation are currently applicable in the matter of safe utilisation of nuclear energy and in respect of nuclear material procurement, accountability, storage and transport:

- Act on the Use of Atomic Energy for Peaceful Purposes (AUAEPP) (Promulgated in the Official State Gazette, issue No. 79 of 1985, amended SG No. 80 of 1985; supplemented and amended SG No. 69 of 1995)

- Regulations for the Application of the Act on the Use of Atomic Energy for Peaceful Purposes (adopted by a Decree of the Council of Ministers No. 37 of 1 July 1986, promulgated SG No. 66 of 22 August 1986);

- Ordinance No. 2 on the Cases and the Procedure for Giving Notice to the Committee on the Use of Atomic Energy for Peaceful Purposes of Any Operation Modifications, Developments and Emergency Situations Relating to Nuclear Safety and Radiation Protection (Promulgated SG No. 26 of 1988, amended SG No. 28 of 1988);

- Ordinance No. 3 on Safety Guarantees on the Design, Construction and Operation of Nuclear Power Plants (Promulgated SG No. 27 of 1988);

- Ordinance No. 4 on Nuclear Material Accountability, Storage and Transport (Promulgated SG No. 66 of 1988; amended SG No. 83 of 1993);

- Ordinance No. 5 on the Licence Issuance Procedure for Utilisation of Atomic Energy (Promulgated SG No. 13 of 1989; amended and supplemented SG No. 37 of 1993);

- Ordinance No. 6 on the Criteria and Requirements for Training, Qualifications and Capacity of Personnel Employed in Nuclear Energy Engineering (Promulgated SG No. 47 of 1989; amended SG No. 43 of 1991);

- Ordinance No. 7 on Collection, Pool Storage, Reprocessing, Away-from-Reactor Storage and Repository of Radioactive Waste on the Territory of the Republic of Bulgaria (Promulgated SG No. 8 of 1992);

- Ordinance No. 8 on the Physical Protection of Nuclear Facility Sites and Nuclear Material (Promulgated SG No. 83 of 1993)

Table 19 lists the new regulations and projects for update of applicable regulations in the matter of safe atomic energy utilisation and the procedures for accountancy, storage and shipping of nuclear material.

TABLE 19. NEW REGULATIONS AND PROJECTS

| Number | NAME OF DOCUMENT |
|---|---|
| 1. | Elaboration of an Ordinance on the Rules for Shipping of Radioactive Cargo |
| 2. | Ordinance on the Exclusion of Small Quantities of Nuclear Material from the Vienna Conv. Scope of Appl. |
| 3. | Ordinance on the Basic Rules for Operating and Storing of Ionising Radiation Sources |
| 4. | Ordinance on Dosimetric Control and Guidelines Manual for Individual Dosimetric Control |
| 5. | Ordinance on the Radiation Protection Concerning the Design of Sites and Apparatuses Having Ionising Radiation Sources |
| 6. | Ordinance on the Organisation of Irradiation Control in the Republic of Bulgaria |
| 7. | Guidelines Manual for the Assessment of the Dose of Irradiation Exposure of the Population |
| 8. | Ordinance on the Nuclear Safety of Nuclear Power Plants |
| 9. | A Quality Assurance Manual for Nuclear Power Plant Operation |
| 10. | Guidelines Manual for Qualifications and Training of Nuclear Power Plant Personnel |
| 11. | Guidelines Manual for Reporting of Operation Data to the CUAEPP |
| 12. | Guidelines Manual for Periodic Tests of Nuclear Power Plant Systems and Equipment |
| 13. | Ordinance on Controls over Nuclear Plant Pressure Vessels and Pipelines |
| 14. | Guidelines Manual for Set Up of Nuclear Plant Emergency Plan |
| 15. | Ordinance on Emergency Planning and Readiness in Case of Radiological Emergency at a Nuclear Facility |
| 16. | Draft of a Prescription and Schedule on the Implementation of State Radiation Control over Imports and Exports of Foodstuffs under Emergency and Non-emergency Circumstances |
| 17. | Norms for Admissible Amount of Residual Radionuclides in Fodder |
| 18. | Elaboration and Legalisation of Normative Acts on Technological Dosimetry in Gamma Radiation Techn. |
| 19. | Ordinance on the Terms and Conditions for Acquisition of Property over Ionising Radiation Sources by Legal Persons and Bulgarian Nationals |
| 20. | Amendments and Supplements to the Basic Norms for Radiation Protection (BNRP – 92) |
| 21. | Regulations for the Structure and Organisation of Activities of the CUAEPP |
| 22. | Ordinance on Radiation Safeguards of Nuclear Power Plants |
| 23. | Ordinance on Fire Safeguard of Nuclear Power Plants |
| 24. | Ordinance on the Technical Inspection of Nuclear Power Plant Facilities, Equipment and Pipelines |
| 25. | Ordinance on the Safe Nuclear Power Plant Decommissioning |
| 26. | Ordinance on the Registration of Ionising Radiation Sources |
| 27. | Ordinance on the Terms, Procedures and Time frames for Issuance of Licences for Atomic Energy Utilisation |
| 28. | Ordinance on the Terms and Procedures for Issuance of Licences for Utilisation of Ionising Radiation Sources for Medical Purposes |
| 29. | Ordinance on the Seismic Durability of Premises, Facilities and Equipment at Nuclear Power Plants. Terms and Procedures for Issuance of Licences for Construction of New and Reconstruction of Existing Ones |
| 30. | Amendments and Supplements to Ordinance No. 6 on the Criteria and Requirements for Training, Qualifications and Capacities of Human Resources Employed in Nuclear Energy Engineering |
| 31. | Amendments and Supplements to Ordinance No. 4 on Nuclear Material Accountancy, Storage and Shipping |
| 32. | Instruction on the Performance of Audits by the Safe Utilisation of Atomic Energy Inspectorate (ISUAE) |
| 33. | Instructions on the Issuance of Licences by the Safe Utilisation of Atomic Energy Inspectorate |
| 34. | Instructions on the Activities of the Emergency Centre of the CUAEPP |
| 35. | Instructions on the Exertion of Operational Control by the Safe Utilisation of Atomic Energy Inspectorate Examiners at the Nuclear Power Plant Site |
| 36. | Regulations on the Structure and Activities of the Council on the Safety of Nuclear Facilities |
| 37. | Regulations on the Structure and Activities of the Council on Radiation Protection |
| 38. | Instructions on the Licensing of Computer Application Programmes Utilised for Analyses of Nuclear Safety and Radiation Protection |

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related safeguards agreement INFCIRC/178 | Entry into force: | 9 February 1972 |
| • Improved procedures for designation of safeguards inspectors | Entry into force: | 16 October 1988 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 18 August 1980 |

*OTHER RELEVANT INTERNATIONAL TREATIES, etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 5 September 1969 |
| • Agreement on privileges and immunities | Entry into force: | 17 June 1968 |
| • Convention on physical protection of nuclear material | Entry into force: | 8 February 1987 |
| • Convention on early notification of a nuclear accident | Entry into force: | 26 March 1988 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency Vienna | Entry into force: | 26 March 1988 |
| • Convention on civil liability for nuclear damage joint protocol | Entry into force: | 24 November 1994 |
| • Convention on nuclear safety | Ratification: | 8 November 1995 |
| • Convention on Black Sea contamination protection; | | |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | No reply | |
| • Nuclear Suppliers Group | Member | |

*BILATERAL AGREEMENTS*

- Agreement between the Government of the Republic of Bulgaria and the Government of the United States of America on Co-operation in the Field of Peaceful Utilisation of Atomic Energy.
  - By way of this Agreement the Contracting Parties reaffirmed their commitment that they would ensure international development in the peaceful utilisation of nuclear energy in

compliance with all agreements which to the maximum possible extent contribute to the objectives of the Treaty on non-proliferation of Nuclear Weapons

- Agreement between the Government of the Republic of Bulgaria and the Government of the Russian Federation on Co-operation in the Field of Peaceful Utilisation of Atomic Energy

  - The Agreement reaffirms the Republic of Bulgaria's membership to the United Institute of Nuclear Research in the city of Dubna, regulates the mutually advantageous co-operation of the Parties in the field of peaceful utilisation of atomic energy. The Parties guarantee their strict adherence to their obligations in respect of the Treaty on non-proliferation of Nuclear Weapons and the continued endeavours towards nuclear safety amelioration.

  - The Agreement covers a rather broad scope of possible joint research domains, such as nuclear physics, controlled thermonuclear fusion and plasma physics, condensed-matter physics (physics of the solids), radiochemistry, radiation chemistry, atomic energy engineering, inclusive of safe and reliable operation decommissioning of nuclear power plants, fuel cycle management, control and issuance of licences, betterment of nuclear fuel storage and transport technologies, prospective nuclear energy sources, nuclear safety and radiation protection, radiological protection from nuclear irradiation, normative and technical documentation, etc.

- Agreement between the Government of the People's Republic of Bulgaria and the Government of the Hellenic Republic on Extended Reporting and Notification in Case of a Nuclear Accident and Interchange of Information on Nuclear Sites and Facilities

  - This Agreement governs the technical aspect of extended operational reporting and notification between the Contracting Parties in case of a nuclear accident pursuant to the Convention on Notification in Case of a Nuclear Accident, signed in Vienna on 26 September 1986. Another subject of the Agreement is the bilateral co-operation of scientific research and other competent organisations in the matter of problems arising from the Agreement itself. Bilateral collaboration shall be effected on the basis of two-year plans in conformity with the terms and conditions agreed by the joint Bulgarian and Greek Commission on Economic and Scientific and Technical Co-operation.

- Financing Protocol between the Government of the Republic of Bulgaria and the Government of the French Republic.

  - To the end of strengthening the friendly relations that have traditionally linked them, the Government of the Republic of Bulgaria and the Government of the French Republic have agreed to conclude this Protocol with the purpose to contribute to the economic development of Bulgaria. 21/2 million French francs shall be lent to assist financing of the purchase from France of full-scale nuclear power plant simulators and the installation thereof.

- Agreement between the Committee for the Use of Atomic Energy for Peaceful Purposes with the Council of Ministers of the Republic of Bulgaria and the Federal Ministry of the Environment, Protection of Nature and the Reactor Safety of the Federal Republic of Germany on Issues of Mutual Interest Relating to Nuclear and Technical Safety and Radiation Protection

  - The Contracting Parties shall notify and inform each other forthwith and directly of accidents under Article 1 of the Convention on Notification in Case of a Nuclear Accident, signed in Vienna on 26 September 1986. The Agreement also provides for the interchange of information and experience in nuclear and technical safety and radiation protection, favourable co-operation between the Parties and also provides that the Federal

Ministry of the Environment, Protection of Nature and the Reactor Safety of the Federal Republic of Germany shall, upon request, endeavour within the limits of possibilities available under the national law to provide assistance on technical aspects of safety by way of attracting German consulting and expert organisations.

- Agreement between the Government of the Republic of Bulgaria and the Government of Romania on Notification in Case of a Nuclear Accident and Interchange of Information on Nuclear Sites and Facilities

  - The Agreement governs the technical aspect of extended bilateral operational reporting and notification to the Parties in case of a nuclear accident pursuant to the Convention on Notification in Case of a Nuclear Accident, signed in Vienna on 26 September 1986.

- Agreement between the Government of the Republic of Bulgaria and the Government of the Republic of Austria on Co-operation and Interchange of Information in the Field of Nuclear Safety and Radiation Protection

  - The Contracting Parties shall develop bilateral co-operation in the form of joint research and studies on nuclear safety and radiation protection issues and shall interchange information on such issues. The Parties shall notify each other in case of a nuclear accident pursuant to the Convention on Notification in Case of a Nuclear Accident, signed in Vienna on 26 September 1986.

- Agreement between the Government of the Republic of Bulgaria and the Government of the Argentine Republic on Co-operation in the Field of Peaceful Utilisation of Atomic Energy

  - The Contracting Parties shall collaborate in the development of scientific research and practical utilisation of atomic energy for peaceful purposes. Specific fields of co-operation are listed. Co-operation shall be based on agreements between institutes, organisations and legal entities of the Parties in compliance with the national law.

- Agreement between the Government of the Republic of Bulgaria and the Government of the Republic of Turkey on Notification in Case of a Nuclear Accident and Interchange of Information on Nuclear Sites and Facilities.

  - The Agreement shall apply in respect of activities on the subject of notification in case of a nuclear accident pursuant to Article 1 and Article 3 of the IAEA Convention.

- Agreement between the Government of the Republic of Bulgaria and the Government of Japan on Co-operation in the Field of Peaceful Utilisation of Atomic Energy.

  - The Contracting Parties shall collaborate in the development of scientific research and practical utilisation of atomic energy for peaceful purposes. Specific fields of possible co-operation are listed. Co-operation shall be based on agreements between institutes, organisations and legal entities of the Parties in compliance with the national law.

## REFERENCES

[1] Committee on the Use of Atomic Energy for Peaceful Purposes, Annual Reports 1991, 1992, 1993, 1994 and 1995.

[2] National Electric Company Annual Reports 1993, 1994 and 1995.

[3] Report No.116110, Bulgaria - Power Demands and Supply Options, WB.

[4] Strategy for Development of the Energy Sector, Committee of Energy December, (1995).

[5] Tariffs for Electricity and Heat Energy Bechtel Int. Inc., prepared for USAID, (June 1996).

[6] European Bank for Reconstruction and Development, Annual Reports 1994, 1995.

[7] Collection of Bulgarian Nuclear Regulatory Documents, Balbok ltd. Sofia, (1994).

[8] Social and Economic Development of Bulgaria 1990 -1993, National Institute of Statistics, Sofia, (1994).

[9] Additional unpublished materials have also been used, like:

a) Reports of NEK prepared for the Commission for State Energy Regulation.

b) Materials prepared for the Council of Ministers concerning the Association procedure of Bulgaria in the European Union.

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Ministry of Energy<br>Triaditz str. 8<br>Sofia 1040, Bulgaria | Tel.: +359-2-878393<br>Fax: +359-2-872550<br>Telex: 22707/8 |
| Committee on the Use of Atomic<br>Energy for Peaceful Purposes<br>Shipchenski Prohod Blvd. 69<br>Sofia 1574, Bulgaria | <br>Tel.: +359-2-720217<br>Fax: +359-2-702143<br>Telex: 23383 KAE BG |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Bulgarian Academy of Sciences<br>Sofia, Bulgaria | |
| Institute of Nuclear Science<br>and Nuclear Energy (INSNE)<br>Tzarigradsko shosse 72<br>Sofia 1784, Bulgaria | <br><br><br>Tel.: +359-2-7431 |
| Institute of Metallurgy<br>at the Bulgarian Academy of Sciences<br>Tchapaev str. 53<br>Sofia-1574, Bulgaria | <br><br>Tel.: +359-2-703485<br>Fax: +359-2-703207 |
| National Electric Company<br>8,Triaditza Str.<br>Sofia 1040, Bulgaria | Tel.: +359-2-86191<br>Fax.: 875826<br>Telex 22707,22708 |
| Kozloduy Nuclear Power Plant<br>Kozloduy 3321<br>Bulgaria | Tel: +359-973 71 77<br>Fax: +359-973 2591<br>Telex 33416 |
| ENERGOPROJEKT Joint stock Co.<br>Bourchier str. 51<br>Sofia-1407, Bulgaria | <br>Tel.: +359-2-6321<br>Fax: +359-2-668529 |
| ATOMENERGOREMONT AD.<br>Kozloduy 3321<br>Bulgaria<br>University of Sofia<br>Sofia 1126, Bulgaria | <br><br>Tel.: +359-973 7177<br>Fax: +359-973 2591<br>Telex 33416 |
| University of Sofia<br>Department of Nuclear Physics<br>and Nuclear Energy<br>J.Bourchier 5<br>Sofia 1126, Bulgaria | <br><br><br>Tel.: +359-2-62561<br>Fax: +359-2-622028 |

University of Sofia
Radiochemical Laboratory
Bourchier str. 1 — Tel.: +359-2-62565
Sofia 1126, Bulgaria — Fax: +359-2-622127

RISK ENGINEERING LTD.
Totleben str. 34 — Tel.: +359-2-521217
Sofia -1660, Bulgaria — Fax: +359-2-9549100

BALBOK ENGINEERING AD.
Dragan Tzankov 37
Sofia, Bulgaria — Tel/Fax: +359-2-73018

# CANADA

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# 1. GENERAL INFORMATION

## 1.1. General Overview

Canada, occupying about 10 million km$^2$ and having a population of about 29 million (Table 1), is one of the least densely populated countries in the world. Canada's birth rate, at present, is below 15 per 1,000 whereas death rate is seven per 1,000 with the result that the rate of natural population increase now stands at seven per 1,000 population. Canada has strong seasonal changes and large regional variations in temperature. The rigorous climate, the energy intensive nature of the country's industries, and the large distances between population centres produce a high per capita energy use.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 17.9 | 21.3 | 24.6 | 27.8 | 28.8 | 29.1 | 1.2 |
| Population density (inhabitants/km$^2$) | 1.8 | 2.1 | 2.5 | 2.8 | 2.9 | 2.9 | |
| Predicted population growth rate (%) 1993 to 2000 | | 1.1 | | | | | |
| Area (1000 km$^2$) | | 9976.1 | | | | | |
| Urban population in 1993 as percent of total | | 77.0 | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

Table 2 gives the statistical Gross Domestic Product (GDP) data and the GDP by sector.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 84,409 | 263,244 | 569,433 | 546,052 | 549,230 | 5.4 |
| GDP (millions of constant 1990 US$) | 275,110 | 429,917 | 569,433 | 576,136 | 602,557 | 2.4 |
| GDP per capita (current US$/capita) | 3,958 | 10,704 | 20,490 | 18,949 | 18,847 | 4.1 |
| GDP by sector (1990): Agriculture 3%, Industry 32%, Services 65% | | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.3. Energy Situation

The energy sector is an important part of Canada's economy. The energy sector employs more than 300,000 Canadians and accounts for 7.4% of Gross Domestic Product (GDP). However, there are marked regional differences in energy production and consumption.

The Canadian energy sector enjoys a strong presence in all primary energy commodities and strong electricity and energy efficiency industries. Canada has more lakes and rivers than any other country in the world. Its hydroelectric resources produce over 30 per cent of domestic energy requirements. Hydraulic resources are estimated to be 4,663,197 Terajoules. Canada is also well endowed with oil, natural gas and coal. Canada produces a surplus of crude oil above its domestic needs. 1993 proven reserves amounted to 5 billion barrels. Proven reserves of natural gas were 3.1 trillion $m^3$, about three per cent of global reserves (Table 3). Canada has extensive bituminous coal (6,435 million Mt.) and lignite reserves (14,355 million Mt.). Alberta, British Columbia and Saskatchewan account for over 90 per cent of total output. Coal production is high due to strong growth in exports, which now account for almost half of the industry's output). Canada produces a wide range of metals and minerals and is the world's leading producer of uranium. Its proven uranium deposits amount to 68,000 metric tons.

Canada has been a net exporter of most energy forms since 1969. In 1993, Canadian energy exports were valued at $15.7 billion. The United States is by far Canada's largest customer (88% of Canada's energy exports). Virtually all of Canada's exports of oil, natural gas and electricity, and 50% of uranium exports go to the US. The energy statistics are given in Table 4.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro (2) | Total |
| Total amount in place | 227.24 | 30.24 | 115.29 | 51.10 | 119.51 | 543.38 |

(1) This total represents essentially recoverable reserves.
(2) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.
Source: IAEA Energy and Economic Data Base

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total(1) | 4.00 | 6.53 | 9.31 | 10.50 | 11.03 | 11.38 | 4.31 | 1.45 |
| - Solids(2) | 0.90 | 0.83 | 1.15 | 1.35 | 1.41 | 1.41 | 1.24 | 1.48 |
| - Liquids | 1.69 | 2.94 | 3.65 | 3.09 | 3.09 | 3.21 | 3.91 | -0.91 |
| - Gases | 0.44 | 1.27 | 1.96 | 2.54 | 2.82 | 3.05 | 7.80 | 3.18 |
| - Primary electricity(3) | 0.97 | 1.50 | 2.55 | 3.52 | 3.71 | 3.72 | 4.94 | 2.74 |
| Energy production | | | | | | | | |
| - Total | 3.25 | 7.09 | 10.23 | 13.36 | 15.39 | 16.33 | 5.91 | 3.39 |
| - Solids | 0.59 | 0.53 | 1.19 | 1.91 | 1.96 | 2.00 | 3.52 | 3.81 |
| - Liquids | 1.09 | 2.92 | 3.45 | 3.81 | 4.22 | 4.42 | 5.91 | 1.79 |
| - Gases | 0.54 | 2.11 | 2.79 | 4.11 | 5.23 | 5.77 | 8.56 | 5.32 |
| - Primary electricity(3)) | 1.02 | 1.52 | 2.81 | 3.53 | 3.97 | 4.14 | 5.20 | 2.81 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.87 | -0.32 | -0.52 | -2.59 | -4.03 | -4.46 | 2.56 | 16.60 |
| - Solids | 0.30 | 0.32 | -0.05 | -0.49 | -0.58 | -0.66 | 8.44 | 20.05 |
| - Liquids | 0.67 | 0.17 | 0.37 | -0.59 | -1.08 | -1.13 | -2.90 | -8.26 |
| - Gases | -0.09 | -0.81 | -0.84 | -1.51 | -2.36 | -2.67 | 11.72 | 8.63 |

(1) *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
(2) *Solid fuels include coal, lignite and commercial wood.*
(3) *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

Canada's energy policy supports a variety of energy sources, including nuclear energy, in order to ensure a secure and "sustainable" energy future for Canadians. The federal government's approach to energy policy has gradually evolved over the last two decades to a stronger market-driven and less interventionist approach to energy development. Environmental protection, energy efficiency and the development of new alternative sources of energy are high on the list of federal objectives for the energy sector.

With respect to nuclear energy, the federal government is supportive of the nuclear energy option for Canada and funds about one half of Atomic Energy Control Limited's (AECL) nuclear R&D programme. Although the federal government is supportive of the nuclear option, decision-making responsibility for planning, construction and operation of nuclear plants reside with the provinces and provincial electric power utilities. The recent economic recession continues to impact on the electricity sector; there are currently no plans to build additional nuclear plants in Canada.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Canada's electric power industry is made up of provincial Crown corporations, investor-owned utilities, municipal utilities and industrial establishments. The federal role is restricted to nuclear energy, international and inter-provincial trade.

Under the Canadian constitution, electricity is primarily within the jurisdiction of the provinces. The provincial governments own the natural resources and are responsible for most aspects of regulation and energy sector development within their geographical boundaries. The federal government is responsible for harmonizing energy policy at the national level, promoting regional economic development, frontier lands, offshore development, inter-provincial works (i.e. pipelines), international and inter-provincial trade. Both levels of governments are involved with energy research.

As a result of the division of power, Canada's electrical industry is organized along provincial lines. In most provinces the industry is highly integrated, with the bulk of the generation, transmission and distribution provided by a few dominant utilities. Although some of these utilities are privately owned, most are Crown corporations owned by the provinces. Among the major electric utilities, seven are provincially owned, five are investor owned, two are municipally owned, and two are territorial Crown corporations. In 1993, provincial electric utilities owned about 82% of Canada's total installed generating capacity and produced about 79% of total generated electricity.

The electric power industry has a significant presence within the Canadian economy. There were almost 94 000 people directly employed by the industry in 1993, (about 0.8% of total Canadian employment, down 2.0% from 1992), reflecting the continuous restructuring of Canada's electric power industry in 1993. Total revenue increased to about $26 billion in 1993. Of this total, approximately $858 million or 3.3% came from export earnings. The electric power industry has steadily increased its contribution to Canada's Gross Domestic Product, from 2.3% in 1960, to 2.5% in 1970, to 3.0% in 1980, to 3.3% in 1991, to 3.7% in 1993.

The electric power industry had the largest investment share in the energy sector in 1993, with total capital expenditures of $9.6 billion accounting for about 47% of the total investment in the energy sector, and 8% of the total investment in the economy. Total assets of the industry were about $140 billion in 1993, accounting for about 7.5% of the capital stock of the economy, excluding the residential sector. This reflects the capital-intensive nature of the electric power industry. Hydro-Québec, Ontario Hydro and B.C. Hydro were the three largest electric utilities in Canada and, in terms of assets, ranked second, third, and eleventh respectively among all Canadian companies. Fig. 1 shows the major generating utilities in Canada.

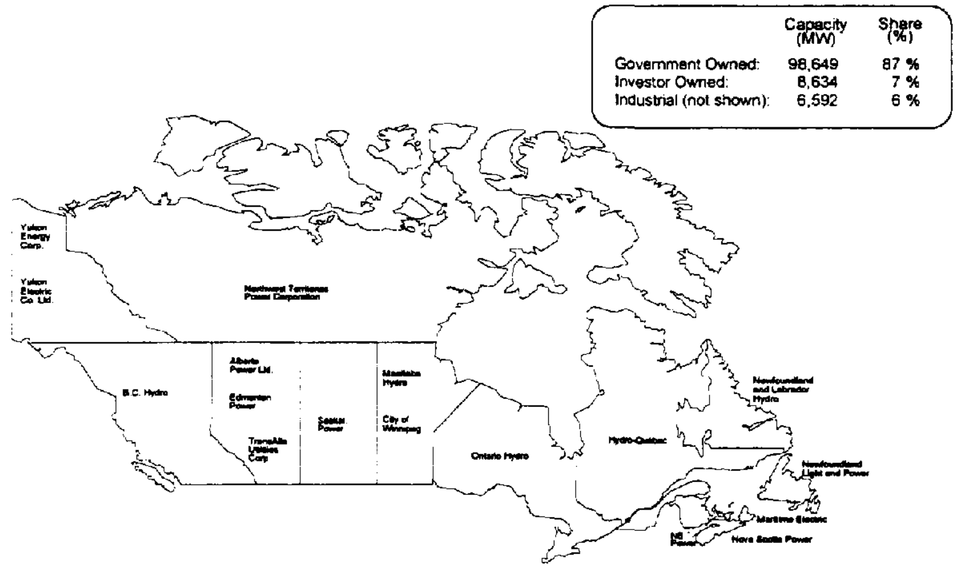



*FIG. 1. Major Generating Utilities in Canada -1994*

## 2.2. Policy and Decision-Making Process

The Canadian nuclear industry consists of a mixture of private sector firms and public sector organizations at both the federal and provincial levels. The federal government provides leadership, support and a regulatory framework for the nuclear industry through AECL and the Atomic Enrage Control Board (AECB), two federal government agencies (known as "Crown" corporations) which report to the Canadian Parliament through the Minister of Natural Resources.

AECL has both a public and commercial mandate. It has overall responsibility for Canada's nuclear research and development (R&D) programme as well as the Canadian reactor design (CANDU), engineering, marketing and construction programme. The AECB regulates the safety and security aspects of nuclear materials and facilities in Canada and participates, on behalf of Canada, in international measures of control. The Minister of Natural Resources relies directly on the Department of Natural Resources for policy advice on nuclear matters including issues pertaining to AECL and the AECB. Private sector firms, which undertake the manufacturing of CANDU components and the engineering and project management work for reactors outside of Canada, act as subcontractors to AECL.

Although both the federal and Saskatchewan governments have played a major role in Canada's uranium industry in the past, through Cameco Corporation and its predecessors, their role is diminishing as Cameco moves towards full privatization (as of February, 1995, 70% of Cameco was privately owned and 30% was owned by the Saskatchewan government). Operation and maintenance of nuclear plants provide the largest single source of jobs in the nuclear industry.

The provincial electric power utilities are responsible for electricity supply and make decisions about the type of technology to be used for electricity generation; they are also responsible for building, operating and maintaining provincial power facilities, including nuclear facilities. Utilities with nuclear plants in operation in Canada are Ontario Hydro, New Brunswick Power Corporation and Hydro-Québec. All three are provincially-owned. These utilities, particularly Ontario Hydro, have had critical roles to play and worked closely with AECL in the design and construction of the power reactors in their respective provinces

## 2.3. Main Indicators

Electricity is one of Canada's fastest growing energy sources. World-wide, Canada ranks fifth in total electricity generating capacity and electric power production. Canada also is a world leader in long-distance electric power transmission. Hydro electric power is the largest domestic source of electric energy representing about 60% of the nation's supply in 1994. Canada also has an indigenous nuclear power industry established around the CANDU reactor technology. Nuclear power represented about 20% of electricity supply in 1994 (Fig. 2). The electricity production and installed capacities are given in Table 5 and the energy related ratios in Table 6.

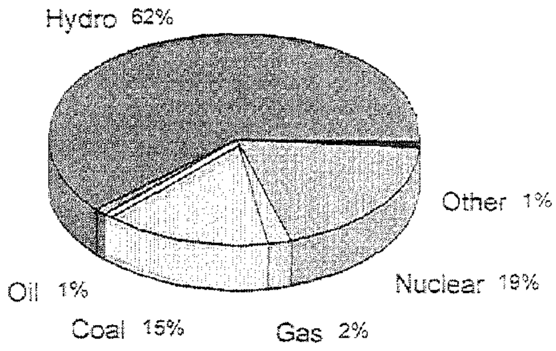



*FIG. 2. Generation by Fuel Type -1994 (534 TW·h)*

Electricity is vital to almost every aspect of the Canadian economy and is projected to continue to expand its role over the next ten years. From 1947 to the end of 1993, net electricity generation increased at an annual average rate of 5.3%, compared with real Gross Domestic Product of 4.1%, and total population growth of 1.8%. Canada's total electricity consumption in 1993 was 500 TW·h with per capita consumption of 17,347 kWh. In the same year, total electricity produced amounted to 527 TW·h.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 114.38 | 204.72 | 377.52 | 482.03 | 527.32 | 554.19 | 6.15 | 2.78 |
| - Thermal | 8.50 | 47.05 | 85.95 | 116.24 | 114.98 | 124.31 | 12.27 | 2.67 |
| - Hydro | 105.88 | 156.71 | 253.07 | 296.92 | 323.69 | 328.12 | 4.45 | 1.87 |
| - Nuclear | | 0.97 | 38.50 | 68.84 | 88.62 | 101.73 | | 7.19 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 23.04 | 42.83 | 82.00 | 104.12 | 110.53 | 113.81 | 6.55 | 2.37 |
| - Thermal | 4.39 | 14.29 | 28.36 | 30.75 | 32.67 | 34.82 | 9.78 | 1.47 |
| - Hydro | 18.64 | 28.30 | 47.77 | 59.38 | 62.10 | 63.21 | 4.82 | 2.02 |
| - Nuclear | | 0.24 | 5.87 | 13.99 | 15.76 | 15.76 | | 7.31 |
| - Wind | | | | | | 0.02 | | |

[1] *Electricity losses are not deducted.*

Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 223 | 306 | 378 | 378 | 383 | 391 |
| Electricity per capita (kW·h/capita) | 6,100 | 9,489 | 13,810 | 16,810 | 16,944 | 16,808 |
| Electricity production/Energy production (%) | 34 | 28 | 35 | 34 | 32 | 32 |
| Nuclear/Total electricity (%) | | | 10 | 15 | 17 | 19 |
| Ratio of external dependency (%)(1) | 22 | -5 | -6 | -25 | -37 | -39 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 57 | 55 | 53 | 53 | 54 | 56 |
| - Thermal | 22 | 38 | 35 | 43 | 40 | 41 |
| - Hydro | 65 | 63 | 60 | 57 | 60 | 59 |
| - Nuclear | | 46 | 75 | 56 | 64 | 74 |

(1) *Total net import / Total energy consumption.*

Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

Canada has developed a successful nuclear programme based on the unique heavy water natural uranium reactor system (now known as CANDU) which uses pressurized fuel channels instead of a pressure vessel, natural uranium instead of enriched uranium and heavy water as coolant/moderator instead of light water as coolant/moderator found in the pressurized water reactor designs.

Since the early 1950's, Canada has pursued the nuclear power option through the development of the CANDU system. Canada decided to proceed with the nuclear programme (a) because it had accumulated considerable experience in the heavy water natural uranium reactor system which enabled Canada to make use of Canadian resources and technology; and (b) because in some regions of Canada (particularly Ontario) major hydro resources had been largely developed and fossil fuels would have to be imported; and (c) because it had abundant supplies of uranium.

The main milestones of the Canadian nuclear programme are:

i) in 1955, AECL, Ontario Hydro and Canadian General Electric (CAGE) made a commitment to build the first small-scale prototype 22 MW CANDU reactor at Rolphton, Ontario;

ii) a larger prototype was constructed at Douglas Point, Ontario. The 200 MW reactor went into service in 1967; these two reactors established the technological base for the larger commercial units to follow and for Canada's nuclear programme;

iii) two 500 MW(e) reactors at Pickering, Ontario were committed under a tri-partite agreement between Ontario Hydro, AECL and the federal government; Ontario Hydro later committed two more units to make an integrated 4-unit station; the units (Pickering A) came into operation between 1971 and 1973;

iv) conceptual design studies on the Bruce A station were initiated in 1968; the 4x800 MW unit Bruce A station came into service from 1977 to 1979;

v) in July 1974, Ontario Hydro decided to add 4 units at the Pickering A station; the 4 units (Pickering B) came into service from 1983 to 1986;

vi) four additional units (Bruce B), came into service from 1984 to 1987;

vii) four 900 MW(e) units at Darlington were committed in the early 1980's; these went into service in 1989-1994.

Canada also made entry into the international power reactor supply field while it was building a major nuclear programme at home. CAGE had played a major role in the export market in the 1960's but abandoned this activity in the late 1960's leaving AECL to pick up the leadership drive for CANDU exports.

AECL assisted India in the construction of two 200 MW Douglas Point-type reactors (RAPP 1 and RAPP 2). An agreement was signed with India in 1963 to build RAPP 1 and RAPP 1 was completed in 1973. Assistance for the construction of RAPP 2 was terminated following India's explosion of a "peaceful nuclear device" in 1974 although India eventually completed RAPP 2 in 1981.

In 1964, CAGE entered into an agreement with Pakistan to supply a 120 MW CANDU-type reactor (KANUPP). The plant entered commercial operation in 1972. As Pakistan did not agree to meet the requirements of Canada's 1974 non-proliferation policy, Canada terminated nuclear co-operation with Pakistan (however, some "limited" safety assistance is currently being provided through the CANDU Owners Group.)

AECL developed the CANDU 6 reactor design and was successful in selling four of these in the early to mid-1970's: Gentilly-2 (Hydro-Quebec, 1973), Point Lepreau (New Brunswick, 1974), Cordoba (Argentina, 1973) and Wolsong (South Korea, 1976). All four of these units went into service in the early 1980's.

In 1979, an agreement was signed with Romania to build a multi-unit 600 MW CANDU station at Cernavoda. The first reactor is now complete; the fuel has been loaded and commercial operation is scheduled for early, 1996. No commitments have been made to complete four other units which were started on the site.

In 1991 AECL sold an additional CANDU 6 unit to South Korea and a further two units in 1992. AECL has initiated studies on a smaller CANDU design (CANDU 3) and on a larger CANDU design (CANDU 9). Both designs employ advanced features to reduce construction schedule and improve performance and maintenance.

### 3.2. Current Policy Issues

The federal government's view is that, on balance, Canada is fortunate to have a variety of energy options at its disposal and that it is necessary to continue to develop a mixture of energy sources. Within the supply system there is an important role for nuclear energy as long as it is responsibly managed and strictly regulated.

The federal government funds about one half of the nuclear research and development (R&D) programme of AECL on the basis of a 1990 joint funding arrangement between the federal government and the CANDU Owner's Group (COG). That agreement expires on March 31, 1997. As part of its overall review of federal programmes, the Department of Natural Resources is currently reviewing the structure and funding of the AECL programme in co-operation with other key departments and AECL. The objective is to maintain a viable programme at reduced cost to the federal government. A programme review of the AECB has been completed.

The provinces have overall responsibility for the development and management of their nuclear supply system, including nuclear power stations. Although the provinces currently do not have any plans to build additional nuclear plants, they have not ruled out the nuclear option for their long-term supply. The Ontario government recognizes that nuclear energy will remain a very important component of the supply mix and that it represents a major technical achievement.

Given the impact of the recent recession on economic and electricity demand growth, it is highly unlikely that there will be any new nuclear plant construction in Canada before the end of the century. On 14 February 1994, the Ontario Hydro Board of Directors announced that surplus generating capacity would be reduced by about 2,700 megawatts during 1994-95. This would be done by mothballing four fossil-fired units (at the Lambton and Lennox stations) and one nuclear unit at the Bruce Nuclear Generating station. The nuclear unit affected, unit #2 at Bruce, was scheduled to be shut down in September, 1995. Ontario Hydro recently indicated that the timing of the shut-down is now uncertain. Ontario Hydro studies have shown that refurbishing relative to other generating options, would yield long-term net economic benefits to Hydro customers.

Another initiative may also impact on the future of the Bruce reactors: the U. S. is looking at a number of options for eliminating its stockpile of weapons-grade plutonium. Included in its list of options is the use of Canadian CANDU reactors, specifically the Bruce reactors for this purpose (the reactors would be used to burn MOX fuel which entails mixing the plutonium oxide with uranium oxide).

Ontario Hydro is currently engaged in a review of the structure of the electricity industry in the province to ensure that the industry remains competitive in a changing global and North American economy; new technology and increased competition are driving the need to change old structures and rules. The review of AECL will undoubtedly take into account pressures to restructure (and possibly privatize) parts of Ontario Hydro's operations.

A radioactive waste policy framework is being developed for the management of all of Canada's radioactive wastes.

In recognition of public concerns about the long-term management of the used nuclear fuel, AECL has developed a concept for deep geologic disposal of the used nuclear fuel in igneous rock of the Canadian shield. It is believed that this approach is technically feasible with present-day technology and would ensure adequate protection of current and future generations. An Environmental Assessment Panel established under the Federal Environmental Assessment and Review Process Guidelines undertook a comprehensive environmental review of the disposal concept. The Environmental Impact Statement (EIS), which describes the disposal concept and anticipated impacts, was submitted to the Panel in September 1994. Public hearings began in 1995. Selection of a site for a repository will not be initiated before a concept has received environmental approval.

Producers, mainly the nuclear utilities pay for disposal of nuclear fuel waste. The federal government is also an owner of fuel waste through AECL.

The EIS on the concept for disposal of nuclear fuel waste contains several recommendations for proposed implementation. Following from the development of the EIS recommendations, AECL, as the proponent for the disposal concept, in consultation with Ontario Hydro and NRCan, proposed eight operational principles to deal with the Panel's request to suggest the next steps on implementation.

For ongoing low-level radioactive waste, some larger producers manage their own waste through to disposal. They might make their facility available to other smaller producers or owners, by incorporating them into the management and financial structure of the operation, or by charging an appropriate disposal fee.

Some smaller producers can organize a separate facility specific to their own needs. In each case the producers would pay for disposal. The number and location of facilities would depend on several factors, including safety and cost-effectiveness. A trade-off for low-level radioactive wastes is the cost and risk of transporting them, balanced against the economies of scale of larger, centralized facilities.

As long as producers were properly organized and funded to achieve federal objectives for disposal, the federal government would not need to be part of a producer's organization. However, the producers might ask for federal government support in developing a national facility, or in ensuring access and fair pricing for all producers. The Low Level Radioactive Waste Management Office (LLRWMO) could establish a national user-pay facility, if one is required.

For historic low-level radioactive waste resulting from nuclear activities, the federal government has accepted responsibility. In some cases, provinces have agreed to accept responsibility for, or assist with, interim storage. LLRWMO has been the federal agent for cleaning up and storing such waste. The federal government will have to identify an agent, similar to LLRWMO, to implement the disposal of historic low-level radioactive waste for which it is responsible. The agent would work closely with the relevant province and with the communities involved.

Uranium tailings are likely to be managed in-situ at mine sites and the producer would take on responsibility for decommissioning in compliance with AECB license conditions. There would appear to be little need, in most cases, for broader organizations to carry out this function. For historic uranium tailings, it is also likely that they would be managed in-situ. The federal government needs to reach agreement with the relevant provincial government on appropriately dividing responsibilities for such tailings. One or more agencies for decommissioning may be required.

The federal government is revising the Nuclear Liability Act of 1976. In 1994, Energy Probe, Sister Rosalie Bertell and the Corporation of the City of Toronto lost a legal case to force changes to the Canadian Nuclear Liability Act. The plaintiffs contended that the Act contravened sections 7 and 15 of the Canadian Charter of Rights and Freedoms. Section 7 claims the right to life, liberty and security of the person. Section 15 deals with equality before the law and equal protection and benefit of the law. The action by Energy Probe (et alia) was dismissed on the grounds that "it is fundamentally just for a government that decides to use atomic energy for peaceful purposes, knowing the inherent risks, to enact legislation which gives the Governor-in-Council authority in the event of a nuclear incident to act in the public interest by providing for special measures and compensation. Such a decision exchanges the court system of compensation for a better compensation scheme." The plaintiffs were assessed costs incurred by the defendant, Natural Resources Canada and intervenors Ontario Hydro and the New Brunswick Power Corporation.

In the fall of 1995, the federal government introduced new legislation to replace the 50 year-old Atomic Energy Control Act, which is the basis for regulating Canada's nuclear industry.

### 3.3. Status and Trends of Nuclear Power

At the end of 1994, Canada had 22 units in operation with a capacity of 15,437 MW(e) accounting for close to 15% of total installed electrical capacity in Canada. Table 7 gives an overview of the main nuclear power data in Canada and its provinces and Table 8 contains the uranium data for Canada.

Currently, about 20% of total electricity generation in Canada comes from the 22 CANDU reactors in Ontario, Quebec and New Brunswick. Almost 60% of Ontario's electricity comes from nuclear energy. The total output of nuclear electricity in Canada in 1994 was 101.7 TW·h. The status of the Canadian nuclear power plants is given in Table 9. One CANDU 6 reactor is in operation in South Korea and one in Argentina. Three CANDU 6 reactors are also under construction in Korea and one is under construction in Romania.

TABLE 7. CANADIAN NUCLEAR POWER DATA AS OF DECEMBER 31, 1994.

| | Canada | Ontario | New Brunswick | Quebec |
|---|---|---|---|---|
| Electricity Demand Growth (% p.a.) | 1.3 | -0.2 | 2.4 | 1.2 |
| Nuclear Share (%) of Electric Utility Generation | 19.9 | 64.7 | 34.7 | 3.5 |
| Reactors in Service | 22 | 20 | 1 | 1 |
| Capacity In Service (Net MW(e)) | 15,437 | 14,164 | 634 | 638 |
| Reactors Under Construction/Commissioning | 0 | 0 | 0 | 0 |
| Capacity Under Construction/Commissioning (Net MW(e)) | 0 | 0 | 0 | 0 |

TABLE 8. CANADIAN URANIUM DATA.

| | 1994 | 1993 | 1992 | 1991 | 1990 |
|---|---|---|---|---|---|
| Known Uranium Resources Recoverable from Mineable Ore (1,000 tU as of January 1)* | 475 [NE] | 471 [NE] | 450 [459] | 443 [594] | 437 [583] |
| Total Primary Production (tU) | 9,647 | 9,155 | 9,297 | 8,160 | 8,729 |
| By-product** Production (tU) [not included above] | 53 | 30 | 40 | 44 | 50 |
| Total Producer Shipments (tU) | 11,200$^{P}$ | 8,727 | 9,152 | 8,199 | 9,720 |
| Value of Shipments ($C millions) | 585$^{P}$ | 497 | 573 | 604 | 888 |
| Average Price for Deliveries under Export Contracts ($C/kgU) / ($US/lb $U_3O_8$) | 51/ 14 | 50/ 15 | 59/ 19 | 61/ 21 | 71/ 24 |
| Exports of Uranium of Canadian Origin (tU) | 10,507 | 8,684 | 7,318 | 7,810 | 8,648 |
| Uranium Exploration Expenditures ($C millions) | 36 | 40 | 46 | 44 | 45 |

* Resources at prices of $150/kgU or less; bracketed figures include tonnes at prices from $150-$300/kgU.

** Uranium from refinery/conversion facility by-products recovered at Elliot Lake

Note: NE - Not Estimated

In the latter part of the 1980's, domestic market prospects were much stronger than they are today. Ontario Hydro's Demand-Supply Plan at this time foresaw the return of a measure of economic growth in the early 1990's and over a 25 year horizon a need for enough new reactor units to establish a solid domestic market base for CANDU. Utilities were also actively considering expanding or establishing their nuclear power capacity. The offshore market was likewise expected to grow but not to be a major market until the turn of the century. (The old plan was premised on a forecast of median load growth and a need to install 15,000 MW of additional capacity by 2014 to augment the 1989 capacity of 23,000 MW. Ten CANDU reactors were to provide 8,880 MW of the new capacity.)

Since 1990, due to Canadian economic and political situation domestic utilities have postponed indefinitely their expansion plans, and their nuclear plans particularly, while offshore markets have rebounded. There is little prospect for a domestic CANDU sale in Canada during the balance of this decade. Offshore markets are currently the major component of the CANDU business and indications are that this situation will continue for some time.

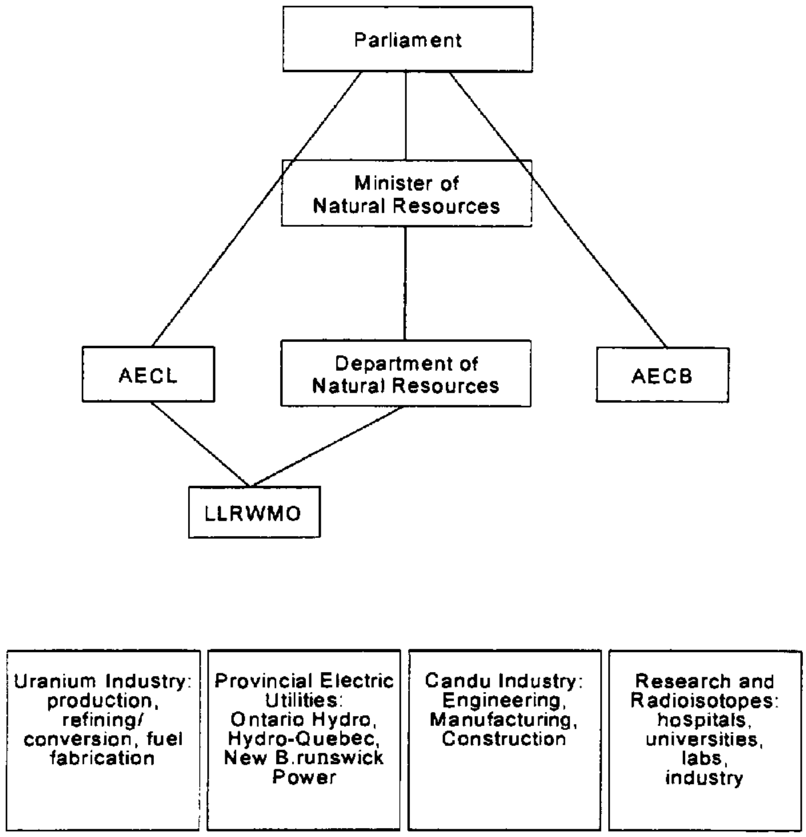
TABLE 9. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| BRUCE-1 | PHWR | 848 | OH | Operational | OH/AECL | 01-Jun-71 | 17-Dec.-76 | 14-Jan-77 | 01-Sept.-77 | |
| BRUCE-3 | PHWR | 848 | OH | Operational | OH/AECL | 01-Jul.-72 | 28-Nov.-77 | 12-Dec.-77 | 01-Feb.-78 | |
| BRUCE-4 | PHWR | 848 | OH | Operational | OH/AECL | 01-Sept.-72 | 10-Dec.-78 | 21-Dec.-78 | 18-Jan-79 | |
| BRUCE-5 | PHWR | 860 | OH | Operational | OH/AECL | 01-Jul.-78 | 15-Nov.-84 | 02-Dec.-84 | 01-Mar-85 | |
| BRUCE-6 | PHWR | 860 | OH | Operational | OH/AECL | 01-Jan-78 | 29-May-84 | 26-Jun-84 | 14-Sept.-84 | |
| BRUCE-7 | PHWR | 860 | OH | Operational | OH/AECL | 01-May-79 | 07-Jan-86 | 22-Feb.-86 | 10-Apr.-86 | |
| BRUCE-8 | PHWR | 860 | OH | Operational | OH/AECL | 01-Aug.-79 | 15-Feb.-87 | 09-Mar-87 | 22-May-87 | |
| DARLINGTON-1 | PHWR | 881 | OH | Operational | OH/AECL | 01-Apr.-82 | 29-Oct-90 | 19-Dec.-90 | 14-Nov.-92 | |
| DARLINGTON-2 | PHWR | 881 | OH | Operational | OH/AECL | 01-Sept.-81 | 05-Nov.-89 | 15-Jan-90 | 09-Oct-90 | |
| DARLINGTON-3 | PHWR | 881 | OH | Operational | OH/AECL | 01-Sept.-84 | 09-Nov.-92 | 07-Dec.-92 | 14-Feb.-93 | |
| DARLINGTON-4 | PHWR | 881 | OH | Operational | OH/AECL | 01-Jul.-85 | 13-Mar-93 | 17-Apr.-93 | 14-Jun-93 | |
| GENTILLY-2 | PHWR | 685 | HQ | Operational | AECL | 01-Apr.-74 | 11-Sept.-82 | 04-Dec.-82 | 01-Oct-83 | |
| PICKERING-1 | PHWR | 515 | OH | Operational | OH/AECL | 01-Jun-66 | 25-Feb.-71 | 04-Apr.-71 | 29-Jul.-71 | |
| PICKERING-2 | PHWR | 515 | OH | Operational | OH/AECL | 01-Sept.-66 | 15-Sept.-71 | 06-Oct-71 | 30-Dec.-71 | |
| PICKERING-3 | PHWR | 515 | OH | Operational | OH/AECL | 01-Dec.-67 | 24-Apr.-72 | 03-May-72 | 01-Jun-72 | |
| PICKERING-4 | PHWR | 515 | OH | Operational | OH/AECL | 01-May-68 | 16-May-73 | 21-May-73 | 17-Jun-73 | |
| PICKERING-5 | PHWR | 516 | OH | Operational | OH/AECL | 01-Nov.-74 | 23-Oct-82 | 19-Dec.-82 | 10-May-83 | |
| PICKERING-6 | PHWR | 516 | OH | Operational | OH/AECL | 01-Oct-75 | 15-Oct-83 | 08-Nov.-83 | 01-Feb.-84 | |
| PICKERING-7 | PHWR | 516 | OH | Operational | OH/AECL | 01-Mar-76 | 22-Oct-84 | 17-Nov.-84 | 01-Jan-85 | |
| PICKERING-8 | PHWR | 516 | OH | Operational | OH/AECL | 01-Sept.-76 | 17-Dec.-85 | 21-Jan-86 | 28-Feb.-86 | |
| POINT LEPREAU | PHWR | 635 | NBEPC | Operational | AECL | 01-May-75 | 25-Jul.-82 | 11-Sept.-82 | 01-Feb.-83 | |
| BRUCE-2 | PHWR | 848 | OH | Shut Down | OH/AECL | 01-Dec.-70 | 27-Jul.-76 | 04-Sept.-76 | 01-Sept.-77 | 08-Oct-95 |
| DOUGLAS POINT | PHWR | 206 | OH | Shut Down | AECL | 01-Feb.-60 | 15-Nov.-66 | 07-Jan-67 | 26-Sept.-68 | 04-May-84 |
| GENTILLY-1 | HWLWR | 250 | HQ | Shut Down | AECL | 01-Sept.-66 | 12-Nov.-70 | 05-Apr.-71 | 01-May-72 | 01-Jun-77 |
| NPD | PHWR | 22 | OH | Shut Down | CAGE | 01-Jan-58 | 11-Apr.-62 | 04-Jun-62 | 01-Oct-62 | 01-Aug.-87 |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organisational Charts

The structure of the Canadian Nuclear Industry is shown in Figure 3.




| | |
|---|---|
| AECB | Atomic Energy Control Board |
| AECL | Atomic Energy of Canada Limited |
| LLRWMO | Low Level Radioactive Waste Management Office |

*FIG. 3. Structure of the Canadian Nuclear Industry*

## 4. NUCLEAR POWER INDUSTRY

The Canadian nuclear industry covers all phases of the fuel cycle. The industry's activities are focused on the design, engineering, construction and servicing of CANDU reactors in Canada and abroad; on fuel and component manufacturing; and, on the mining, milling, refining and conversion of uranium. The most significant members of the industry are AECL, the AECB, provincial utilities, and private sector firms involved in equipment manufacturing, engineering and the mix of private and government (both domestic and foreign) firms involved in uranium production. In addition, there are about 125 hospitals and universities across Canada that are involved in nuclear medicine and radiology.

### 4.1. Supply of Nuclear Power Plants

AECL is responsible for engineering, nuclear design, business management, and construction of CANDU reactors in Canada and abroad. It leads the marketing and sales initiatives on behalf of the nuclear industry. It also manages contracts for building the reactors and servicing them. AECL's CANDU operations are based in Mississauga, Ontario and Montreal, Quebec. It also has offices around the world.

AECL sold its first CANDU 6 reactor to Argentina in 1974, the second to South Korea in 1976 and the third to Romania in 1979. It currently has three additional CANDU 6 reactors under construction in South Korea.

The industry is not vertically integrated. In 1992-93, there were about 150 companies that supplied products and/or services to AECL and the utilities. 58% of these firms are located in Ontario, 14% in Alberta and 12% in Quebec. The remaining provinces have 16% of the suppliers to the nuclear industry. 66% of the nuclear industry supplier companies are in the manufacturing sector, 30% are in engineering and design and 16% in R&D.

*Manufacturing:* Because of the cyclical nature of the nuclear industry, most of the firms are also active suppliers to other industries.

*Engineering:* A number of Canadian engineering consulting firms, working closely with AECL, assume the conventional design responsibilities as well as project and construction management and other services which are often required during plant construction.

*Operation and Maintenance:* A number of private sector suppliers work as sub-contractors for provincial utilities for some of the O&M work.

*Construction:* This activity is cyclical in nature and the impact on employment can be significant (for example, the construction of a CANDU 6 requires 15,000 person-years over the construction period of 7-8 years). The construction of reactors is undertaken by general construction contractors.

### 4.2. Operation of Nuclear Power Plants

All Canadian electric utilities are under provincial jurisdiction and are responsible for building, operating and maintaining provincial power facilities, including nuclear facilities. The utilities with nuclear facilities, namely Ontario Hydro, Hydro-Québec and New Brunswick Power are provincial agencies and wholly owned by the respective provincial government. The main activity of the utilities is operation and maintenance. This activity provides the largest single source of jobs in the nuclear industry. Private sector suppliers work as sub-contractors for utilities for some of this work.

The utilities are members of the CANDU Owners Group (COG) and share in funding the industry's R&D effort. COG was formed in mid-1984 by the Canadian utilities which own CANDU plants and AECL. COG was set up to promote closer co-operation among the nuclear utilities in matters relating to plant operations and maintenance and to foster co-operative development programmes leading to improved plant performance.

### 4.3. Fuel Cycle and Waste Management Service Supply

Canada is the world's leading producer and exporter of uranium, with output of some 9,700 tU in 1994 representing about 30% of total world production. In 1994, most of the uranium produced came from higher-grade, lower-cost production centres at Key Lake, Rabbit Lake and Cluff Lake in Saskatchewan's Athabasca Basin; production in Ontario has been reduced to only one operation at the Stanleigh mine at Elliot Lake, where operations are scheduled to cease in 1996. Several new uranium mining proposals are progressing through the environmental review process. Canada's largest uranium producer, Cameco Corporation, also operates Canada's only uranium refining and conversion facilities at Blind River and Port Hope, Ontario, respectively. Fuel fabrication in Canada is carried out by two companies which produce fuel assemblies for the CANDU reactor. There are no uranium enrichment or reprocessing facilities in Canada.

The key companies involved in the nuclear fuel cycle in Canada are Cameco Corporation, COGEMA Resources Inc., Uranerz Exploration and Mining Limited, Denison Mines Limited and Rio Algom Limited (uranium mining and milling); Cameco (refining and conversion); and General Electric Canada Inc. and Zircatec Precision Industries Inc. (fuel fabrication).

The general approach to radioactive waste management is that the producer/owner is responsible for complying with regulatory criteria. The producers of the largest volumes of nuclear wastes, AECL and the three nuclear utilities have in-house expertise for the management of these wastes. AECL also provides services to smaller entities which produce small volumes of wastes.

The federal regulatory authority is AECB which exercises authority under the Atomic Energy Control Act. AECB expects all organizations that produce radioactive wastes to prove their technical and financial capability of appropriately dealing with wastes as a condition of licensing. The producers ensure that forecasted costs for waste disposal are recovered in the price of their products and services. The electric utilities, for example, add a fee into their rate bases to cover the estimated future costs of waste disposal. The revenues from the fees, plus accumulated interest, are self-invested by the utilities and carried as liabilities on their books.

AECL has developed a concept for the deep geological disposal of Canada's used nuclear fuel. It has conducted a 16-year research programme to develop a disposal concept for used nuclear fuel based on a geologic repository in crystalline igneous rock of the Canadian Shield. The concept is based on burial, at depths of 500 m to 1,000 m, using a series of engineered and natural barriers. The major research facility is the Underground Research Laboratory in Manitoba. The concept is presently undergoing a federal Environmental Assessment and Review Process. Selection of a site will not proceed until a disposal option has been approved. A decision is not expected before 1997.

For low level waste, Ontario Hydro hopes to have a facility in operation by 2015. AECL is developing a below grade concrete vault for the disposal of similar waste. The federal Low Level Radioactive Waste Management Office (LLRWMO) is planning for a disposal facility for historic waste. LLRWMO is developing a comprehensive inventory of waste in Canada and conducting waste management studies for long-lived waste, mixed waste, and decontamination and decommissioning waste.

Uranium tailings are decommissioned on-site. Uranium producers in co-operation with provincial and federal governments are involved in on-going research on the decommissioning of uranium tailings, specifically tackling the problem of acid mine drainage and increasing the stability of engineered barriers. Successful decommissioning has been achieved at a few sites in Saskatchewa and Ontario. Other sites are either being decommissioned or are still in operation.

AECB requires that all nuclear facilities be properly decommissioned. Planning for such activities should be initiated at the earliest stages of design of the nuclear facility and further refined during the operating life.

CANDU reactors are to be decommissioned in a staged fashion. NPD (a 25 MW(e) reactor), Douglas Point (a 220 MW(e) reactor) and Gentilly-1 (a 266 MW(e) reactor), all owned by AECL, are in a shutdown phase. The used nuclear fuel has been stored and the containment buildings are intact. After a period of about 30 years, remaining structures will be dismantled, the site restored and the waste disposed of off-site.

Under the authority of AECB, other nuclear facilities, such as uranium mines, mills and fuel fabrication plants, have been successfully decommissioned. All three nuclear utilities in Canada have established funds with annual contributions from operating revenues to pay for eventual decommissioning of their reactors and disposal of irradiated fuel.

### 4.4. Research and Development Activities

AECL is responsible for Canada's nuclear research and development programme which includes activities in support of CANDU technology as well as basic science activities to support AECL's applied programmes in the nuclear, biological and material sciences. AECL's internationally acclaimed research centres at Chalk River, Ontario and Whiteshell, Manitoba play a critical role in the development of the CANDU reactor, in safety and environmental protection, in nuclear medicine, in health sciences, in nuclear fuel waste management and in the basic sciences that spawn the technological advances.

Nuclear research and development in Canada began in the 1940's as a responsibility of the federal government. The Chalk River Laboratories (CRL) were originally established as a part of the National Research Council's wartime research effort. Early CRL pursuits were in the "new" sciences at the time - nuclear physics, nuclear chemistry and radiation biology - and the creation of the National Research Experimental Reactor (NRX).

The NRX facility and the National Research Universal (NRU) reactor brought on-stream a decade later were critical to CRL's early programmes of basic science and isotope production and to the development of the CANDU reactor system. CRL supported federal government's initiatives to develop national radiological health and safety regulations and to contribute to international efforts to control the proliferation of nuclear materials.

Nuclear R&D in Canada has always been distinct from that undertaken in other nuclear countries. This is because the Canadian research reactors were designed to use natural (rather than enriched) uranium and heavy (rather than light) water.

Although responsibility for the design, construction and operation of nuclear power plants has generally been shared between AECL, the nuclear power utilities and private companies, most of the related R&D activities have remained in the AECL laboratories. Such activities have included the development of CANDU design methods, experimental verification of CANDU reactor components and design characteristics, as well as detailed safety analyses. On going work has been on improved durability and reliability of CANDU components, and flexibility of fuel cycles. Basic and applied sciences not related to nuclear energy have also been significant research components in these laboratories.

As the CANDU nuclear energy system is unique in concept among nuclear systems in the world, the required R&D support is also unique and cannot be derived from research results in other countries. Therefore, a continuing R&D programme specific to CANDU is necessary to support existing and future plants, either at home or abroad. In terms of the accumulated electricity produced, however, the costs of R&D specific to Canada's nuclear energy programme has been much less than the costs in any other country's civilian nuclear programme.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Private and public organizations in Canada's nuclear programme are active in bilateral co-operative work in many countries often under the umbrella of a Memorandum of Understanding between parties. Co-operative work is carried out with countries with which Canada has established formal nuclear relations under a Nuclear Co-operation Agreement. Canadian public and private sector firms are also active in a variety of multilateral activities carried out in a number of international nuclear fora including the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD), the G-7 Nuclear Safety Working Group, etc.

An example of bilateral nuclear co-operation involving more than one Canadian entity is the Canadian Nuclear Safety Initiative (CNSI). This programme, which is paid for by the Canadian government, is designed to improve the safety of the RBMK reactors in Russia and Lithuania. They key players are AECL, AECB and Ontario Hydro.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

AECB was created in 1946 with the passage of the Atomic Energy Control Act which gave the federal government control over the development, application and use of nuclear energy and established the Atomic Energy Control Board (AECB). The five-member Board administers and enforces the Act, from which it derives its authority to regulate the health, safety, security and environmental aspects of nuclear energy. The AECB reports to Parliament through a designated Minister, currently the Minister of Natural Resources.

AECB is responsible for the regulation of safety, security and environmental aspects of all nuclear materials and nuclear facilities and the administration of Canada's safeguards policy. It controls the development, application and use of nuclear energy in Canada and administers Canada's domestic and international safeguards commitments under the authority of the Atomic Energy Control Act. AECB regulates nuclear facilities and nuclear materials through a comprehensive licensing system extending to the import and export of nuclear materials.

It involves Canadian participation in the IAEA activities and compliance with Canada's non-proliferation policy and the Treaty on the Non-Proliferation of Nuclear Weapons. A number of other agencies, both provincial and federal, are involved in the regulation of some activities in the nuclear fuel cycle, but AECB retains the primary regulatory function and is the only agency empowered to license the operation of nuclear facilities.

The licensing process for all nuclear facilities is the most visible function of the AECB in the control of safety of the nuclear fuel cycle. AECB regulations require prior authorization in the form of a license to possess, use, export or import nuclear materials or to operate uranium mines and mills, refineries, fuel fabrication plants, heavy water plants, nuclear reactors and waste management facilities.

In its regulatory role, AECB develops safety standards, assesses applications, issues licenses, and inspects facilities. Standards applied for radiological protection have been developed over the years at both national and international levels. The basis for the Canadian regulatory limits on permissible exposures originates from the recommendations of the International Commission on Radiological Protection (ICRP).

The basic approach in all regulatory matters is that the applicant is primarily responsible for safety. The AECB's role is to ensure that the applicants live up to their responsibility. The onus is on the applicant or the holder of the license to justify the selection of a site, design, method of construction, and mode of operation of a facility, etc.

### 5.2. Main National Laws and Regulations

The three main national laws relevant to Canada's nuclear programme are the Atomic Energy Control Act of 1946, the Nuclear Liability Act of 1976, and the Canadian Environmental Assessment Act which came into force in January, 1995.

The Atomic Energy Control Act is the most important piece of legislation; it sets out the overall scheme for the control and supervision of the development, application and use of nuclear energy in Canada. The following additional regulations and guidelines under the Act are also relevant:

- The Atomic Energy Control Act regulations pursuant to the Atomic Energy Control Act set out the AECB's licensing process for the possession and abandonment of prescribed substances including radioactive waste.

- The Uranium and Thorium Mining Regulations set out the licensing process for uranium and thorium mining.

- The Physical Security Regulations set out the licensing process for physical protection of nuclear facilities.

- The AECB Cost Recovery Regulations which set out the rules and regulations for the recovery of the costs from licensees of AECB activities.

- Disposal of Radioactive Waste: AECB regulatory document R-104 "Regulatory Objectives, Requirements, and Guidelines for the Disposal of Radioactive Wastes - Long Term Aspects" describes the regulatory objectives, requirements and guidelines for disposal of radioactive wastes.

- Decommissioning of Nuclear Facilities: AECB regulatory Document R-90, "Policy on Decommissioning of Nuclear Facilities" describes the AECB's Policy defined in the Atomic Energy Control Regulations.

- The AECB is the lead Agency for the regulation of the concept of disposal of used fuel involving deep geological disposal. It has developed regulatory documents setting out its requirements (R-71 and R-72).

- Transportation of Radioactive Wastes: the AECB's "Transport Packaging of Radioactive Materials Regulations" and Transport Canada's "Transportation of Dangerous Goods Regulations" set out Canadian regulations in this area.

The new legislation currently developed to replace the Atomic Energy Control Act will require that licensees of nuclear facilities, including mine sites and nuclear plants, provide financial assurance for decommissioning of those facilities.

The Canadian Environmental Assessment Act establishes, for the first time in legislation, a process for the systematic conduct of environmental assessments of public or private projects involving the federal government.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE AGENCY*

| | | |
|---|---|---|
| • NPT related safeguards agreement INFCIRC/164 | Entry into force: | 21 February 1972 |
| • Improved procedures for designation of safeguards inspectors | Accepted (orally) | 8 June 1989 |

*OTHER MULTILATERAL SAFEGUARDS AGREEMENTS*

| | | |
|---|---|---|
| • India/Canada<br>INFCIRC/211 | Entry into force: | 30 September 1971 |
| • Japan/Canada<br>INFCIRC/85 | Entry into force: | 20 June 1966 |
| • Pakistan/Canada<br>INFCIRC/135 | Entry into force: | 17 October 1969 |
| • Spain/Canada<br>INFCIRC/247 | Entry into force: | 10 February 1977 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 8 January 1969 |
| • Agreement on privileges and immunities | Entry into force: | 15 June 1966 |
| • Convention on physical protection of nuclear material | Entry into force: | 8 February 1987 |
| • Convention on early notification of a nuclear accident | Entry into force: | 18 February 1990 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Signature: | 26 September 1986 |
| • Conventions on civil liability for nuclear damage and joint protocol | Non-Party | |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | No reply | |
| • Nuclear Suppliers Group | Member | |

- Agenda 21 of the UN Conference on Environment and Development (1992).

*BILATERAL AGREEMENTS*

Canada has bilateral nuclear co-operation agreements with the following countries: Argentina, Australia, China, Colombia, Egypt, Euratom, Finland, Hungary, Indonesia, Japan, Lithuania, Philippines, Republic of Korea, Romania, Russia, Sweden, Switzerland, Turkey, Mexico, Uruguay and the United States.

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*FEDERAL GOVERNMENT DEPARTMENTS AND AGENCIES*

| | |
|---|---|
| Uranium and Nuclear Energy Branch<br>Department of Natural Resources<br>580 Booth Street<br>Ottawa, Ontario, KIA 0E4 | |
| Atomic Energy of Canada Limited<br>344 Slater Street, 18th Floor<br>Ottawa, Ontario K1A 0S4 | Tel.: (+1-613) 237-3270<br>Fax: (+1-613) 782-2061 |
| Atomic Energy Control Board<br>280 Slater Street, 4th Floor Reception<br>P.O. Box 1046, Station B<br>Ottawa, Ontario K1P 5S9 | Tel.: (+1-613) 995-5894<br>Fax: (+1-613) 995-5086 |

*FIRMS INVOLVED IN THE FRONT END OF THE FUEL CYCLE*

| | |
|---|---|
| Cameco Corporation<br>2121 - 11th Street West<br>Saskatoon, Saskatchewan S7M 1J3 | Tel.: (+1-306) 956-6200<br>Fax: (+1-306) 956-6302 |
| Uranerz Exploration and Mining Limited<br>410 - 22nd Street E., Suite 1300<br>Saskatoon, Saskatchewan S7K 5T6 | Tel.: (+1-306) 668-1711<br>Fax: (+1-306) 652-3731 |
| Cogema Resources Inc.<br>817 - 825, 45th Street West, Box 9204<br>Saskatoon, Saskatchewan S7K 3X5 | Tel.: (+1-306) 343-4502<br>Fax: (+1-306) 653-3883 |
| Rio Algom Limited<br>120 Adelaide Street West, Suite 2600<br>Toronto, Ontario M5H 1W5 | Tel.: (+1-416) 367-4000<br>Fax: (+1-416) 365-6870 |
| Denison Mines Limited<br>Atrium on Bay - Suite 320<br>40 Dundas Street West<br>Toronto, Ontario M5G 2C2 | Tel.: (+1-416) 979-1991<br>Fax: (+1-416) 979-5893 |

*RELEVANT ASSOCIATIONS*

| | |
|---|---|
| Uranium Saskatchewan Association Inc.<br>600 Spadina Crescent East<br>Saskatoon, Saskatchewan S7K 3G9 | Tel.: (+1-306) 242-8222<br>Fax: (+1-306) 244-4441 |
| Canadian Nuclear Association<br>144 Front Street West, Suite 725<br>Toronto, Ontario M5G 2L7 | Tel.: (+1-416) 977-6152 ext. 25<br>Fax: (+1-416) 979-8356 |

Canadian Electrical Association
1 Westmount Square, Suite 1600 — Tel.: (+1-514) 937-6181
Montréal, Québec H3Z 2P9 — Fax: (+1-514) 937-6498

Electrical and Electronic Manufacturers Association
10 Carlson Court
Suite 210 — Tel.: (+1-416) 674-7410
Rexdale, Ontario M9W 6L2 — Fax: (+1-416) 674-7412

*RELEVANT POWER UTILITIES*

Ontario Hydro
700 University Avenue
Toronto, OntarioM5G 1X6 — Tel.: (+1-416) 592-3453

Hydro-Québec
75, boul. René Lévesque ouest — Tel.: (+1-514) 289-3811
Montréal, Québec H2Z 1A4 — Fax: (+1-514) 289-3342

SaskPower Corporation
2025 Victoria Avenue — Tel.: (+1-306) 566-2121
Regina, Saskatchewan S4P 0S1 — Fax: (+1-306) 566-3523

New Brunswick Power Corporation
515 King Street
P.O. Box 2000 — Tel.: (+1-506) 458-4342
Fredericton, New Brunswick E3B 4X1 — Fax: (+1-506) 458-4390

*CANDU INDUSTRY*

Monenco Agra Inc.
Monenco Agra Building
2010 Winston Park Drive, Suite 100 — Tel.: (+1-905) 829-5399
Oakville, Ontario L6H 6A3 — Fax: (+1-905) 829-5401

Babcock and Wilcox Canada
P.O. Box 310
581 Coronation Boulevard — Tel.: (+1-519) 621-2130
Cambridge, Ontario N1R 5V3 — Fax: (+1-519) 621-5610

Canatom Inc.
2020 University, Suite 2200 — Tel.: (+1-514) 288-1990
Montréal, Québec H3A 2A5 — Fax: (+1-514) 289-9813

CAE Electronics Ltd.
C.P. 1800 — Tel.: (+1-514) 341-6780
Saint-Laurent, Québec H4L 4X4 — Fax: (+1-514) 341-7699

CAE Electronics Ltd.
C.P. 1800 — Tel.: (+1-514) 341-6780
Saint-Laurent, Québec H4L 4X4 — Fax: (+1-514) 341-7699

Dominion Bridge
500 Notre-Dame Street
Lachine, Québec H8S 2B2

Tel.: (+1-514) 634-3551
Fax: (+1-514) 631-2668

GE Canada Inc.
Nuclear Products
107 Park Street North
Peterborough, Ontario K9J 7B5

Tel.: (+1-705) 748-7509
Fax: (+1-705) 748-7338

*RADIOISOTOPES*

Nordion International Inc.
447 March Road
Kanata, Ontario K2K 1X8

Tel.: (+1-613) 592 2790
Fax: (+1-613) 592 5302

# CHINA

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# 1. GENERAL INFORMATION

## 1.1. General Overview

China, the world's largest country has a population of 1.2 billion people. The population is growing at a rate of 14 to 17 million people a year (Table 1). Its land area is 9,561,000 square kilometres. It is rich in coal and water resources, which are unevenly distributed throughout the country. Coal deposits are predominantly in the north and north-western regions while water resources are mainly in the south-western region. In contrast south-eastern China is densely populated and has extensively developed industry and agriculture, but is deficient in coal and hydro resources.

Transportation of vast amounts of coal accounts for 48% of the railway capacity and 25% of the highway capacity. This adds to the high price of coal. Environmental pollution from burning coal is rapidly becoming a serious problem. Improvement of China's energy infrastructure includes developing nuclear power. During the last 40 years, a relatively complete nuclear fuel cycle system has been built in China.

China has two nuclear power stations in operation, with a total capacity of 2.1 GW(e), one is 300 MW(e) PWR at Qinshan, Zhejiang Province; the other has two 900 MW(e) PWRs at Daya Bay, Guangdong Province.

Qinshan Nuclear Power Plant is north of Hangzhou Bay, which is eight kilometres from the city of Haiyan, 90 km from Shanghai, and 78 km from Hangzhou. The Qinshan nuclear power plant site enjoys a subtropical maritime climate. The mean annual temperature is 16.3°C, with maximum 37.4°C and minimum -5.3°C. The relative humidity is higher than 80%. The plant site is located on a mountainous peninsula with a low population density (240 people per $km^2$). There are about 18,600 inhabitants within five kilometres of the plant.

Daya Bay Nuclear Power Plant is located in Longgang Zone, Shenzhen city, Guangdong Province. The site faces Dapeng Bay, a small bay Southwest of Daya Bay, and is close to low mountains (700 m high) on the Dapeng peninsula. Similar to Qinshan, the site has a subtropical maritime climate. The mean annual temperature is 21.8°C, with maximum 36.7°C and minimum 0.2°C. The relative humidity follows the monsoon seasons with the highest humidity (80%) in spring and summer and the lowest (16%) in winter. The mountainous peninsula has a low population density (37 people per $km^2$). There are about 2 900 inhabitants within five kilometres radius from the plant.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 646.9 | 816.2 | 981.2 | 1135.1 | 1175.4 | 1187.2 | 1.4 |
| Population density (inhabitants/$km^2$) | 67.7 | 85.4 | 102.6 | 118.7 | 122.9 | 124.2 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.9 |
| Area (1000 $km^2$) | 9561.0 |
| Urban population in 1994 as percent of total | 29.0 |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

In 1994, China's Gross Domestic Product (GDP) was 4,380 billion RMB Yuan, a 12% increase from 1993. 1993 GDP was 544.6 billion US$ with the per capita GDP of 459.5 US$ and annual growth rate of 13.4%. Total industrial assets increased to 2,126 billion RMB Yuan with a growth rate of 17.4% over the previous year. Agricultural sector grew to 823 billion RMB Yuan with a growth rate of 3.5% over the previous year. Service sector rose by 1,431 billion RMB Yuan or 8.7%. In 1993 national income by sector, agriculture amounted to 25%; industry and construction 60%; and, transport and commerce 15%. Table 2 shows the historical Gross Domestic Product (GDP) data.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 123,424 | 392,056 | 505,750 | 718,327 | 508,197 | 1.9 |
| GDP (millions of constant 1990 US$) | 117,970 | 215,498 | 505,750 | 694,261 | 776,701 | 9.6 |
| GDP per capita (current US$/capita) | 151 | 400 | 446 | 611 | 428 | 0.5 |
| GDP by sector : | | | | | | |
| Agriculture 19% | | | | | | |
| Industry 48% | | | | | | |
| Services 33% | | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.3. Energy Situation

China has abundant coal and hydro resources. Total coal deposits are estimated at 5,059 billion metric tons, and a hydroelectric resource potential is about 380,000 MW, see Table 3.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro (2) | Total |
| Total amount in place | 3020.05 | 137.09 | 65.05 | | 570.90 | 3793.08 |

(1) This total represents essentially recoverable reserves.
(2) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.
Source: IAEA Energy and Economic Data Base

In 1993, the growth of primary energy production was higher than the growth of the demand. The total output of primary energy was 1.1 billion tons of standard coal equivalent (3.7% higher than the previous year). The coal production accounted for 74% of total primary energy production while petroleum, natural gas and hydropower were 19%, 2%, and 6% of total energy production, respectively.

In 1993, primary energy consumption amounted to 1.1 billion tons of standard coal equivalent (a 2.4% annual growth rate). The proportions of coal, petroleum, natural gas and hydropower were 73%, 20%, 2% and 6%, respectively. Statistical energy data are given in Table 4. The per capita energy consumption in 1993 was 0.94 tons of standard coal.

## 1.4. Energy Policy

China's energy policy adheres to the following principles:

i) Laying equal stress on both energy development and energy conservation;
ii) Harmonizing development with environmental protection;
iii) Considering power sources construction in accordance with local conditions;
iv) Developing simultaneously hydraulic and fossil power;
v) Developing nuclear power.

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 8.70 | 10.22 | 19.02 | 28.90 | 33.46 | 36.47 | 3.99 | 4.76 |
| - Solids[2] | 8.27 | 8.62 | 14.18 | 22.26 | 25.42 | 27.98 | 2.73 | 4.98 |
| - Liquids | 0.32 | 1.29 | 3.73 | 4.80 | 5.84 | 6.08 | 13.11 | 3.56 |
| - Gases | 0.04 | 0.11 | 0.56 | 0.60 | 0.66 | 0.68 | 13.99 | 1.50 |
| - Primary electricity[3] | 0.07 | 0.20 | 0.56 | 1.24 | 1.54 | 1.73 | 10.89 | 8.34 |
| Energy production | | | | | | | | |
| - Total | 8.64 | 10.26 | 19.81 | 32.05 | 34.28 | 36.51 | 4.24 | 4.46 |
| - Solids | 8.31 | 8.67 | 14.26 | 24.44 | 26.05 | 27.96 | 2.74 | 4.93 |
| - Liquids | 0.22 | 1.28 | 4.44 | 5.79 | 6.08 | 6.12 | 16.27 | 2.32 |
| - Gases | 0.04 | 0.11 | 0.56 | 0.60 | 0.66 | 0.68 | 13.99 | 1.50 |
| - Primary electricity[3]) | 0.07 | 0.20 | 0.56 | 1.22 | 1.49 | 1.75 | 10.86 | 8.47 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.06 | -0.05 | -0.79 | -1.29 | -0.59 | -0.37 | -14.22 | -5.22 |
| - Solids | -0.04 | -0.06 | -0.08 | -0.34 | -0.45 | -0.59 | 3.16 | 15.11 |
| - Liquids | 0.10 | 0.01 | -0.71 | -0.95 | -0.14 | 0.21 | -10.34 | 8.28 |
| - Gases | | | | | | | | |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

There are fourteen electrical power grids, including five major trans-provincial and regional networks and one inter-linked network in China. The structure of the electricity sector is given in Figure 1. At the end of 1993, their total installed capacities amounted to 166 GW, 91% of the nation's capacity. Among these, the largest one is the East-China Power network with 31 GW of installed capacity. The next two largest networks are North-China Power Network and Central China Power network with combined capacity of more than 27 GW. The North-east China Power Network, the Southern four provinces (Guangdong, Guangxi, Guizhou, and Yunnan) and Region Inter-linked Power Network installed capacity exceed 26 GW. The Northwest China Power Network's installed capacity is 11.4 GW. Shandong Provincial Power Network also reached an installed capacity of 11.4 GW. All the power networks are state-owned.

### 2.2. Decision Making Process

The State Planning Commission (SPC) is responsible for planning, budgeting and final accounting of economic construction nation-wide. Construction projects exceeding a certain limit and new construction must seek pre-approval from SPC. Short and long term planning of China's national economy are all established under the leadership of SPC. Large projects like the Three Gorges Power Station must be approved by the State Council.

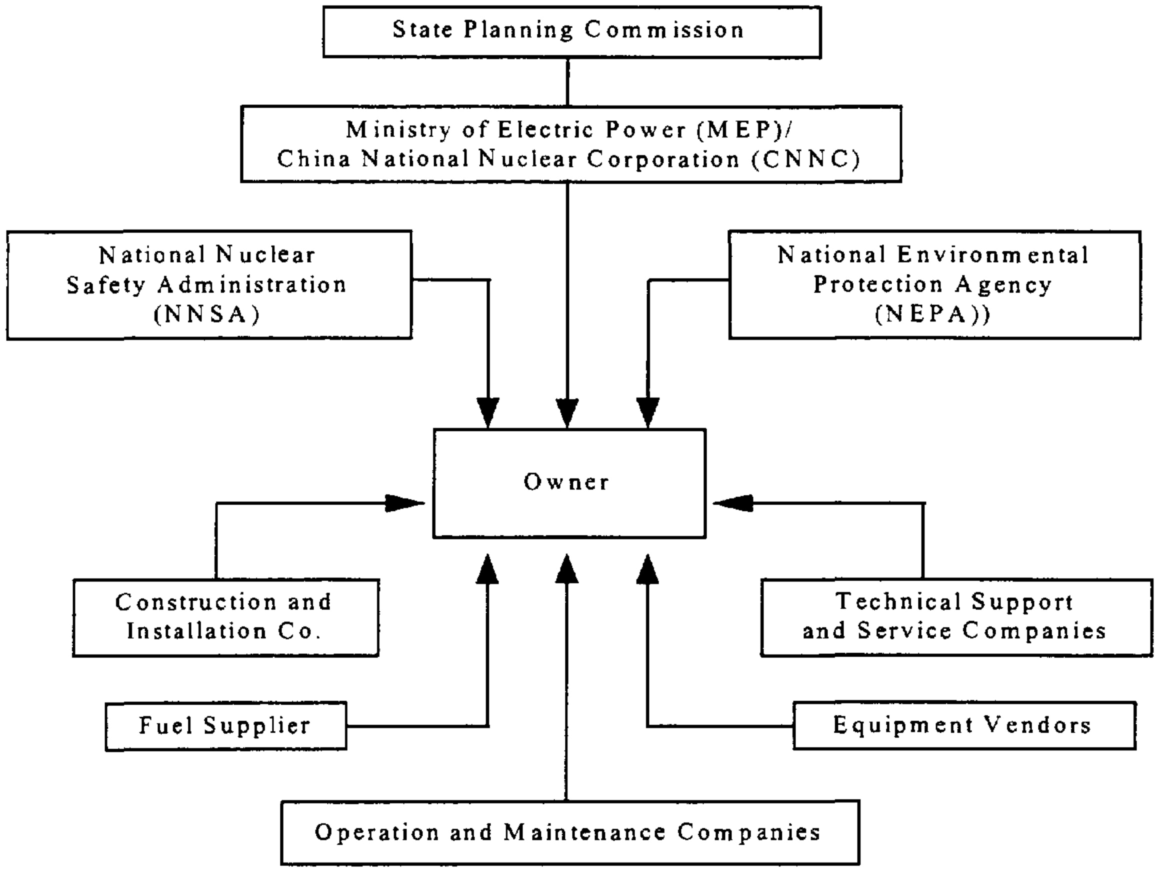



*FIG. 1. Structure of Electricity Sector*

The Ministry of Electric Power (MEP) is responsible for short and long term planning of electricity development according to the needs of the national economy. MEP is authorised to initiate a new power project. The owner of the power project prepares and submits the Preliminary Feasibility Study Report (PFSR), the Project Proposal and the Feasibility Study Report (FSR) to MEP for review. MEP reports its comments and decision to SPC for final approval.

For new nuclear power projects, MEP and China National Nuclear Corporation (CNNC) are jointly responsible for the review and approval of the Preliminary Feasibility Study Report (PFSR), the Project Proposal and the Feasibility Study Report as submitted by the utility, the owner of the nuclear power plant. The utility first submits the siting part of the FSR for the project to NNSA. The utility receives a "Review Report for Siting of the Nuclear Power Plant" from NNSA. NEPA reviews the Environmental Impact report of the nuclear power plant. Favorable reviews by the two organizations are required before final project approval is granted by SPC.

### 2.3. Main Indicators

The total installed generation capacity was 175.2 GW of which fossil power accounted for 74%, hydro power 24%, and nuclear power 0.15%. The average annual load factor was 53%. The total electricity production in 1994 amounted to 920 TW·h with a growth rate of 9.6% over the previous year. The per capita electricity consumption was 767.6 kWh. Nuclear electricity production in 1994 was 13.5 TW·h accounting for 1.5% of total electricity production. Table 5 gives the historical electricity production and installed capacities and Table 6 the energy related ratios.

In 1994, installed generation capacity amounted to 199,000 MW with the share of fossil power of 148,000 MW (75%), hydropower 48,500 MW (24%) and nuclear power 2,100 MW (1%). Electricity accounted for about 30% of total energy consumption.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 59.40 | 115.90 | 300.62 | 126.72 | 839.45 | 928.08 | 8.45 | 8.38 |
| - Thermal | 52.00 | 95.40 | 242.42 | | 685.16 | 746.47 | 8.00 | 8.36 |
| - Hydro | 7.40 | 20.50 | 58.20 | 126.72 | 151.80 | 168.11 | 10.86 | 7.87 |
| - Nuclear | | | | | 2.49 | 13.50 | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | | 24.18 | 65.87 | 36.05 | 175.19 | 190.10 | | 7.86 |
| - Thermal | | 16.00 | 45.55 | | 129.97 | 141.93 | | 8.46 |
| - Hydro | | 8.18 | 20.32 | 36.05 | 44.00 | 46.00 | | 6.01 |
| - Nuclear | | | | | 1.22 | 2.17 | | |

[1] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 13 | 13 | 19 | 25 | 28 | 31 |
| Electricity per capita (kW·h/capita) | 92 | 142 | 287 | 79 | 666 | 780 |
| Electricity production/Energy production (%) | 7 | 11 | 14 | 3 | 22 | 25 |
| Nuclear/Total electricity (%) | | | | | | 1 |
| Ratio of external dependency (%)[1] | 1 | | -4 | -4 | -2 | -1 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | | 55 | 52 | 40 | 55 | 56 |
| - Thermal | | 68 | 61 | | 60 | 60 |
| - Hydro | | 29 | 33 | 40 | 39 | 42 |
| - Nuclear | | | | | 23 | 71 |

[1] *Total net import / Total energy consumption.*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

In 1970, then former premier Zhou Enlai pointed out the necessity for peaceful use of atomic energy and development of nuclear power. This triggered the first step of nuclear power development in China. In November 1981, the first nuclear project proposal, Qinshan 300 MW PWR, was reviewed and approved. Seven months later, in June 1981, site construction began. In December 1991, the Qinshan nuclear power plant was connected into the grid for the first time. Thus, nuclear power generation began in mainland China.

Meanwhile, another proposal for building a nuclear power plant with two 900 MW PWRs on Daya Bay site was put forward and adopted by Chinese Government in 1982. In February, 1985, Guangdong Electricity Power Company and China Light and Power Company Limited (Hong Kong) established a joint venture, Guangdong Nuclear Power Joint Venture Company, to construct the Daya Bay nuclear power project. The first pouring of concrete took place in August, 1987. The two units began commercial operation in February and May, 1994, respectively.

### 3.2. Current Policy Issues

The main proportion of electricity production in China is supplied with fossil fuel and hydro power. Nuclear power generation would play an important role as an alternative and supplementary energy resource, especially for the coastal areas where the economy is developing rapidly and there is severe electricity shortage.

Pressurized Water Reactors have been selected as the mainstream of nuclear power development in China. However, other types of reactors are considered where suitable.

Nuclear fuel assemblies of nuclear power plants are fabricated and supplied by local Chinese fuel manufacturers.

It is important to achieve domestic manufacturing of nuclear power equipment and self-reliance of design and project management of nuclear power plants.

International co-operation on the nuclear power development is encouraged.

### 3.3. Status and Trends of Nuclear Power (as of September 1995)

Table 7 shows the status of the operating nuclear power plants. The Qinshan 300 MW PWR nuclear power plant was connected into the grid for the first time on December 15, 1991. As a prototype NPP, its operation has been very satisfactory. Its capacity factor in 1994 was 66.7%. It shut down for refueling and overhaul in mid-November 1994. The unit was restarted in January 1995, and is now operating very smoothly.

The two imported units of Daya Bay nuclear power plant began commercial operation in 1994. They have a good operation record with a capacity factor of 98% based on 1994 operational data. Unit 1 shut down for refueling and overhaul in December, 1994. Its restarting was temporarily halted by the National Nuclear Safety Administration (NNSA) because of problems with control rod drive mechanism. Unit 2 has completed its refueling and was restarted in May, 1995.

The project proposal of Qinshan PWR nuclear power plant phase 2 (twice 600 MW(e)) has been reviewed and approved. The site excavation began 1993. By the end of 1994, 60 per cent of the total excavation work had been completed. The first pouring of concrete for Unit 1 is scheduled to be carried out in the first half of 1996.

In January 1995, a memorandum was signed for the Guangdong NPP phase 2 by Chinese and French Governments. The project proposes a building of two imported PWR units with 1,000 MW(e) at Lingao next to Daya Bay. A loan memorandum between National Development Bank of China and French Bank of Paris was signed to fund the project. The Feasibility Study Report of the project is being written for approval. Particular attention has been paid to the CRDM experienced at the Daya Bay NPP.

Wafangdian city, Liaoning province has been chosen and approved by the Government as the site for Liaoning nuclear power plant. The Preliminary Feasibility Study Report and the project proposal have been approved. The project is divided into two stages. The first stage calls for construction of two 1,000 MW Russian design VVER-91 units. An agreement on co-operative construction of the NPP between Chinese and Russian Governments has been signed. The Feasibility Study Report of the project is being prepared.

Coastal and inland provinces like Zhejiang, Shandong, Jiangsu, Fujian, Hunan, Jiangxi, Jilin are considering the development of nuclear power. Some preliminary work has been done and a few sites have already been selected and approved by the relevant Authorities.

Negotiations between CNNC and AECL of Canada to build two CANDU 6 units at the Qinshan site have made very good progress. It is expected that the Preliminary Feasibility Study Report for this project will soon be approved. Table 8 lists the status of (not yet firmly) planned nuclear power plants.

TABLE 7. STATUS OF OPERATING NUCLEAR POWER PLANTS

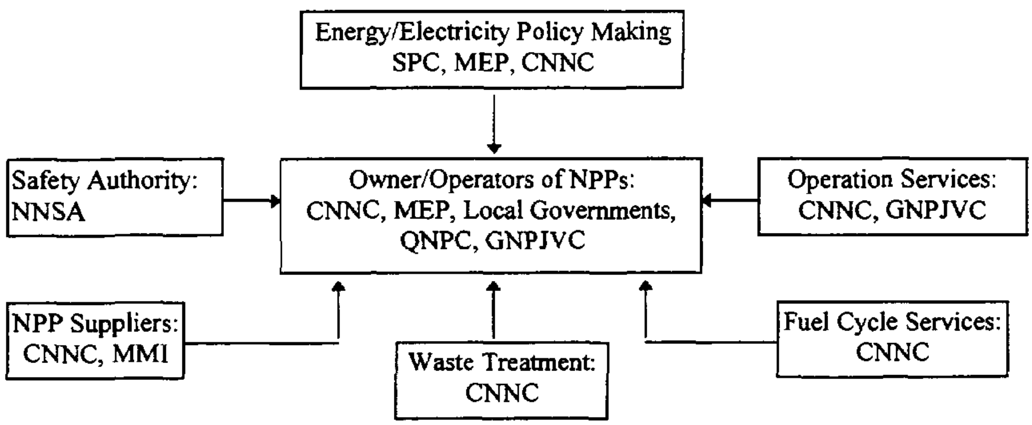
| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| GUANGDONG-1 | PWR | 944 | GNPJVC | Operational | FRAM |
| GUANGDONG-2 | PWR | 944 | GNPJVC | Operational | FRAM |
| QINSHAN-1 | PWR | 279 | QNPC | Operational | CNNC |
| QINSHAN-2A | PWR | 600 | QNPC | Under Construction | CNNC |
| QINSHAN-2B | PWR | 600 | QNPC | Under Construction | CNNC |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| GUANGDONG-1 | 07-Aug.-87 | 28-Jul.-93 | 31-Aug.-93 | 01-Feb.-94 | |
| GUANGDONG-2 | 07-Apr.-88 | 21-Jan-94 | 07-Feb.-94 | 06-May-94 | |
| QINSHAN-1 | 20-Mar-85 | 31-Oct-91 | 15-Dec.-91 | 01-Apr.-94 | |
| QINSHAN-2A | 02-June-96 | | | 01-June-02 | |
| QINSHAN-2B | 02-June-96 | | | 01-June-02 | |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organisational Chart

The organizations involved with nuclear power is given in Figure 2.




SPC: State Planning Commission; MEP: Ministry of Electrical Power; CNNC: China National Nuclear Corporation; NNSA: National Nuclear Safety Administration; MMI: Ministry of Machine Industry; QNPC: Qinshan Nuclear Power Company; GNPJVC: Guangdong Nuclear Power Joint Venture Company.

*FIG. 2. Organizational Chart*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

Architect Engineering services are provided by:

- Shanghai Nuclear Energy Research and Development Institute (SNERDI);
- Beijing Institute of Nuclear Engineering (BINE);
- Nuclear Power Institute of China (NPIC).

Construction and installation companies belonging to CNNC are:

- Huaxia Installation Co.
- Huatai Construction Co.
- Huachang Construction Co.
- Huaxing Construction Co.
- Huakang Construction Co.
- Huayang Construction Co.

The following companies also have experience in the construction and installation of nuclear power projects:

- Zhejiang Electricity Power Construction Company
- Shandong Electricity Power Construction Company
- Jilin Electricity Power Construction Company

The main component suppliers and their subsidiary companies are:

| | |
|---|---|
| • Steam generators: | Shanghai Boiler Works |
| • Turbine and generators: | Shanghai Turbine Works<br>Harbin Turbine Works<br>Dongfang Turbine and Generator Works |
| • Reactor vessels: | Fularji Heavy Component Works<br>Deyang Heavy Component Works |
| • I & C, safety class valves: | China Baoyuan Industry and Trade Corporation |

### 4.2. Operation of Nuclear Power Plants

CNNC and GNPJVC supply operation and maintenance services for Qinshan NPP and Daya Bay NPP, respectively (see Table 8).

TABLE 8. OWNERS AND OPERATORS OF NPPs

| Project | Owner | Operator |
|---|---|---|
| Qinshan NPP | CNNC | Qinshan Nuclear Power Company |
| Daya Bay NPP | CNNC(33.8%), GEPC(33.8%), MEP(7.5%), CLPCL(25%) | Guangdong Nuclear Power Joint Venture Company |

CNNC China National Nuclear Corporation;
GEPC Guangdong Electricity Power Company;
MEP Ministry of Electrical Power;
CLPCL China Light and Power Company Limited.

### 4.3. Fuel Cycle and Waste Management Service Supply

China has a comprehensive range of fuel cycle facilities capable of supporting the domestic nuclear power programme.

The main entities related to fuel cycle are:

i) Hengyang Uranium Plant, Hengyang, Hunan province
ii) Fuzhou Uranium Centre, Fuzhou, Jiangxi province
iii) Yiling Uranium Mine, Yiling, Xingjiang Autonomous
iv) Lantian Uranium Mine, Lantian, Sanxi province
v) Qinglong Uranium Mine, Qinglong, Ganshu province
vi) Yibin Nuclear Fuel Element Plant

vii) Qingyuan Corporation, Beijing (totally responsible for issues of waste management, facility design, etc.)

### 4.4. Research and Development Activities

Main entities engaged in nuclear power research and development activities are:

i) China Atomic Energy Institute (CAEI);
ii) Nuclear Power Institute of China (NPIC);
iii) Beijing Institute of Nuclear Engineering (BINE);
iv) Shanghai Nuclear Energy Research and Development Institute (SNERDI);
v) Research Institute of Nuclear Power Operations (RINPO);
vi) Institute of Nuclear Energy Technology, Tsinghua University (INET).

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

- Co-operation with Framatome and GEC/Alsthom to build Daya Bay nuclear power plant.
- Negotiations with Framatome and GEC/Alsthom on Guangdong nuclear power plant Phase 2.
- Co-operation with AECL to build two CANDU 6 units at Qinshan site.
- Research reactor project in Algeria and nuclear power plant construction in Pakistan undertaken by the China Zhongyuan Engineering Corporation (CZRC).
- Zhongyuan Engineering Corporation (CZRC).
- Co-operation with Fragema, France, for technical upgrading of Yibin Fuel Element Plant, Sichuan.
- Qinshan nuclear power plant participated in World Association of Nuclear Operators WANO-TC as an ordinary member.
- Daya Bay nuclear power plant participated in WANO-PC as an ordinary member.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

The National Nuclear Safety Administration (NNSA) was established in October 1984 to maintain independent surveillance and control on nuclear safety matters of all civilian nuclear installations and nuclear materials in China.

The main functions and duties of NNSA are:

i) establish nuclear safety principles and policies; prepare and promulgate nuclear safety regulations and implement the rules; issue nuclear safety codes and guides; review and endorse national technical standards related to nuclear safety;

ii) review and assess nuclear installations safety performance and their operating organizations' capabilities in ensuring safety; issue or revoke nuclear licenses; carry out nuclear safety surveillance; review and supervise on-site emergency plan and preparedness; investigate and deal with nuclear accidents; conduct mediation and settlement of disputes relating to nuclear safety.

The headquarters of NNSA is located in Beijing. There are three regional inspection offices which report to NNSA, i.e., Shanghai Regional Office, Guangdong Regional Office and Chengdu Regional Office. They are authorised to conduct on-site inspection activities in their respective regions.

China implements a safety licensing system for civilian nuclear installations in accordance with the provisions of the "Regulations on the Supervision and Control for Civilian Nuclear Installations". NNSA is responsible for examining all applications submitted and for issuance of licenses for nuclear installations. The licensing system adopted by NNSA for supervision of civilian nuclear installations is in line with international practices.

The functions of the safety licenses which are granted by NNSA are to authorize the performance of activities related to safety; to specify requirements and conditions; to place time constrains on the licensee's activities.

Stages of the Licensing Process:

- Nuclear power plant licenses specify permitted activities and conditions for five major stages, i.e., sitting, construction, commissioning, operation, and decommissioning in accordance with the regulations.

- For site approval, the applicant at first submits the siting part of the project's Feasibility Study Report to NNSA. The applicant receives a "Review Report For Siting of the Nuclear Power Plant'' from NNSA. Meanwhile, NEPA reviews the Environmental Impact Report of the nuclear power plant. Positive comments from both NNSA and NEPA are required prior to the approval of the project by the State Planing Commission. Site approval is linked to a specific nuclear installation project. For additional units at the same site, a complementary review is performed. Site approval allows site preparation (pre-construction).

- A construction permit must be obtained from NNSA, before the utility can start the construction of the nuclear plant.

- Initial fuel loading is allowed after the utility obtains authorization to proceed from NNSA. The successive steps, such as first criticality, power raising and trial operation for one year must also be pre- approved by NNSA.

- An operating license must be granted, which allows commercial operation under specified conditions for the life of the installation. For instance, 30 years for Qinshan NPP and 40 years for Daya Bay NPP.

- An authorization from NNSA must be obtained for the utility to start decommissioning of a nuclear installation at the end of its lifetime.

Other licenses issued by NNSA include licenses for operators and senior operators of the nuclear power plant, licenses for nuclear material control and licenses for the entities engaged in design, manufacture and installation of nuclear pressure retaining components.

### 5.2. Main National Laws and Regulations

NNSA is responsible for drafting and enacting the national nuclear safety regulations. These documents are based on international experience and IAEA Nuclear Safety Standards, but also reflect specific conditions in China. They are divided into two main categories; namely, administrative regulations and technical standards.

In the category of administrative regulations, four types of documents can be identified:

- Nuclear safety surveillance and control regulations. These are legal documents issued by the State Council. The documents establish the objectives and the scope of surveillance, authority of the regulatory body, and the principles and procedures of regulatory activities.

- Implementation rules. These are legal documents issued by NNSA. The documents establish details concerning implementation in accordance with applicable nuclear safety surveillance and control regulations.

- Nuclear Safety codes. These are legal documents issued by NNSA. The documents determine safety goals and basic safety requirements.

- Nuclear safety guides. These are non-mandatory documents issued by NNSA. These documents provide specific and detailed guidance on acceptable technical and administrative approaches which satisfy the safety requirements specified in the legal documents.

The category of technical standards includes industrial standards and technical criteria. They belong to the national technical standard system. NNSA reviews the standards related to nuclear safety.

The national nuclear safety legislation documents are:

- Atomic Energy Act (under approval).

- Regulations on the Safety Supervision and Control for Civilian Nuclear Installations (Oct. 29, 1986, State Council).

- Regulations on Nuclear Materials Control (June 15, 1987, State Council).

- Implementation of Rules and Regulations on Nuclear Materials Control (September 25, 1990, NNSA).

- Safety Supervision of nuclear power plants (April 14, 1988, NNSA).

- Code on the Safety of nuclear power plant Siting (July 27, 1991, NNSA).

- Code on the Safety of nuclear power plant Design (July 27,1991, NNSA).

- Code on the Safety of nuclear power plant Quality Assurance (July 27, 1991, NNSA).

- Code on the Safety of nuclear power plant Operation (July 27, 1991, NNSA).

- Code on the Safety for Managing Radioactive Waste from nuclear power plants (August 29,1991, NNSA).

- Code on the Safety Supervision and Control for Civilian Nuclear Pressure-Retaining Components (March 4, 1992, NNSA).

- Regulations on Nuclear Accident Emergency Control of nuclear power plants (Aug. 4, 1993, State Council).

- The Application and Issuing of Safety License for nuclear power plants (Dec. 31, 1993, State Council).

### 5.3. International, Multilateral and Bilateral Agreements

The National Nuclear Safety Administration (NNSA) submits its budget plan to State Science and Technology Commission (SSTC) and gets the funding to cover staff salary and all of activities, although NNSA's funding mainly comes from three budgetary sources.

Technical activities, including the full budget for Beijing Nuclear Safety Centre (BNSC), has to be approved by State Planning Commission and then Ministry of Finance. The Bureau of Administration of State Council provides financial support for administrative budget of NNSA including BNSC.

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 22 June 1990 |
| • Safeguard agreement concluded on the basis of a voluntary offer INFCIRC/369 | Entry into force: | 18 September 1989 |
| • Improved procedures for designation of safeguards inspectors | Prefers the present system until more experience is gained. | |
| • RCA | Entry into force: | 12 June 1987 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 9 March 1992 |
| • Agreement on privileges and immunities | Entry into force: | 16 July 1984 |
| • Convention on physical protection of nuclear material | Entry into force: | 9 February 1989 |
| • Convention on early notification of a nuclear accident | Entry into force: | 11 October 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 11 October 1987 |
| • Conventions on civil liability for nuclear damage and joint protocol | Non-Party | |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines | Not adopted, however see 3 principles of nuclear export policy, quoted on pp. 9 and 10 of PRC statement to 36th GC, in Att. 1. | |
| • Acceptance of NUSS Codes | All codes (except the one on Governmental Organizations) have been formally introduced into the regulatory system. Regulations were amended in 1991, based on the Revised NUSS Codes. | |

*BILATERAL AGREEMENTS*

There are bilateral agreements for co-operation in the peaceful use of nuclear energy between the Chinese government and 14 countries. In addition, there are the following bilateral nuclear safety co-operation agreements between NNSA and:

- USNRC;
- DISN of France;
- BMU of Germany;
- CSN of Spain;
- ENEA/DISR of Italy;
- DNSRP of Pakistan;
- MITI, STA of Japan;
- MOSI of Korea.

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITIES*

| | |
|---|---|
| China Atomic Energy Authority (CAEA)<br>Sanlihe Nansanxiang 1<br>P.O. Box 2102<br>Beijing 100822 | <br><br>Tel.: +861-68716507<br>Fax: +861-68513717 |
| China National Nuclear Corporation (CNNC)<br>Office of IAEA Affairs<br>Sanlihe Nansanxiang 1<br>P.O. Box 2102<br>Beijing 100822 | <br><br>Tel.: +861-8512211/3296<br>Fax: +861-68513717<br>Telex: 222315 FACNC CN |

National Nuclear Safety Administration (NNSA)

State Science and Technology Commission

# CZECH REPUBLIC

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## CZECH REPUBLIC

# 1. GENERAL INFORMATION

## 1.1. General Overview

The Czech Republic (CR) is a relatively small country of 78,864 square kilometres with 10.3 million inhabitants (Table 1). It is situated in the centre of Europe and has a mild climate. The country has no gas or oil and very limited hydro resources.

The development of the Czech economy is characterised particularly by the process of the economic reform and of transformation of all spheres of economy, since the year 1989. In the year 1990 the basic strategy of the economic reform has been formulated, still at the Federal level, consisting of liberalisation of the internal market, expeditious opening of the economy to the external environment, as wide as possible application of market principles in the economics sphere and preservation of stable currency.

In the year 1991 the main processes of the reform were started, such as liberalisation of prices, demonopolisation of the foreign trade, introduction of the internal convertibility of the Czech crown and the beginning of the small privatisation. The years 1992 and 1993 were characterised by the privatisation process moving forward. Small privatisation was completed and the big privatisation of the basic branches of economy was started.

Highly significant from the point of view of the reform progress and economy development was the year 1993 when on January 1st, Czechoslovakia (CSFR) was partitioned and at the same time the taxation system fully restructured. After a temporary drop of the economic development connected with the necessary adaptation to the new conditions brought on by the partition of Czechoslovakia, the economic growth was restored in the year 1994, accompanied with positive development of most macroeconomics indicators. In the same year the exigencies of primary energy sources (PES) consumption needed for Gross Domestic Product (GDP) dropped significantly for the first time and continued dropping in the year 1995 too.

TABLE 1. POPULATION INFORMATION

| | 1990 | 1991 | 1992 | 1993 | 1994 | Growth rate (%) 1990 to 1995 |
|---|---|---|---|---|---|---|
| Population (millions) | 10.3 | 10.3 | 10.3 | 10.3 | 10.3 | 0.2 |
| Population density (inhabitants/km$^2$) | 130.5 | 130.8 | 130.6 | 130.6 | 130.9 | |
| Predicted population growth rate (%) 1994 to 2000 | -0.4 | | | | | |
| Area (1000 km$^2$) | 78.9 | | | | | |
| Urban population in 1994 as percent of total | 65.0 | | | | | |

## 1.2. Economic Indicators

Development of all the energy indicators responded to the drop of economic activities with a certain delay; in particular due to a significant share of constant energy consumption (heating of buildings, hot water preparation, lighting), see Tables 2 and 3. In the whole time period concerned the dynamics of drop of the final energy consumption did not reach the level of the drop of the economy performance. Further on the mentioned indicators were affected by the restructuring processes connected with privatisation and with changed or limited extent of certain processing industries and with other pressures resulting from the opening of economy and from its adaptation to the western markets.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| GDP (Kc billion) fixed prices 1984 | 503.7 | 432.1 | 403.6 | 400.7 | 411.2 | 431.1 |
| Index (%): year-on-year rate | 98.78 | 85.79 | 92.92 | 99.68 | 102.62 | 104.80 |
| basic rate | 100.00 | 85.79 | 80.13 | 79.55 | 81.64 | 85.60 |

| GDP by sector (1995): | |
|---|---|
| Agriculture, forestry | 5.2% |
| Industry | 34.8% |
| Construction | 6.2% |
| Services | 53.8% |

TABLE 3. ENERGY INTENSITY OF THE CZECH REPUBLIC ECONOMY

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| EN/GDP (MJ/Kc) | 4.110 | 4.395 | 4.420 | 4.362 | 4.103 | 3.906 |
| Index (%): year-on-year rate | 97.42 | 106.93 | 100.57 | 98.69 | 94.06 | 98.96 |
| basic rate | 100.00 | 106.93 | 107.54 | 106.13 | 99.83 | 94.76 |
| EL/GDP (kWh/Kc) | 0.123 | 0.134 | 0.139 | 0.142 | 0.132 | 0.142 |
| Index (%): year-on-year rate | 100.42 | 108.94 | 103.73 | 102.16 | 92.5 | 100.30 |
| basic rate | 100.00 | 108.94 | 113.01 | 115.45 | 107.3 | 113.00 |

Note: EN = Energy intensity
E = El. power intensity of GDP (gross electricity consumption per GDP)

## 1.3. Energy Situation

Coal represents the most important local energy source in the Czech Republic because nearly 60% of primary energy sources are assured by coal. Regardless the continuing trend of lowering that rate, coal will be of significant importance in future too; considering the present forecast it will be about 48% by the year 2000 and 40% by the year 2005. Table 4 shows the estimated Czech energy resources.

Significant changes are taking place in the coal mining industry, mainly the restructuring process connected at present with the final stage of the privatisation process. Such changes were initiated by the government of the CR-Decree, stipulating the programme of the restructuring processes and of the declination of non-effective mining localities or of parts thereof.

In 1994 the share of solid fuels was 58.6 %, of liquid fuel (mainly crude oil) 18,1 %, of natural gas 14.5 %, of hydroenergy 0.3 %, of nuclear energy 8.5 % of total domestic primary energy sources consumed in the Czech Republic. Table 5 gives the basic energy statistics. The steam power plants provide 74.9 % of total electricity generation, nuclear power station Dukovany 22.1% and hydro plants only 3.0%.

In 1994, per capita energy consumption in the Czech Republic was 3.86 toe.

TABLE 4. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro | Total |
| Total amount in place | 3,320 | | | 33,300 | | 36,620 |

(1) *This total represents essentially recoverable reserves.*

TABLE 5. ENERGY STATISTICS

Exajoule

| | 1990 | 1991 | 1992 | 1993 | 1994 | Average annual growth rate (%) 1990 to 1994 |
|---|---|---|---|---|---|---|
| Energy consumption | | | | | | |
| - Total[1] | 2.07 | 1.93 | 1.78 | 1.8 | 1.67 | -4.8 |
| - Solids[2] | 1.35 | 1.25 | 1.10 | 1.1 | 0.98 | -6.8 |
| - Liquids | 0.36 | 0.30 | 0.30 | 0.3 | 0.30 | -4.2 |
| - Gases | 0.22 | 0.25 | 0.25 | 0.2 | 0.24 | 2.3 |
| - Primary electricity[3] | 0.14 | 0.13 | 0.13 | 0.1 | 0.15 | 1.8 |
| Energy production | | | | | | |
| - Total | 1.72 | 1.61 | 1.50 | 1.48 | 1.38 | -4.9 |
| - Solids | 1.57 | 1.47 | 1.35 | 1.32 | 1.22 | -5.1 |
| - Liquids | 0.002 | 0.003 | 0.003 | 0.005 | 0.005 | 37.5 |
| - Gases | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0 |
| - Primary electricity[3]) | 0.14 | 0.13 | 0.14 | 0.14 | 0.15 | |
| Net import (import - export) | | | | | | |
| - Total | 0.28 | 0.31 | 0.27 | 0.26 | 0.30 | |
| - Solids | -0.26 | -0.23 | -0.26 | -0.26 | -0.25 | |
| - Liquids | 0.36 | 0.29 | 0.30 | 0.29 | 0.31 | |
| - Gases | 0.18 | 0.26 | 0.23 | 0.24 | 0.24 | |

[1] *Energy consumption = Primary energy consumption − Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*

## 1.4. Energy Policy

The Czech energy policy was approved by the government in February 1992. Since then, substantial changes of a number of conditions have appeared: the former CSFR has been divided, the association of the Czech Republic with the European Union and the convertibility of the Czech currency was reached. In the energy sector, a major part of the energy industry companies were privatised, prices of part of the energy commodities were deregulated, the decision to complete the construction of the Temelín nuclear power plant was confirmed, the oil pipeline Ingolstadt completed, etc. The realisation of these changes, including the changes in the structure of energy sources demand, has activated the necessity of updating the energy policy.

The updated energy policy is based on the Programme Declaration of the government of the Czech Republic issued in July 1992, and on other documents related to the energy sector approved or negotiated by the government It is also based on the first rate on the State policy in the field of the environment in the Czech Republic (document approved by government of the Czech Republic on August 23rd, 1995), on the European Agreement founding association of the Czech Republic with the European Union (joined by the Czech Republic on February 1st, 1995), on European Energy Charter (signed in Brussels on February 3rd, 1993), on Agreement related to that Charter (recommended by the Parliament for ratification by the President of the Czech Republic), furthermore on significant international activities in the field of the environment shared by the Czech Republic - understood are results of the Conference of the United Nations dealing with the environment and development (Rio de Janeiro, 1992), Conferences on the level of ministers „The Environment for Europe“ (Luzern, 1993), „The Environment and Health for Europe“ (Helsinki, 1994) and „Tenable Production and Consumption“ (Oslo, 1995).

In the Czech energy policy, the requirements have been specified to determine the conditions of energy procurement, production and consumption in the next 10 to 15 years. The energy policy as a part of the economy policy is market-oriented. Considering the market function, the entrepreneurial subjects are playing the main role in this sphere, bearing the risks connected with investments in the energy sector.

Specification of conditions set for utilisation of different kinds of energy will be important for the future decision-making of the population and of the entrepreneurial subjects in their choice of the form of energy supplies.

The government has therefore specified in its energy sector policy the basic rules of shared responsibilities of the enterprises and of the governmental executive bodies in the sphere of energy sources supply, intending to minimise the direct interventions of state. For solving that issue, the government has accentuated necessity of reaching social and economic consensus.

***Long-term objectives of the energy sector policy***

The strategic position of the energy sources in the economic performance, their share in the society development and mainly in the general competitiveness are fundamental points of view for the choice of long-term aims of the Czech Republic energy policy.

In the energy policy the following main long-term socially-political and economic aims have been specified:

a) Reserve a reliable supply of energy to the economy at acceptable prices: aims directed to assure a balanced demand/supply on energy markets, a higher effectiveness of energy sector economy, competitiveness and reliability of supply are to be harmonised with the long-term requirements of the environment protection, the quality of which is highly affected by energy industries and energy consumers.

b) To reduce adverse effects of energy production, distribution and consumption on the environment to the level usual in the states of the European Union: issues of the environment and of energy economy cannot be assessed separately. Importance of the environment protection in the energy sector policy gets increased. The energy sector policy respects the requirements of an economic and rational utilisation of natural resources. Requirements of the environment protection will prefer economic end balanced solutions including a complex of measures applied in the countries of the European Union.

c) To prepare the energy economy of the Czech Republic for joining the European Union in every legislative and technical aspect: the energy policy of the Czech Republic of the next period will be increasingly influenced by integration processes taking place in Europe, especially by tighter growing co-operation with the European Union countries. The state bodies responsible for the sphere of energy sector legislation and energy policy will co-operate with the appertaining international institutions in preparing the legislative, technical and organisational prerequisites of joining the European Union. The following essential steps are concerned:

    i) implementation of the European Agreement on association of the Czech Republic with the European Union and on harmonisation of the legislation of the European Union with the legislation of the Czech Republic;

    ii) incorporation of Agreement to the European Energy Charter including the Protocols in the legislation of the Czech Republic;

    iii) preparation of membership in the International Energy Agency in connection with the membership of the Czech Republic in OECD.

***Short-term and medium-term objectives***

Considering the existing level of effectiveness of energy economy in the economic system, the development of the ownership and organisation structure, the prevailing negative effect of energy sector on the environment and the problems connected with the gradual creation of legislative framework, it is necessary to determine the individual short-term aims and to assure the priorities thereof for realisation of the above mentioned long-term objectives.

**a) Balanced demand/supplies**

The temporary drop of economy performance and the herewith connected reduced demand of energy supplies afforded time to the Czech Republic to increase the performance of energy industries. In the present period of economic growth the structure of demand of energy sector services is constantly changing under influence of the reform steps. The structure of demand is more and more determined by private consumers; the traditional users - mass industrial consumers - will play a reduced role. In the period of transition when the low prices of energy sources (including the lower rate of taxation of most fuels and energy sources) do not so far bring a higher effectiveness in the industrial sector consumption nor in the field of domestic use, and in conditions of the still prevailing out-of-date manufacturing processes structure, the priority task of the energy sector will be assurance of balanced demand and supplies of energy sources.

**b) Increased energy efficiency**

Improvement of energy efficiency is an important priority of economy. It supports also the environment protection and helps to reduce dependence on energy imports.

High energy exigencies of the Czech Republic economy, inherited from the past years (roughly double if compared to those of most European Union countries) are one of the barriers preventing attainment of higher competitiveness of the Czech industries. Neither the existing price level of energy sources nor the economic interests of the entrepreneur do stimulate sufficiently an energy-saving behaviour in consumption.

Therefore, in addition to the generally valid prerequisite, i.e. creation of conditions needed for the optimum function of energy markets, priority is given to the governmental support of energy-saving programmes, including the legislation amendments and introduction of a system of indirect tools stimulating rational management in the sphere of energy sources.

From the macroeconomics point of view, important is the incidence of the price development in the sphere of energy on the balance of trade and balance of payments of the Czech Republic. Practically complete supplies of crude oil and of natural gas are imported and any rise of the price of imports (what can be expected in the coming years) represents a loss of real income of the economy. Therefore it is in the interest of a dynamic development of the economy to initiate savings of so important energy sources. Due to that fact it will be necessary to support - in addition to the tools of the price and taxation policy - investments in the energy-saving technological processes (be it imports of complete units or R/D).

A similar problem exists at the microeconomic level, where in the Czech Republic industries the energy cost represents a small share of the total production cost and does not motivate the manufacturers to work economically. In addition to the expected rise of labour cost and to the necessary inclusion of ecology investments in the cost of production, the so far existing high energy exigencies of the Czech manufactures will be one of the decisive factors determining the competitiveness of individual industries as well as of the individual groups of products. Also from this point of view it is necessary to emphasise the preference of energy savings as one of the objectives of the energy policy.

c) **Safety of supply - diversification - openness of assurance of supplies**

A reliable covering of demand for energy sources is to be assured physically and economically from: inland sources obtained at acceptable economic conditions and accessible, diversified, stable foreign energy sources of high safety of supply.

The state policy in the sphere of economy and of energy is not a policy of self-dependence. In order to increase the safety level of supplies, a higher and versatile participation in international trade in energy sources is needed.

In the transition period characterised by gradual widening of linkages with the countries of European Union it is necessary to reach conditions similar to the commercial/political standards of countries embraced in that process. That concerns also the principle of reliability and responsibility for the safety of supplies.

d) **Lowering of adverse effects of energy production, distribution and consumption on the environment to the level usual in the countries of the European Union.**

For assuring that aim it is necessary to get it in harmony with competitiveness and with safety of energy supplies. To that purpose it will be necessary to apply a number of supporting measures. In addition to the introduction of emission limits and fiscal motivation it will be necessary to harmonise with the European Union practice the policy of standards valid for products and technology from the point of view of the specific energy consumption. In its choice of priorities and of tools for harmonising those aims, the government will apply a process of gradual successive steps corresponding to the approach of the European Union.

The main task in the energy sector is to use profitable actions motivated by requirements of the environment protection; important selection criteria of individual tools are especially the effectiveness of the measures to be realised and the shared responsibility of all economic subjects for the environment conditions. In addition to the supporting programmes, the government will stimulate projects in the energy market which include voluntary agreements about the realisation of programmes for improvement of the environmental conditions.

***Basic tools of the energy policy***

In order to meet the long-term and short-term objectives, the energy policy delimits the method and tools to reach them in the market environment under the condition of keeping balanced conditions on the energy markets. The basic prerequisite for using the tools available to that policy is a clear delimitation of responsibilities, especially in the area of safe, sure and quality supplies as well as of consumer protection. It is necessary to prepare a legislation framework taking into consideration specifics of the energy industries while respecting the general legislation for this purpose.

Enforcement of the aims of the energy sector policy in the next time period will be based on the following principles:

i) free function of the market is a pre-condition of the policy realisation;

ii) state interventions will be gradually reduced mainly to the assurance of equal conditions of access on the market and maintenance of effective competitiveness;

iii) by using the legislation and economic tools the state will create conditions for assurance of safe supplies and for the environment protection;

iv) state will create conditions for strengthening shared responsibilities of enterprise subjects for assurance of stable supplies of energy and for the environment protection.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Approximately 80 % of the electricity production is concentrated in ČEZ, a.s., the joint - stock company, (nine coal power plants, Nuclear Power Plant Dukovany, two pumped-storage hydro power plants, large hydro power plants) that also owns the power transmission system (400 kV and 220 kV lines) together with distribution control system facilities for the entire electricity network within the Czech Republic (dispatching). The remaining part of the electrical power domestic production is provided by independent producers (Elektrárna Opatovice a.s., Elektrárna Kolín a.s., Elektrárna Mělník III owned by Pražská teplárenská a.s.), by power plants in ownership of large industrial corporations and by heat energy companies.

The electricity distribution is provided by eight electrical power distribution companies (Pražská energetika, a.s., Středočeská energetika, a.s., Jihočeská energetika, a.s., Západočeská energetika, a.s., Severočeská energetika, a.s., Východočeská energetika, a.s., Jihomoravská energetika, a.s., Severomoravská energetika, a.s.,). The transmission system is also accessed by some minor electricity producers whom, however, do not supply electricity directly to the ČEZ grid.

According to the Act No. 222/94 Coll. an independent Central Energy Dispatching (CED) has been set up, apart from the ČEZ, a.s. framework. All subjects participating at management of the CED hold the permit authorising to do business in the electrical power sector.

### 2.2. Decision Making Process

In the Czech Republic the legislation and competence for the technical regulation (the Ministry of Industry and Trade) and price regulation (the Ministry of Finance) are separated.

Practically, all major energy companies have been privatised, under the framework of either the first or the second "voucher privatisation wave". In most of the privatised energy companies, their major share is still held by the National Property Fund. The next privatisation steps (sale of shares held by the National Property Fund) will be differentiated in two basic sections:

i) companies that will remain state enterprises, or, in case of which the state will hold the major share, for at least 5 years;

ii) company shares which will be sold to a determined strategic partner or which are in the possession of the National Property Fund will be sold.

In a long-term perspective, the state influence in the energy sector is anticipated, only, in a form of indirect measures (legislation, pricing, tax) and regulating natural monopolies in particular industries.

### 2.3. Main Indicators

Table 6 shows the electricity production and installed capacity since 1990 and Table 7 the energy related ratios.

## 3. NUCLEAR POWER INDUSTRY

### 3.1. Historical development

The nuclear power era in the former CSFR has started off in the 50s because of the lack of oil resources. A heavy water gas-cooled reactor was built and operated in Jaslovské Bohunice (now

Slovakia). The further development of nuclear power in the Czech Republic was determined by the influence of former Soviet Union in Eastern Europe.

TABLE 6. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1990 | 1991 | 1992 | 1993 | 1994 | Average annual growth rate (%) 1990 to 1994 |
|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | |
| - Total[1] | 62.56 | 60.65 | 59.29 | 58.88 | 58.70 | -1.5 |
| - Thermal | 48.52 | 47.20 | 45.40 | 44.66 | 43.95 | -2.4 |
| - Hydro | 1.45 | 1.32 | 1.64 | 1.59 | 1.77 | 5.5 |
| - Nuclear | 12.59 | 12.13 | 12.25 | 12.63 | 12.98 | 0.8 |
| Capacity of electrical plants (GW(e)) | | | | | | |
| - Total | 15.28 | 14.99 | 14.5 | 14.2 | 13.85 | -2.3 |
| - Thermal | 11.94 | 11.63 | 11.4 | 11.2 | 10.65 | -2.7 |
| - Hydro | 1.38 | 1.36 | 1.4 | 1.4 | 1.40 | 0.4 |
| - Nuclear | 1.76 | 1,76 | 1.6 | 1.6 | 1.76 | 0 |

[1] *Electricity losses are not deducted.*

TABLE 7. ENERGY RELATED RATIOS

| | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 201 | 187 | 173 | 170 | 162 |
| Electricity per capita (kW·h/capita) | 6,118 | 5,623 | 5,453 | 5,497 | 5,643 |
| Electricity production/Energy production (%) | 32 | 33 | 35 | 36 | 38 |
| Nuclear/Total electricity (%) | 20.1 | 20.0 | 20.7 | 21.5 | 22.1 |
| Ratio of external dependency (%)[1] | 14 | 16 | 15 | 15 | 18 |
| Load factor of electricity plants | | | | | |
| - Total (%) | 48 | 47 | 48 | 48 | 49 |
| - Thermal | 47 | 47 | 47 | 47 | 48 |
| - Hydro | 12 | 11 | 14 | 13 | 15 |
| - Nuclear | 84 | 81 | 82 | 84 | 86 |

[1] *Net import / Total energy consumption.*

In the 70s, VVERs 440 of Soviet design were built and the Czech industry was involved in the production of NSSS components and partly in primary circuit - e.g. vessel, control rod drive mechanism. The Czech industry became the supplier of these parts in other Eastern European countries (e.g. 20 reactor vessels were made by Skoda). In the 80s, construction of the VVERs 1000 started. In 1993, a resolution was adopted to change the reactor control system (I&C) to meet the state-of-art criteria of unit control.

### 3.2. Current Policy Issue

Both Czech nuclear power plants, i.e. Temelín and Dukovany, are built, operated and owned by the ČEZ, a.s.. The nuclear research reactors at Řež are operated and owned by the Nuclear Research Institute (ÚJV-Řež, a.s.). The university nuclear research reactor, in Prague, is operated and owned by ČVUT, a state technical university. The training nuclear reactor of Škoda - Jaderné strojírenství, s.r.o., in the town of Plzeň, is currently being decommissioned and Škoda Company has transferred the nuclear fuel from this reactor to ÚJV-Řež, a.s.

Investment projects of ČEZ, a.s. are based on its business plan and they are financed from ČEZ, a.s., own resources. The only state budget obligation will be represented by the Czech government guarantee provided to US Eximbank, regarding the loan from the Citibank, for Westinghouse supplies to Temelín nuclear power plant.

Supplies (purchasing of equipment and services) for nuclear power plants are procured by the ČEZ, a.s.

The uranium for nuclear fuel of Dukovany nuclear power plant is supplied by a domestic producer, with an exception of one-year consumption of the Russian uranium for nuclear fuel, purchased a few years ago.

The decision whether spent fuel is to be reprocessed is, in principle, left to its owner. At present, the ČEZ, a.s. does not consider the reprocessing as economical. Due to the fact that the preparation of a final repository of radioactive waste is the responsibility of the state, the procedure of both the ČEZ, a.s. and the state, regarding the reprocessing issue must be co-ordinated in the long-term. This co-ordination should be ensured by the prepared Atomic Act, using rather both organisational and economic instruments, as opposed to administrative ones.

Within the Dukovany nuclear power plant complex, a shallow land repository of radioactive waste is operated, designed to accommodate all future low and intermediate radioactive wastes from both nuclear power plants, and also a cask-type (CASTOR) interim storage of spent fuel.

Nuclear safety and radiation protection in the Czech Republic are supervised by the National Regulatory Authority - the State Office for Nuclear Safety (SÚBJ). It was established on 1 January 1993 as a follow-up organisation of the former Czechoslovak Atomic Energy Commission. The responsibilities of the SÚBJ concerning nuclear safety, the licensing of nuclear facilities, including fuel and waste treatment facilities, and nuclear safeguards are given by the Act No. 28/1984 Coll.

According to the Act No 28/1984 Coll the licensee is obliged to have on-site emergency plan approved by the SÚBJ and the off-site emergency plan approved by appropriate district office before nuclear installation starts. Emergency planning structure has two levels - local and national.

An environmental impact assessment of a nuclear installation project, as well as, of another civil construction including other significant sources of ionising radiation, is determined in, especially, three Laws of the Czech legislation:

- The Act No. 50/1976 Coll. (the Civil Construction Act) determines proceedings of the Civil Construction Office that is an administrative body making decisions in regard to the siting, construction and operation. Licence concerning nuclear installation needs approval of the SÚBJ.

- The Act No. 244/1992 Coll. (Environmental Impact Assessment, EIA) determines that, prior to an administrative decision, the environmental control bodies, including the Ministry for the Environment, issue an official attitude to the environmental impact assessment (even if the attitude is not binding for the final decision of an administrative body). Within the EIA process, a public discussion is required of environmental impact documentation. If a public initiative forms during this process, it becomes a participant of the proceedings according, also, to the above mentioned Act.

- The Act No. 28/1984 Coll., concerning the state supervision on the nuclear safety, together with associated regulations, determine, apart from others, proceedings of the SÚBJ when issuing the approval according to the Civil Construction Act. Prior to an issue of the approval, the SÚBJ considers safety analysis including a proof that the construction impact on the population and environment will not exceed limits determined by this Office. The SÚBJ proceedings are not open to the public.

The above stated activities are subject to a strict regulation, on non-proliferation of nuclear weapons and business aspects pertaining to uranium and fuel.

### 3.3. Status and Trends of Nuclear Power

In the Czech Republic, there are four units operating at Dukovany nuclear power plant. The units are Russian VVER 440/V213 type PWRs with the total installed power of 1760 MW(e). The production of the plant represents currently over 22% of the total electricity production in the Czech Republic.

The construction of Temelín nuclear power plant (two units with VVER 1000 MW(e) each) is in the stage of completion.

The ČEZ, a.s. finances directly the completion of Temelín nuclear power station, the planned upgrading of Dukovany station and the construction of a spent fuel storage facility. The ČEZ, a.s. is using its own resources and credits provided by financiers, without, however, any financial participation of the state. As soon as Temelín nuclear power station commences operation, the proportion of nuclear electricity produced in the Czech Republic will approximately double and it will exceed 40 %. The construction of another nuclear power plant is, however, very unlikely in the forthcoming years.

TABLE 8. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| DUKOVANY-1 | WWER | 412 | EDU | Operational | SKODA |
| DUKOVANY-2 | WWER | 412 | EDU | Operational | SKODA |
| DUKOVANY-3 | WWER | 412 | EDU | Operational | SKODA |
| DUKOVANY-4 | WWER | 412 | EDU | Operational | SKODA |
| TEMELIN-1 | WWER | 912 | ETE | Under Construction | SKODA |
| TEMELIN-2 | WWER | 912 | ETE | Under Construction | SKODA |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| DUKOVANY-1 | 01-Jul.-78 | 12-Feb.-85 | 24-Feb.-85 | 03-Nov.-85 | |
| DUKOVANY-2 | 01-Jul.-78 | 23-Jan-86 | 30-Jan-86 | 21-Sept.-86 | |
| DUKOVANY-3 | 01-Jul.-78 | 28-Oct-86 | 14-Nov.-86 | 20-Jul.-87 | |
| DUKOVANY-4 | 01-Jul.-78 | 01-Jun.-87 | 11-Jun.-87 | 19-Jan-88 | |
| TEMELIN-1 | 01-Jan-84 | 01-March-99 | 01-July-99 | 01-Apr.-00 | |
| TEMELIN-2 | 01-Jan-85 | 01-May.-00 | 01-Aug.-00 | 01-Apr.-01 | |

Source: IAEA Power Reactor Information System, year end 1996

According to the governmental proposal of the Atomic Act the ČEZ, a.s. should, under the state control, prepare both financial and technical means for decommissioning of its nuclear facilities and it should provide payments to the Czech National Bank (the State Bank of the Czech Republic) to accumulate means necessary for a preparation and construction of a spent fuel repository that should be put into operation, approximately, in about the year 2030.

At present, costs of the future decommissioning of an nuclear power plant and disposal (deposit) of spent fuel are not directly reflected in prices of electrical energy and the nuclear power plant utility creates provisions based on its consideration, from the net profit to its reserve fund, under the state control.

### 3.4. Organisational Chart(s)

The National Property Fund (NPF) owns 67.5 % of shares of the ČEZ, a.s., privatised in the year 1992. The fund delegated the shareholding rights to the minister of industry and trade. Remaining ČEZ shares that are traded on the Stock Exchange are owned, at present, by both legal (28 %) and natural (4.5 %) persons. An early reduction of the state share is not considered.

In the ÚJV-Řež, a.s. (the Nuclear Research Institute), privatised in the year 1992, 3 % of shares are owned by the municipality where the institute resides, 11 % are owned by Škoda, a.s., 30 % are owned by the ČEZ, a.s., and 56 % are owned by the NPF. The share held by the NPF should be reduced, soon, or sold off entirely, with an exception of the, so called, golden share, ensuring the orientation of the institute to nuclear research.

The Škoda - Jaderné strojírenství, s.r.o. is 100 % owned by Škoda, a.s., where a group of private owners has held a major share, since 1992.

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of NPPs

Supplies (purchasing of equipment and services) for nuclear power plants are procured by the ČEZ, a.s. Also, ÚJV Řež, a.s. and ČVUT (the State Technical University) purchase fuel for their research reactors.

The uranium for nuclear fuel of Dukovany nuclear power plant is supplied by a domestic producer, with an exception of one-year consumption of the Russian uranium for nuclear fuel, purchased a few years ago. Both conversion and enrichment services, together with fuel fabrication, for Dukovany nuclear power plant are purchased in Russia. As for Temelín nuclear power plant, the fuel for the initial loading is under production and contracts in regard of a few reloadings are signed. The uranium for initial fuel load has been supplied from Russia, the conversion and enrichment have been performed in Russia and in the United Kingdom, the fabrication is being performed in the USA. The Czech uranium is ensured to be converted by French and Canadian suppliers and enriched and fabricated in the USA for Temelín nuclear power plant reloading,

### 4.2. Operation of NPPs

The ČEZ, a.s., owns and operates Dukovany nuclear power plant and ensures operator training. Maintenance service are supplied both by ČEZ itself and by many other companies from which the most important are listed in Annex 1.

The ČEZ, a.s., builds Temelín nuclear power plant and the main contractors are: Škoda Praha, a.s., Škoda Jaderné strojírenství, s.r.o., EZ Praha, a.s., Královopolská strojírna, a.s., Vodní stavby Bohemia, a.s., WEC ETE, Modranská potrubní, a.s., Regula Praha, a.s.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management Service Supply

The uranium for Dukovany nuclear power plant's nuclear fuel is supplied by a domestic producer, with the exception of one-year consumption of the Russian uranium for nuclear fuel, purchased a few years ago. Both conversion and enrichment services, together with fuel fabrication, for Dukovany nuclear power plant are purchased in Russia. For Temelín nuclear power plant, the fuel for the initial loading is under production and contracts for a few reloadings are signed. The uranium for initial fuel load has been supplied from Russia, the conversion and enrichment have been performed in Russia and in United Kingdom, the fabrication is being performed in the USA. For Temelín nuclear power plant reloading, the Czech uranium is ensured, to be converted by French and Canadian suppliers, and enriched and fabricated in the USA. The fuel for the Czech research reactors, including uranium, comes from the Russian Federation.

At present, the current yearly production of uranium in the Czech Republic is 600 metric tonnes, recalculated to metal. The uranium is processed into a form of a chemical concentrate (yellow cake). There are no other uranium processing plants in the Czech Republic.

The storage of spent fuel, in this interim time period, is ensured by its originators, i.e. ČEZ, a.s. as regards of spent fuel from nuclear power plant, and ÚJV-Řež, a.s. as regard of spent fuel from research reactors. The preparation of the final solution of spent fuel and radioactive waste elimination commenced in 1993. A preliminary timetable expects approval of the site near 2015, a start of the repository construction in, approximately, the year 2020 and an operation start-up in the year 2035.

Within the Dukovany nuclear power plant complex, a shallow land repository of radioactive waste is operated, designed to accommodate all future low and intermediate radioactive wastes from both nuclear power plants, and also a cask-type (CASTOR) interim storage of spent fuel.

The spent fuel storage capacity in reactor pools is sufficient for 6 years of operation of the each nuclear power plant unit. In Dukovany nuclear power plant, a spent fuel storage with capacity of 600 tonnes of heavy metal was introduced into operation, in 1995.

Currently, a construction of another interim storage is being prepared, with a projected operation start-up in 2005, for spent fuel from both Dukovany nuclear power plant and Temelín nuclear power plant.

The issue of reprocessing spent fuel remains open. A decision to reprocess or directly dispose spent fuel (after its conditioning) as a waste is suspended for the time of its storing in interim storage, envisaged for the time of 40 to 50 years.

In ÚJV-Řež, a.s. facilities, a new spent fuel interim storage was put into operation in 1996, with the sufficient capacity for the entire life cycle of operated research reactors.

### 4.4. Research and Development Activities

The responsibility for the research state policy in the area of nuclear energy is divided between the Ministry of Industry and Trade of the Czech Republic and the State Office for Nuclear Safety. The following organisations are active in the area of nuclear energy research and development: ÚJV-Řež, a.s., (Nuclear Research Institute), Nuclear Fuel Institute (former daughter company of DIAMO State Enterprise), and EGÚ Praha; marginally, also, some departments of the Academy of Science and universities; some companies have a research capacity, catering for their needs.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

The Czech Republic is a member of a number of international nuclear organisations including the International Atomic Energy Agency, Nuclear Energy Agency (NEA) as well as other bilateral and multilateral organisations such as WANO.

It takes part in international research activities in NEA´s programmes namely in Halden Reactor Project, ISOE, INEX, IRS, programmes of CERN, Dubna etc.

The relatively large volume of the nuclear safety related technical support continued to come from the IAEA and European Union. The Czech Republic participates in IAEA programme of technical co-operation and PHARE Programme, especially Regional PHARE- Nuclear Safety programme.

Of particular importance for the activities of SÚJB, ČEZ,a.s. and some other Czech organizations in 1995 was the so-called IAEA Extra-budgetary Programme, aimed at enhancing nuclear safety of VVER reactors. Within the framework of this programme, with active participation of VVER-operating countries, were prepared lists of design shortcomings established in the individual types of VVER reactors, which these countries will remedy step-by-step in the future.

Czech Republic also receives a significant support from the USA government through US AID programme. In 1995 within this programme the American Science Application International Corporation in co-operation with the NRI-Řež and Dukovany nuclear power plant completed the so called Risk Monitor for Dukovany nuclear power plant - a plant's computer model based on the probabilistic approach. This advanced decision-making tool for the immediate assessment of nuclear power plant operational safety is first-of-the-kind application for VVER units.

Among other assistance programmes organized through the SÚJB is the Japanese assistance which in 1995 included several-weeks training of Czech experts in Japan in the area of nuclear safety and seismic resistance of nuclear power plants.

As for the technical and industrial co-operation there are many activities based on bilateral contracts that are not subject to any centralised review.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and Licensing process

The Czech Republic's National Regulatory Authority in nuclear safety and radiation protection field is the State Office for Nuclear Safety (SÚBJ). It was established as of 1 January 1993 by the Act No. 21/1992 Coll. as a follow-up organization of the former Czechoslovak Atomic Energy Commission. The legal framework of the SÚBJ is given by two basic acts - Act No. 287/1993 Coll. on the authority of the State Office for Nuclear Safety, amended and supplemented by Act No. 85/1995 Coll. and Act No. 28/1984. The other legal documents specifying powers of SÚBJ are listed in the paragraph Main National Laws and Regulations.

The powers of the SÚBJ concerning nuclear safety, the licensing of operating nuclear facilities, including fuel and waste treatment facilities, and nuclear safeguards are given by the Act No. 28/1984 Coll., especially by its articles No. 5, 6 and 13.

The SÚBJ is an independent central body of the state administration with its own budget. It is headed by the Chairman appointed by the Czech Government. The Office (chairman of the Office) reports to the government either directly or through the Minister of Trade and Industry. Regulatory decisions of the SÚBJ (except of fines) cannot be changed by any other body. Deputy Chairmen, Directors of Departments and Heads of Divisions are appointed by the Chairman of the SÚBJ.

The Chairman acts at the same time as the Nuclear Safety Inspector General. He appoints the SÚBJ nuclear safety and radiation protection inspectors. The inspectors' authorities, to perform their function, are stipulated in the provisions of Act No. 287/1993 Coll., on the State Office for Nuclear Safety authority, amended and supplemented by Act No. 85/1995 Coll. and Act No. 28/1984 Coll.

### 5.2. Main National Laws and Regulations

At present, the Czech legislation in the sphere of nuclear energy and ionising radiation consists of a number of generally binding regulations, especially the following:

- Act No 28/1984 Coll. on the State Supervision over the Nuclear Safety of the Nuclear Installations.
- Act No 287/1993 Coll. on the Authority of the State Office for Nuclear Safety, amended and supplemented by Act No 85/1995 Coll.
- Regulation of CSKAE No 28/1977 Coll. concerning Nuclear Material Accountancy and Control.

- Regulation of CSKAE No 67/1987 Coll. on Ensuring of Nuclear Safety in Radioactive Waste Management.

- Regulation of CSKAE No 100/1989 Coll. on Physical Protection of Nuclear Installations and Nuclear Materials.

- Regulation of CSKAE No 191/1989 Coll. on the Conditions for Verification of Professional Qualification of Nuclear Facilities Personnel.

- Regulation of CSKAE No 436/1990 Coll. on Quality Assurance of Selected Components with Regard to Nuclear Safety of Nuclear Facilities.

- Regulation of CSKAE No 2/1978 on Nuclear Safety Assurance during Designing, Permission or License Issuance and Construction of Nuclear Power Facilities.

- Regulation of CSKAE No 6/1989 on Nuclear Power Plants Safety Assurance during their Commissioning and Operation.

- The Decree No. 59/1972 Coll., of the Health Ministry of the Czech Socialist Republic, concerning protection of health from ionising radiation.

The new, currently prepared Law, concerning peaceful utilisation of nuclear energy and ionising radiation (Atomic Act), unifies and complements the legislation in the sphere of deposing radioactive wastes, loss liability and emergency readiness. This Law and the associated procedure regulations are based on internationally accepted principles of both nuclear safety and radiation protection of IAEA, ICRP and WHO and corresponds, to a sufficient extent, with the reciprocal legislation of European Union member countries, as stated in the European Union's expert study from the end of the year 1995.

**5.3. International, Multilateral and Bilateral Agreements**

The Czech Republic succeeded into the Agreement between the government of the Czechoslovak Socialist Republic and the International Atomic Energy Agency (IAEA) concerning a number of agreements indicated below.

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related safeguards agreement INFCIRC/173/Add.1 | Succeeded: A new Safeguards Agreement has been approved by the Czech Government on 5 June 1996 and would be submitted to the Board in September 1996 | 1 January 1993 |
| • Improved procedures for designation of safeguards inspectors | Accepted | |
| • Supplementary agreement of provision of technical assistance by the IAEA | A draft was submitted in November 1994: | No reply |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Succeeded: | 1 January 1993 |
| • EURATOM | Non-member | |
| • Treaty for prohibition of nuclear and other mass-destruction weapons located on sea and ocean bottoms and underground | | |
| • Agreement on privileges and immunities | Succeeded: | 27 September 1993 |
| • Convention on physical protection of nuclear material | Entry into force: | 1 January 1993 |
| • Convention on early notification of a nuclear accident | Entry into force: | 1 January 1993 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 1 January 1993 |
| • Vienna convention on civil liability for nuclear damage | Entry into force: | 24 June 1994 |
| • Joint protocol | Entry into force: | 24 June 1994 |
| • Convention on nuclear safety | Approved: | 18 September 1995 |
| • ZANGGER Committee | Former CSFR was member | |
| • Nuclear export guidelines | Adopted by former CSFR | |
| • Acceptance of NUSS codes | Accepted by former CSFR | |
| • Nuclear Suppliers Group | Member | |

*BILATERAL AGREEMENTS*

- The Agreement between the Government of the CSSR and the Government of Austria on the Issues of Common Interest Related to Nuclear Safety and Radiation Protection
- The Agreement between the Government of the CSFR and the Government of Germany on the Issues of Common Interest Related to Nuclear Safety and Radiation Protection
- The Agreement between the Government of the CSFR and the Government of Hungary on the Issues of Common Interest Related to Nuclear Safety and Radiation Protection
- The Agreement between the Government of the CSFR and the Government of USA on Co-operation in Peaceful Uses of Nuclear Energy

- The Agreement between the Government of the CR and the Government of the Russian Federation on Co-operation in the Nuclear Energy Field

- The Agreement between the Government of the CR and the Government of Canada on Co-operation in the Peaceful Uses of Nuclear Energy

- The Agreement between the Nuclear Installations Safety Directorate (France) and the State Office for Nuclear Safety (Czech Republic) for the Exchange of Information and Co-operation in the Regulation of Nuclear Safety

- The Agreement between the Between the United States Nuclear Regulatory Commission and the Czech Republic State Office for Nuclear Safety

**NOTE*** The Czech Republic is, since its origination, a member of NSG and ZANGGER Committee and fully accepted the requirements, including the Trigger List, and is bound to co-operate according to INFCIRC/209/Rev.1/Mod.3, INFCIRC/254/Rev.1/Part 1 and INFCIRC/254 /Rev. 1/Part 2, including the memorandum NSG/DUR. In the Czech Republic, these requirements are determined in the Act No. 547/1990 Coll.

## REFERENCES

[1] Internal documents of Ministry of Industry and Trade.

[2] Internal documents of State Office for Nuclear Safety.

[3] Analysis of the Czech Economy and MIT Sectors in 1995, (1996).

[4] Energy Economy, Year Book, Czech Republic (MIT), (1994).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

Ministry of Industry and Trade
Energy Division
Na Františku 32
110 15 Praha 1 - Staré mešto — Tel.: (422) 248 51 111

State Office for Nuclear Safety
Senovážné namésti 9
110 00 Prague 1 — Tel.: (422)216 24 111
Czech Republic — Fax: (422)216 24 704

*OTHER NUCLEAR ORGANIZATIONS*

**Nuclear Utility Company**

ČEZ, a.s., Jungmannova 29
111 48 Praha 1

**Nuclear Technology Supplier**

Škoda Praha, a.s.
M. Horakové 109/116
160 00 Praha 6

Škoda Jaderné strojirenstivi
Plzeň, s.r.o.
Orlik 266
316 06 Plzeň

EZ Praha, a.s.
Na Poříči 5 a 7
111 74 Praha 1

Královopolská strojirna, a.s.
divize R.I.A.řižikova 68
660 90 Brno

Vodni stavby Bohemia, a.s.
T. Bati 424
391 02 Sezimovo Usti

WEC
Voršilská 10
110 00 Praha 1

Modřanská potrubní, a.s.
Komořanská 326/63
14 Praha 4 - Modřany

**Research Institutions**

National Radiation Protection Institute
Šrobárova 48
100 00 Praha 10

ÚJV Řež, a.s.
2250 68 Řež u Prahy

EGÚ Praha, a.s.
190 11 Praha 9 - Běchovice

**Universities**

Czech Technical Universith Praha
Zikova 4
160 00 Praha 6

Charles University
Faculty of Mathematics and Physics
Ke Karlovu 3/5
120 00 Praha 2

# FINLAND

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**FINLAND**

# 1. GENERAL INFORMATION

## 1.1. General Overview

Finland (in Finnish Suomi) is a republic in northern Europe, bounded on the north by Norway, on the east by Russia, on the south by the Gulf of Finland and Estonia, on the south-west by the Baltic Sea and on the west by the Gulf of Bothnia and Sweden. Nearly one third of the country lies north of the Arctic Circle. The area of Finland, including 31,557 km$^2$ of inland water, totals 338,000 km$^2$. The terrain is generally level, hilly areas are more prominent in the north and mountains are found only in the extreme north-west.

The average July temperature along the southern coast is 15.6°C, February average is about -8,9°C. Precipitation (snow and rain) averages about 460 mm in the north and 710 mm in the south. Light snow covers the ground for four to five months a year in the south, and about seven months in the north.

Finland has a population of 5.1 million (1994) and average population density of 15 per km$^2$. Historical population data is shown in Table 1. The predicted population growth rate to year 2000 is 0.4%. More than two thirds of the population reside in the southern third of the country.

Finland's energy intensity is about 20% higher than the European Union average; per capita intensity is about 70% higher than the European Union average. This is mainly due to the weather, which demands space heating, and the structure of the industry, which is energy intensive processing industry (wood, especially paper, heavy metal and chemical). A third factor is relatively high transportation requirements per capita caused by the low population density.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 4.4 | 4.6 | 4.8 | 5.0 | 5.1 | 5.1 | 0.4 |
| Population density (inhabitants/km$^2$) | 13.1 | 13.6 | 14.1 | 14.7 | 15.0 | 15.0 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.4 |
| Area (1000 km$^2$) | 338.1 |
| Urban population in 1994 as percent of total | 63.0 |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

The Gross Domestic Product (GDP) was FIM 511 billion, US$ 108 billion, in 1994. The historical GDP data are given in Table 2.

## 1.3. Energy Situation

The primary indigenous energy resources in Finland are hydro power, wood, wood waste, pulping liqueurs and peat. The estimated peat reserves in Finland are about 800 Mtoe. These could be exploited with an annual rate of 4 Mtoe. It has also been estimated that the annual production capacity of wood and wood based fuels could be raised to 5-6 Mtoe. Unexploited hydro power reserves are estimated to correspond to an annual production of the order of 9 TW·h.

About 30% of the energy demand is covered by indigenous fuels and hydro power. Finland imports all of its oil, natural gas, coal and uranium. Total demand for primary energy in 1994 was

31.6 Mtoe and the different energy sources used are given in Table 3. The 1994 energy use in % is given in Table 4.

High proportion of energy-intensive processing industries and high requirements for space heating and long transportation distances make the total energy consumption per capita in Finland one of the highest in OECD area. In 1994 the primary energy consumption in Finland per capita was 6.1 tons of oil. The historical energy statistics are given in Table 5.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 10,775 | 51,307 | 134,788 | 82,531 | 97,211 | 4.7 |
| GDP (millions of constant 1990 US$) | 69,703 | 98,701 | 134,788 | 120,244 | 125,113 | 1.7 |
| GDP per capita (current US$/capita) | 2,339 | 10,734 | 27,033 | 16,311 | 19,121 | 4.2 |
| GDP by sector (1992): | | | | | | |
| Agriculture 5% | | | | | | |
| Industry 31% | | | | | | |
| Services 64% | | | | | | |

Source: IAEA Energy and Economic Data Base

TABLE 3. PRIMARY ENERGY SOURCES IN 1994

| | Mtoe | % |
|---|---|---|
| • oil | 8.8 | 28 |
| • coal | 4.2 | 13 |
| • natural gas | 2,7 | 8 |
| • indigenous fuels | 6.9 | 22 |
| • hydro power | 2.9 | 9 |
| • nuclear power | 4.6 | 15 |
| • net imports | 1.5 | 5 |

TABLE 4. 1994 ENERGY USE IN %

| | |
|---|---|
| • industry | 48 |
| • heating | 22 |
| • traffic | 12 |
| • others | 18 |

### 1.4. Energy Policy

The objectives of Finnish energy policy are: security of supply; effective energy markets and economy; environmental acceptability and safety. In Finland, energy supply decisions on energy systems take place at a fairly decentralised level. A substantial proportion of energy is imported and produced by private enterprises. The state-owned energy companies are also run on a purely commercial basis.

Since Finland's energy mix is diverse and well-balanced, its power plants can be optimised for up to three different fuels. About 40 per cent of all Finnish homes are connected to district heating networks. The figure is expected to rise up to 50 per cent by the end the century. More than 60 per cent of all district heat is produced in combined heat and power plants.

Finland is highly dependent on foreign supplies. Crude oil and oil products constitute a major part of imported energy. Other main fuels imported to Finland are coal and natural gas. During the last years the imports of gas have had the fastest growth rate. Alternative gas supply sources to Russian gas are under investigation.

TABLE 5. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 0.24 | 0.62 | 0.98 | 1.16 | 1.11 | 1.16 | 7.31 | 1.25 |
| - Solids[2] | 0.08 | 0.16 | 0.23 | 0.26 | 0.27 | 0.32 | 5.46 | 2.28 |
| - Liquids | 0.10 | 0.37 | 0.54 | 0.42 | 0.33 | 0.36 | 8.57 | -2.84 |
| - Gases | | | 0.04 | 0.11 | 0.12 | 0.13 | | 9.76 |
| - Primary electricity[3] | 0.05 | 0.10 | 0.17 | 0.38 | 0.39 | 0.35 | 5.92 | 5.23 |
| Energy production | | | | | | | | |
| - Total | 0.05 | 0.17 | 0.21 | 0.37 | 0.39 | 0.42 | 7.31 | 4.99 |
| - Solids | | 0.08 | 0.05 | 0.09 | 0.07 | 0.13 | 22.18 | 6.90 |
| - Liquids | | | | | | | | |
| - Gases | | | | | | | | |
| - Primary electricity[3]) | 0.05 | 0.09 | 0.16 | 0.28 | 0.31 | 0.29 | 5.95 | 4.28 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.20 | 0.63 | 0.77 | 0.72 | 0.64 | 0.80 | 7.07 | 0.33 |
| - Solids | 0.08 | 0.11 | 0.16 | 0.18 | 0.18 | 0.22 | 3.17 | 2.43 |
| - Liquids | 0.11 | 0.52 | 0.57 | 0.43 | 0.35 | 0.45 | 8.55 | -1.72 |
| - Gases | | | 0.04 | 0.11 | 0.12 | 0.13 | | 9.76 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

Due to the attempts to stabilise the $CO_2$ emissions and gradually reduce them (e.g., with a carbon oxide tax), and due to the decision taken by the Parliament not to build a new nuclear power plant in Finland, the significance of added import of natural gas, role of domestic fuels and research and development of new and renewable energy sources have increased in the long run. Also, intensified conservation of energy and more efficient use thereof is insisted.

It is a generally accepted view that Finland should have an average economic growth of 5% by the year 2000 and beyond, in order to be able to reduce the present very high unemployment rate and, at the same time, reduce the foreign debt. This growth rate would mean heavy domestic investments mostly on the traditional energy intensive sectors of industry (wood, metal and chemical industries). These investments would require at least 5% annual growth of electricity generation capacity per year. New generation capacity of 4,000 MW should be available by the year 2005.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Energy supply in Finland is highly competitive and both the state-owned and private sector energy and electricity supply utilities operate essentially on the same commercial basis as the industry in general. The Finnish power system is widely decentralised and has a diverse organization. There are about 370 power stations in Finland, owned by 130 generating companies or utilities. The main types of ownerships are:

i) state-owned power companies (share of capacity 41%);
ii) industrial companies (41%);
iii) municipal and other distribution companies (18%).

The three largest energy producers account for about a half of the power generated in Finland. The ten largest have a market share of about 70%. The state-owned utilities, Imatran Voima Oy (IVO) and others, are responsible for 45% of the electricity produced. A further 38% is provided by private and state-owned industrial companies and 17% by municipal and other distributing companies with generating facilities. Teollisuuden Voima Oy (TVO) provided 17% of the electric energy supply in 1994 in Finland. IVO has a 25% share of the TVO.

IVO, a limited liability company founded 1932, is owned directly (96%) and indirectly by the state of Finland. IVO is interested in expanding its ownership base to include private investors. TVO was founded in 1969 by a number of Finnish industrial companies with the purpose of building and operating large power plants. The company supplies electricity to its shareholders at cost. The company has public sector and private sector shareholders (Table 6).

TABLE 6. PUBLIC AND PRIVATE SECTOR SHAREHOLDERS (1995)

| | % | MW |
|---|---|---|
| Public sector | | |
| Etelä-Pohjanmaan Voima Oy | 6,5 | 93 |
| Imatran Voima Oy | 26,6 | 377 |
| Kemira Oy | 1,8 | 26 |
| Oy Mankala Ab | 6,1 | 86 |
| Revon Sähkö Oy | 2,1 | 30 |
| Total public sector | 43,1 | 612 |
| Private sector | | |
| A Ahlström Oy | 0,1 | 1 |
| Etelä-Suomen Voima Oy | 7,2 | 102 |
| Pohjolan Voima Oy | 49,6 | 705 |
| Total private sector | 56,9 | 808 |
| Total | 100,00 | 1420 |

In Finland all generators and transmission lines, irrespective of ownership, are interconnected. High voltage power transmission lines are owned by about 50 companies. The transboundary transmission lines are owned by IVO. In 1992, IVO separated its production, engineering and transmission activities into different companies. The power transmission company is called IVO Voimansiirto Oy (IVS). IVS owns about 70% of the national transmission network. The remainder is owned by Teollisuuden Voimansiirto Oy (TVS), formed by four companies. Plans for founding a new independent power transmission and distribution company formed by TVS and IVS are under discussion.

### 2.2. Decision-Making Process

Industrial and domestic consumers are free to use the energy they prefer. The main government influence on energy decisions is through taxes and some minor subsidies. Anyone has the right to construct a power station or a transmission line. The construction of a transmission line requires a license. The license of electricity imports has been abolished. This deregulation has made it possible for Finnish electricity consumers to co-operate directly with foreign power producers.

The power industry is covered by the same laws as other commercial activities. Companies are fully responsible for their economic operations. None of the individual companies has national responsibility for the operation of the whole system.

The New Electricity Market Act (1994) came into force in 1995 and has opened access to distribution of electricity. According to the Act, transmission and distribution companies are licensed by the Electricity Market Authority. The licenses specify the franchised territory only for the distribution companies. The transmission companies have no franchised territories. In their territories the distribution utilities are obligated to connect customers to the distribution network against proper compensation.

Transmission and distribution companies are obligated to transmit electricity in their networks if transmission capacity is available. Electricity companies are obliged to make a sales offer in their marketing region. License for construction of power plants is needed only for nuclear and hydropower plants. All new power plant projects need environmental impact assessment. Foreign ownership in electricity supply is also possible. The main principles of the New Electricity Market Act are presented in Figure 1.

Generation and transmission investments are funded by loans from the domestic and international financial market by self-financing and in part by equity capital. The state does not fund investments by the utilities and gives no guarantee for debts. The state is only involved as an equity investor in the state-owned companies and requires return on equity capital.

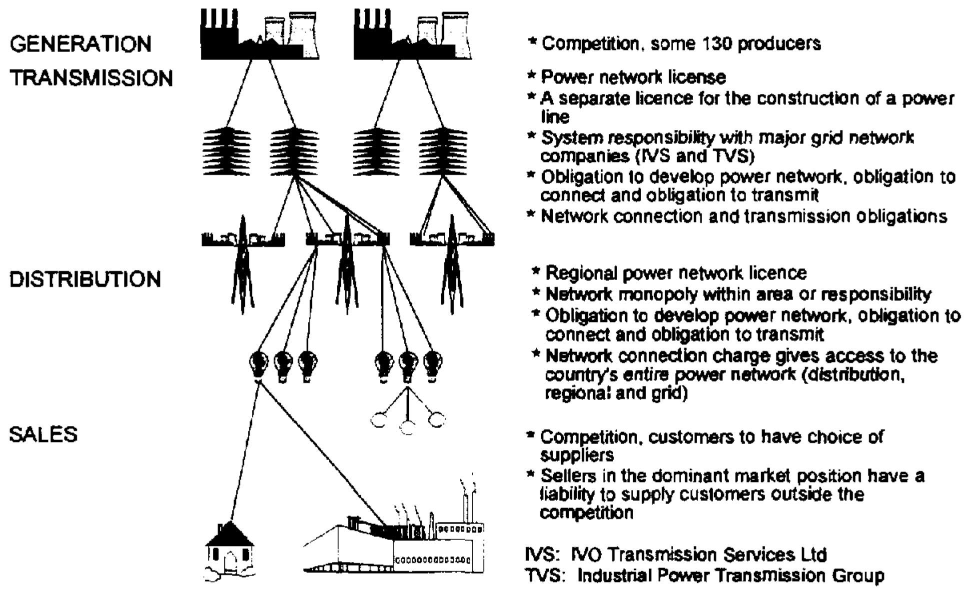


*FIG. 1. New Electricity Market Act in the Nutshell*

## 2.3. Main Indicators

The historical electricity production and the installed capacities are given in Table 7 and the related energy ratios in Table 8. The total electricity production in 1994 in Finland was 68.2 TW·h (Table 9). The primary energy sources in electricity supply and electric energy consumption (68.2 TW·h) in 1994 are given in Table 11.

The per capita electricity consumption in 1994 was about 13,400 kW.h. The capacity of electricity production in 1994 was about 13,200 MW. Electricity now represents about 25% of the primary energy consumption. The share is expected to rise to 50% by the end of the century. In the industry sector electricity is the main source of energy. The most important branch is pulp and paper production, which consumes about 60% of the total energy needs of industry. Other significant branches are the metal and chemical industries. In 1994, the Finnish industry consumed 34.8 TW·h of the electricity, up by 1.8 TW·h on 1993.

The rise in industrial production, projected at almost 12% in 1994, was reflected in industry's energy consumption. The rise in demand for electricity is primarily due to increasing production of wood-based printing paper. (The Energy Federation of Finnish Industries, TELI).

TABLE 7. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total(1) | 8.63 | 21.19 | 38.71 | 54.38 | 61.17 | 65.64 | 7.79 | 3.84 |
| - Thermal | 3.36 | 11.83 | 21.96 | 25.39 | 28.77 | 35.52 | 9.84 | 3.49 |
| - Hydro | 5.27 | 9.35 | 10.12 | 10.86 | 13.60 | 11.79 | 3.32 | 1.10 |
| - Nuclear | | | 6.63 | 18.13 | 18.80 | 18.33 | | 7.53 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 2.83 | 4.31 | 10.42 | 13.22 | 14.08 | 14.14 | 6.73 | 2.20 |
| - Thermal | 1.28 | 2.35 | 6.47 | 8.24 | 8.99 | 9.06 | 8.46 | 2.43 |
| - Hydro | 1.56 | 1.96 | 1.75 | 2.62 | 2.73 | 2.73 | 0.58 | 3.23 |
| - Nuclear | | | 2.20 | 2.36 | 2.36 | 2.36 | | 0.49 |

(1) *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 8. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 54 | 135 | 204 | 233 | 219 | 228 |
| Electricity per capita (kW·h/capita) | 2,042 | 4,714 | 8,351 | 12,482 | 12,981 | 13,617 |
| Electricity production/Energy production (%) | 161 | 123 | 176 | 136 | 145 | 144 |
| Nuclear/Total electricity (%) | | | 17 | 35 | 32 | 29 |
| Ratio of external dependency (%)(1) | 82 | 101 | 79 | 62 | 58 | 69 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 35 | 56 | 42 | 47 | 50 | 53 |
| - Thermal | 30 | 58 | 39 | 35 | 37 | 45 |
| - Hydro | 39 | 54 | 66 | 47 | 57 | 49 |
| - Nuclear | | | 34 | 88 | 91 | 89 |

(1) *Total net import / Total energy consumption.*
Source: IAEA Energy and Economic Data Base

TABLE 9. 1994 ELECTRICITY PRODUCTION AND EXPORT/IMPORT

| | TW·h | % |
|---|---|---|
| Nuclear power | 18.3 | 27 |
| Conventional condensing power | 12 | 18 |
| Hydropower | 11.7 | 17 |
| Cogeneration, district heating | 10.5 | 15 |
| Cogeneration, industry | 9.6 | 14 |
| Net imports | 6.1 | 9 |

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

The Technical Research Centre in Finland has a research reactor in operation since 1962. Much of the research is done through participation in bilateral and international projects.

The Loviisa Power Plant units, owned by IVO, on the South coast, were ordered in 1969 and 1971 and entered commercial service in 1977 and 1981. The Olkiluoto Power Plant units, owned by TVO, on the West coast, were ordered in 1972 and 1974 and entered commercial service in 1979 and 1982. The Loviisa power plant has two Russian (Soviet) VVER 465 MW(e) PWR's and Olkiluoto power plant has two Swedish 735 MW(e) BWR's (gross capacity).

In 1986, IVO and TVO established Perusvoima Oy (PEVO) for the construction of a fifth nuclear power plant unit in Finland. The formal application for the fifth unit was filed in 1991. However, in 1993, this was turned down by the parliament.

TABLE 10. PRIMARY ENERGY SOURCES IN ELECTRICITY SUPPLY AND ELECTRIC ENERGY CONSUMPTION IN 1994

| | TW·h | % |
|---|---|---|
| Primary energy sources | | |
| • nuclear power | 18.3 | 27 |
| • coal | 13.1 | 19 |
| • hydropower | 11.7 | 17 |
| • other domestic renewables | 6.8 | 10 |
| • net imports | 6.1 | 9 |
| • natural gas | 5.7 | 8 |
| • peat | 4.8 | 7 |
| • oil | 1.6 | 2. |
| Electric energy consumption | | |
| • industry | 36.0 | 53 |
| • household | 15.1 | 22 |
| • agriculture | 2.8 | 4 |
| • service | 7.4 | 11 |
| • public | 4.3 | 6 |
| • losses | 2.6 | 4 |
| • Total | 68.2 | |

### 3.2. Current Policy Issues

Newly-elected Minister of Trade and Industry stated in May 1995 that the new government policy does not include nuclear power for two reasons. First of all, the former parliament made a decision against the fifth nuclear unit in Finland; and secondly, the present government does not support nuclear power. The decision against nuclear power assumed expansion of coal-fired capacity.

A public survey conducted in 1994 by Yhdyskuntatutkimus Oy, an opinion research institute, concerning energy attitudes in Finland, indicates that the belief in growing electricity consumption is stronger than before and that economic values seem to be more appreciated than before. The survey was a continuation to the series of studies initiated in autumn 1983.

The latest survey shows that two out of three Finns believe that future electricity consumption will be much higher than it is today. The downward trend in consumption since autumn of 1988 took a sharp upward turn in 1994. Attitudes towards the potential of energy conservation took a similar turn. Compared to 1992 ten per cent fewer Finns are now willing to lower their standard of living in order to alleviate environmental impacts and reduce risks associated with energy generation. Nearly half of the respondents opposed lowering the competitiveness of the Finnish industry through energy taxation.

Acceptance of nuclear power is somewhat greater, while the opposition is smaller. Natural gas, the most popular energy form, for the first time now, received somewhat less support. Today half of the Finns believe that nuclear power is economical, up to ten percent since Autumn 1983. Although the safety of the nuclear waste management is widely suspected, people have a more understanding attitude towards safety of nuclear waste disposal. Half of the people in the two municipalities with nuclear power plants would accept a disposal site for nuclear waste in the municipality, if the studies would prove this to be safe. The majority of Finns, however, have a much more negative attitude towards nuclear waste disposal.

By amendment to the Nuclear Energy Act in 1994 that placed IVO's Loviisa NPP's spent fuel shipments to Russia (Chelyabinsk) on hold, IVO and TVO agreed on future co-operation in nuclear waste management concerning spent fuel treatment and disposal. The two companies have founded a shareholding company, Posiva Oy, of which TVO owns 60% and IVO 40%. The site for a joint permanent repository for the nuclear waste will be chosen in the year 2000 according to the programme approved by the government. The waste will be placed in the final repository beginning in 2020. Responsibility for nuclear waste management stays with the company who produced the waste.

IVO's and TVO's co-operation does not cover medium and low level waste, nor the decommissioning of the nuclear power plants. A medium- and low level waste depositories are located in Olkiluoto. A second site is under construction in Loviisa. The Loviisa depository will start operations in 1997. IVO and TVO are independently responsible for funding despite their spent fuel management co-operation.

Power companies in Finland pay annual contributions to the state nuclear waste fund, which operates under the auspices of the Ministry of Trade and Industry. This provision covers all future measures: treatment, storage and final disposal of spent fuel and radioactive waste, as well as decommissioning of the plants. The power companies contributing to the fund are entitled to borrow back 75% of the contributions against securities in order to ensure that the state fund accumulates sufficient interest revenues.

### 3.3. Status and Trends of Nuclear Power

Today, about a third of electricity in Finland is produced by nuclear power (Table 11). Finland's four nuclear power plant units have a total capacity of 2 310 MW(e). They have operated reliably and complied with existing safety and environmental protection standards. For years, the load factors of all the units have been around 90%. Both companies have invested a lot to keep the annual outages as short as possible.

TABLE 11. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| LOVIISA-1 | WWER | 445 | IVO | Operational | AEE |
| LOVIISA-2 | WWER | 445 | IVO | Operational | AEE |
| OLKILUOTO-1 | BWR | 755 | TVO | Operational | ASEA |
| OLKILUOTO -2 | BWR | 710 | TVO | Operational | ASEA |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| LOVIISA-1 | 01-May-71 | 21-Jan-77 | 08-Feb.-77 | 09-May-77 | |
| LOVIISA-2 | 01-Aug.-72 | 17-Oct-80 | 04-Nov.-80 | 05-Jan-81 | |
| OLKILUOTO -1 | 01-Feb.-74 | 21-Jul.-78 | 02-Sept.-78 | 10-Oct-79 | |
| OLKILUOTO -2 | 01-Aug.-75 | 13-Oct-79 | 18-Feb.-80 | 10-Jul.-82 | |

Source: IAEA Power Reactor Information System, year end 1996

IVO operates two PWR type plants in Loviisa and TVO operates two BWR plants in Olkiluoto. Nuclear energy production by IVO in 1994 was 6.6 TW·h and TVO 11.7 TW·h. Since the beginning of 1994, TVO is modernising and upgrading the Olkiluoto nuclear power station to increase the safety and operational security of the station. These upgrades will increase Olkiluoto's electricity capacity by about 250 MW (125 MW per unit). Modernisation will extend the units' operating life. IVO is planning to improve the capacity of the Loviisa power station as well. The plants' service life was originally designed for 40 years but substantial prolongation of the lifetime is under design. All Finnish nuclear power plants are scheduled to be in operation well into the next century.

The state gives subsidies or other forms of support for promoting the use of indigenous fuels. The Nuclear Energy Act of 1988 sets specific application requirements for new nuclear plants irrespective of private or state ownership. The same is true what comes to the waste management and decommissioning. General safety regulations are issued by the Council of State. Detailed regulations and regulatory guides are issued by the Centre for Radiation and Nuclear Safety (STUK). The licensing of nuclear installations in Finland (construction permit and operation license) is the responsibility of the Council of State. A major nuclear facility also needs a positive decision in principle by the Council of State, subject to ratification by the Parliament. However, licenses for small nuclear facilities (e.g., research reactors with thermal power below 50 MW(e)) are granted by the Ministry of Trade and Industry, which has overall responsibility for control of nuclear energy in Finland.

### 3.4. Organizational Charts

The licensing of nuclear power plants in Finland is shown in Figure 2 and the structures of the IVO Group, TVO and STUK are shown in Figures 3, 4 and 5 respectively.

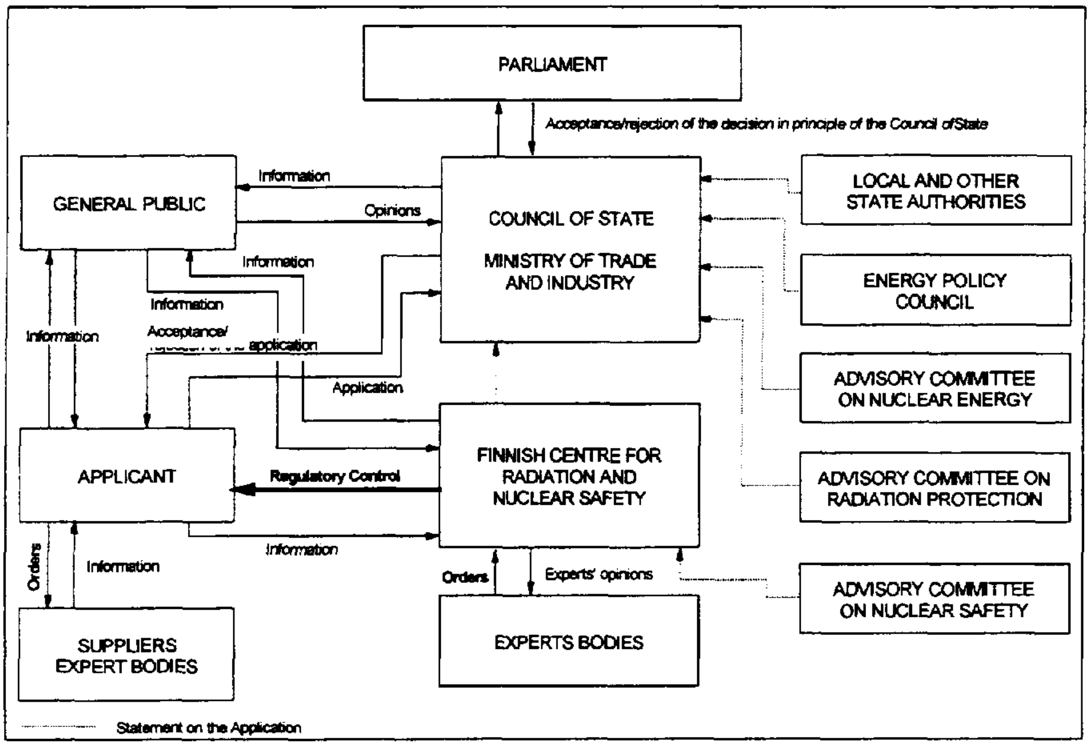


*FIG. 2. Licensing of nuclear power plants in Finland.*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

The nuclear steam supply system (NSSS) and twin turbine generators for Loviisa nuclear power plant were supplied by V/O Atomenergoexport of the former USSR. IVO acted as its own architect engineer and co-ordinated the design and supply of equipment from several countries. This included the integration of West German instrumentation and, under Westinghouse license, an ice condenser containment system. The pressure relieve system in Loviisa was supplied by domestic sub-deliverers.

The Olkiluoto units were ordered on turnkey contracts from Asea-Atom (now ABB Atom) in 1972 and 1974. TVO had the responsibility for the second unit's civil engineering systems. In 1993, the containment buildings were retrofitted with Siemens pressure reduction system and filters. The Olkiluoto units were upgraded in 1985 from 660 MW(e) to 710 MW(e) (net capacity).

Collaboration with foreign vendors provided Finnish companies with experience in supplying conventional equipment to nuclear power stations. Domestic capabilities have also been developed for simulators, fuel handling, storage equipment, radiation dosimeters and monitoring equipment.

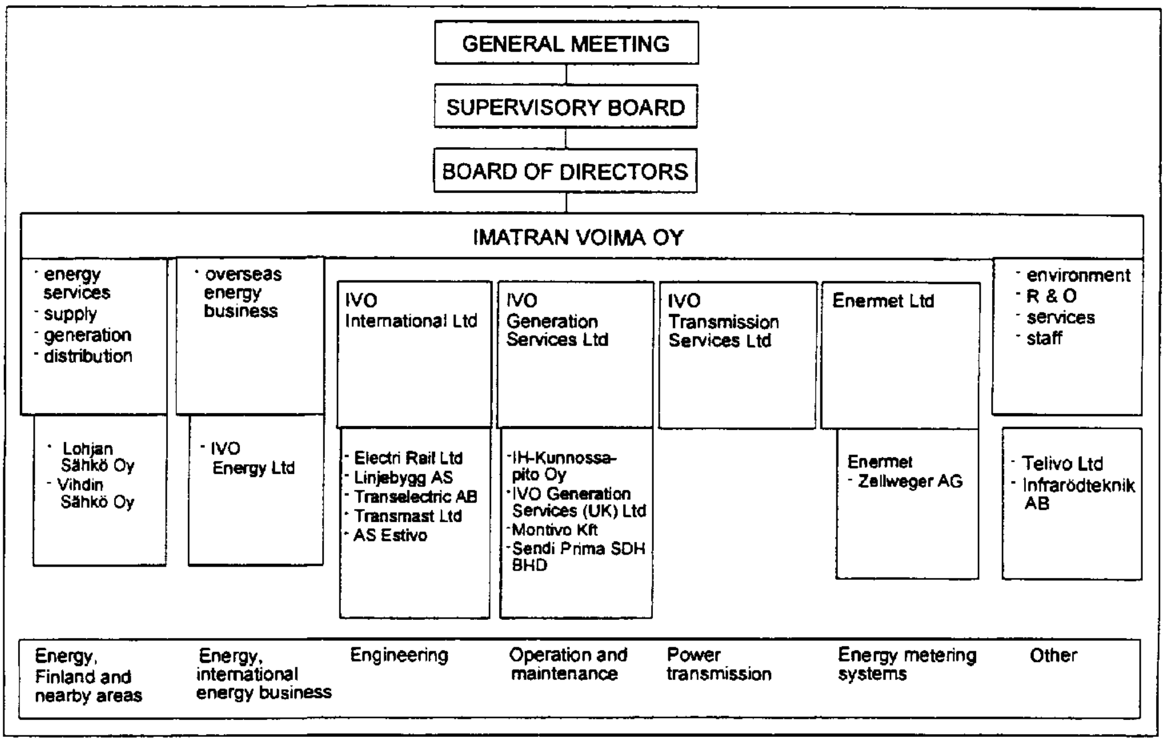


*FIG. 3. Structure of IVO Group*

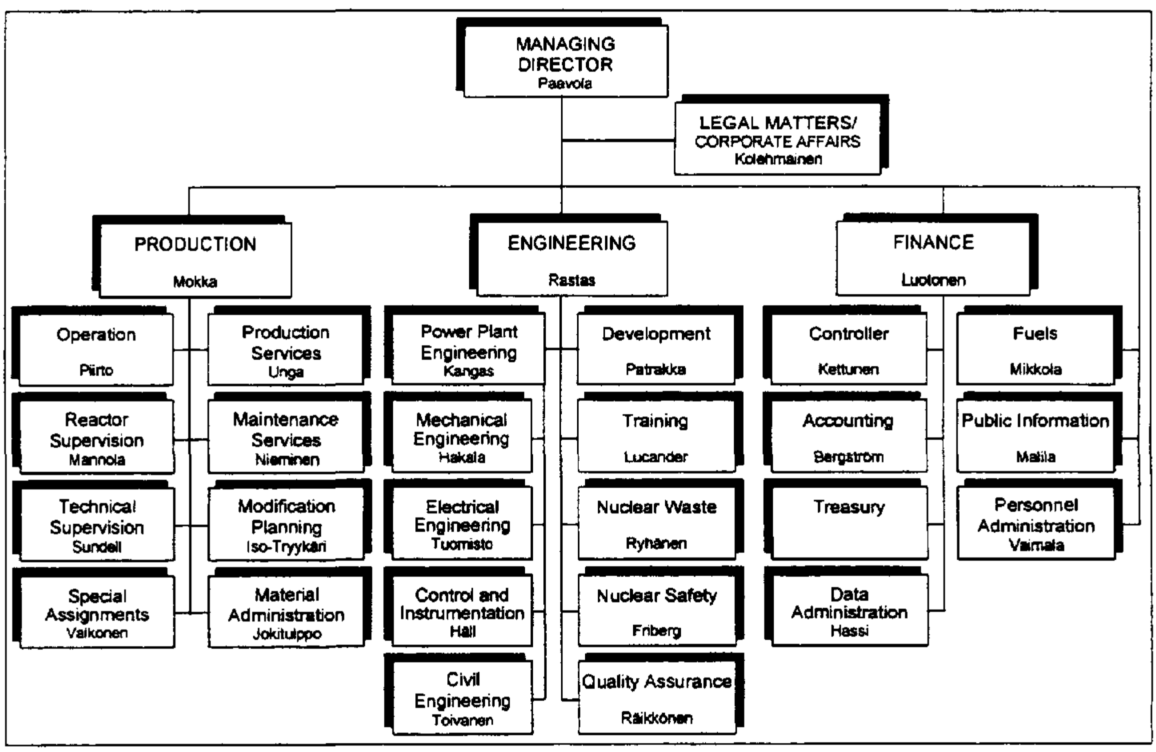


*FIG. 4. Teollisuuden Voima Oy - Organization 1.6.1994*

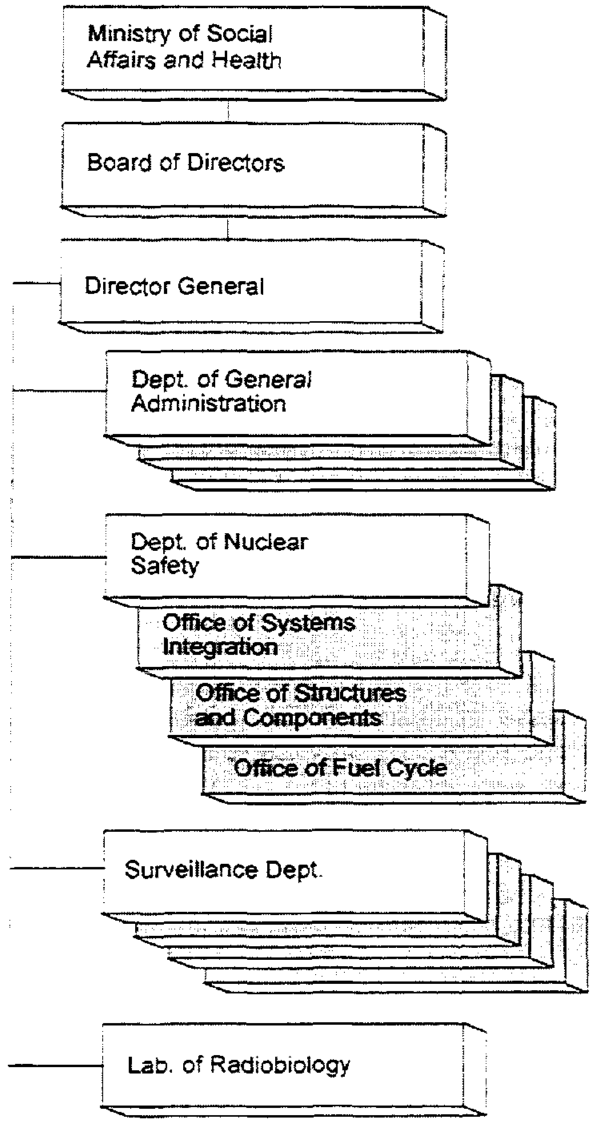


*FIG. 5. Organization of STUK*

### 4.2. Operation of Nuclear Power Plants

The operation, maintenance, and training at Loviisa are carried out by IVO. TVO supplies operation and maintenance services and the operator training for Olkiluoto.

### 4.3. Fuel Cycle, and Waste Management Service Supply

Nuclear fuel elements used in the Loviisa power plant are imported from Russia. The fuel is delivered to the plant as fuel rod bundles. The reactor contains a total of 313 elements. One third of the fuel is replaced by fresh fuel during the annual outages. At the same time the positions of the fuel bundles inside the reactor core are changed to improve the operation efficiency.

Uranium for TVO 1 and TVO 2 comes from Canada, Austria, Niger, China and Russia. Most of the enrichment has taken place in Russia, the rest in Western Europe. Fuel elements delivered to Olkiluoto are manufactured by ABB Atom in Sweden and by Siemens in Germany. Each of the TVO units contains 500 fuel elements. Each year about one fourth of these is replaced. Spent fuel is stored for a few years in the fuel pools at the reactor buildings. Thereafter, they are transferred in a heavy container to an interim spent fuel storage at the power plant site. TVO is responsible for both the acquisition of fuel and the management of spent fuel.

Each producer of nuclear waste is responsible for the safe handling, management and disposal of the waste as well as for the financing of these operations. The funding required for nuclear waste management is raised gradually during the plant's production life time. The utilities are obliged to make annual payments to the State Nuclear Waste Management Fund in order to cover the future waste management costs.

In accordance with a recent amendment to the new Nuclear Energy Act, current shipments of spent fuel to Russia will be terminated in 1996. After the last transport to Russia in 1996 about 144 tons of spent fuel from Loviisa Power Plant will remain in Finland. Later, after the immediate storage, it will be placed into a final bedrock repository. Final storage of spent fuel will be done jointly by IVO and TVO, as described above. Medium- and low level waste final depositories are in use at Olkiluoto site and under construction at Loviisa site. The Loviisa depository will begin operation in 1997.

### 4.4. Research and Development Activities

Finland has no institutes dedicated solely for nuclear research. Most research takes place at the Technical Research Centre of Finland (VTT). Other major research institutes include the Geological Survey of Finland (GTK), the universities of Helsinki and Kuopio, the universities of technology in Helsinki and Lappeenranta (TKK, LTKK) and the Meteorological Institute. In addition, the reactor safety authority (STUK) and the power companies IVO and TVO carry out internal research. The Advisory Committee on Nuclear Energy (YEN) assists the Ministry of Trade and Industry (KTM) in directing the publicly funded nuclear energy research. KTM has appointed a steering group for each research programme to supervise and direct the research.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

As a member of the European Union, IAEA, OECD/NEA and Nordic Council of Ministers, Finland participates in most nuclear research and development activities conducted by intergovernmental organizations. Multilateral co-operation is supplemented by several bilateral projects and co-operation agreements that the Finnish research institutes, safety authorities and industrial enterprises have with foreign organizations.

The importance of international co-operation in the field of nuclear power research and development is most evident in experimental research and development of large computer codes where large man-power and financial rescues are involved. International collaboration is also extensive in developing technical solutions for final disposal of high level nuclear wastes.

Finland participates in IAEA work on all programme areas. The main emphasis is on nuclear safety and safeguards programmes. Finland also supports the IAEA's work through voluntary contributions. Finland is a member of all IAEA conventions.

When Finland joined the European Union together with Austria and Sweden in early 1995, it also became a member of the European Atomic Energy Community, Euratom. In March 1995, Finland made a contract of association with the European Commission to participate in research on controlled thermonuclear fusion. Through this contract, Finland is also involved with the global International Thermonuclear Experimental Reactor (ITER) project.

Finnish research organizations have contributed to the Euratom's nuclear fission safety research programme from 1990 to 1994 in many areas at the project level. As the implementation of the next nuclear research and training programme starts behind the original schedule, the new member countries are able to compete on the Union's funds on an equal basis with the old member countries. Based on the preliminary results from the bidding process, Finnish organizations have managed to integrate themselves well with the European nuclear research community.

Finnish nuclear safety authorities and nuclear research institutes take part in committees and expert groups established in OECD/NEA. Finland has been a member of the OECD Halden reactor project since its beginning in the late 1950's.

The five Nordic countries have carried out joint research programmes since 1977. The goal is to maintain a high level competence in the field of reactor safety, waste management and emergency preparedness as well as promoting a unified view on safety issues. The current fifth programme covers the years 1994 - 1997.

Finland's bilateral assistance in the field of nuclear safety and other sectors of nuclear technology is mainly directed to the neighbouring areas in Russia, the Baltic states and Ukraine. In Russia, work is focused on the Kola and Leningrad nuclear power plants. By mid-1995, Finland's total financial commitments in regard to Russia and other CEECs for nuclear safety amounted to about 50 million Finnish marks (FIM). Contributions to the Nuclear Safety Account of the EBRD was 15.3 million FIM.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

In Finland, ultimate management and supervision of nuclear matters is the responsibility of the Ministry of Trade and Industry (KTM). The Ministry also drafts the policies and licensing procedures for adaptation by the Council of State. Preparation of legislation drafts and implementation of international agreements, nuclear waste management, and administration of the state's nuclear waste fund are the duties of the Ministry's Energy Department. The Ministry is assisted by the Advisory Committee on Nuclear Energy for the preparation of the most important matters related to nuclear energy.

The Finnish Centre for Radiation and Nuclear Safety (STUK) works to ensure that radiation equipment, radioactive materials, nuclear energy and the nuclear materials are used safely. STUK is also responsible for handling of radioactive materials and radiation exposure in workplaces, at home and in the environment. STUK operates under the auspices of the Ministry of Social Affairs and Health. The centre maintains close contacts with the Ministry of Trade and Industry, other government bodies, research institutes, universities and power companies. STUK is assisted by the Advisory Committee on Nuclear Safety in major nuclear safety issues. Licensing of nuclear power plants includes three stages: the decision in principle, the construction license and operating license. The safety aspects of the license applications are assessed by STUK and the Advisory Committee on Nuclear Safety. All licensees must meet the following prerequisites:

i) nuclear energy shall be generally beneficial for society;
ii) nuclear energy shall be safe and it shall not cause any detriment to human beings, the environment and property;
iii) physical security, emergency preparedness and other arrangements shall be sufficient to mitigate nuclear accidents and to safeguard the use of nuclear energy against illegal actions.

The application for the Council of State's decision in principle may concern one or more alternative nuclear installation projects. Before the decision is made, an overall description of the installation including environmental effects and safety plans are made available to the public. Public and local authorities are given the opportunity to present their opinions in a public hearing. If the general prerequisites are met and if the municipal council of the site in question is in favour (municipal right of binding veto) of the construction of the installation, the Council of State may make the decision in principle. The decision is submitted to parliament which either confirms or rejects it (political consideration).

The Council of State enforces regulations on nuclear safety, security and emergency preparedness drafted by STUK. The Ministry of Interior is responsible for regulating public rescue services.

The application for a construction license is more detailed and includes safety analysis reports and security plans.

The application for an operating license must be accompanied with detailed construction information of the facility and cover the facility's operation plans. The license can be granted only for a fixed period. All current operating licenses expire in the end of 1998.

During the operation, a nuclear power plant is subjected to three types of regulatory inspections: periodic inspections; inspections that the operating organization must pass in order to continue operation; and, continuous re-evaluation of the safety level of the operating plant. Operating licenses are granted for a limited period. When renewing a license, an overall evaluation of the safety of the plant is carried out by STUK based on the annual re-evaluation results and on the findings of the inspections.

### 5.2. Main National Laws and Regulations

The Nuclear Energy Act 990/1987 (Ydinenergialaki) and Decree No. 161/1988 (Ydinenergia-asetus) gives parliament the final authorisation for building new major nuclear installations including waste disposal facilities. The Act and Decree also define the licensing procedure and the conditions for the use of nuclear energy including waste management, as well as the responsibilities and authority of STUK.

The Radiation Act 592/1991(Säteilylaki) establishes the conditions to prevent and limit harmful radiation effects to health.

Nuclear Liability Act 484/1972 (Ydinvastuulaki) implements the Paris Convention on the Third Party Liability in the Field of Nuclear Energy and the Brussels Supplementary Convention. Law No 588/1994 adopts Joint Protocol bridging Paris and Vienna Conventions.

The Electricity Market Act 386/1995 (Sähkömarkkinalaki) opened access to the distribution networks and allowed foreign ownership of electricity supply. The Competition Act 480/1992 (Laki kilpailunrajoituksista) is compatible with EC directives on competition. Cartels and abuse of dominating position are prohibited by the act. Several laws also cover electricity sector:

- Law on Environmental Impact Assessment sets IEA compulsory for nuclear facilities;
- Law on Construction and Land Use Planning requires a site permit for a power plants and major nuclear facilities;
- Law on Water Resources requires special permits of water courts for the use of cooling water in the power plants;
- Law on Air Protection includes the government decision on limits for air emissions;
- Law on Public Health.

The Finnish licensing requirements for nuclear installations are outlined in the STUK regulatory guides (YVL guides). The YVL guides now include about 60 directives in the following eight series: general guides, systems, pressure vessels, civil engineering, equipment and components, nuclear materials, radiation protection and radioactive waste management.

### 5.3. International, Multilateral and Bilateral Agreements[1]

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | |
| • Improved procedures for designation of safeguards inspectors | Accepted on: | 25 April 1989 |
| • NPT related safeguards agreement INFCIRC/155 [SopS 2/72] | Entry into force: | 9 February 1972 |
| • Research project related safeguards agreement | | |
| a) Contract for the transfer of enriched uranium for a research reactor, in Washington and in Vienna | | 23 December 1960 |
| INFCIRC/24 | Entry into force: | 30 December 1960 |
| b) Agreement between IAEA and the Government of Finland for assistance in establishing a research reactor project, in Vienna INFCIRC/24 | | 30 December 1960 |
| c) Contract for the transfer of enriched uranium for a research reactor in Finland, in Vienna INFCIRC/24/Add. 2 | | 8 July 1966 |
| d) Contract for the transfer of enriched uranium for a research reactor in Finland, in Vienna INFCIRC/24/Add.3 | | 5 November 1967 |
| e) Five-year contract for the transfer of enriched uranium for a research reactor in Finland, in Vienna INFCIRC/24/Add.4 | | 27 November 1969 |
| • A sub-critical assemblies project: | | |
| a) Agreement between the IAEA and the Government of Finland for assistance in establishing a sub-critical assemblies project, in Vienna INFCIRC/53 | | 30 July 1963 |
| b) Contract No. 543/60 INFCIRC/53 | | |

[1] Note: If the text has been published as an IAEA Information Document the corresponding code of this document (INFCIRC/xxx) is given. The code [SopS xx/xx] refers to the number used in the publication "Suomen säädöskokoelman sopimussarja".

| | | | |
|---|---|---|---|
| • | Treaty on the non-proliferation of nuclear weapons, in London, Moscow and Washington INFCIRC/140 [SopS 11/70] | | 1 July 1968 |
| • | Nordic mutual emergency assistance agreement in connection with radiation accidents, in Vienna INFCIRC/49 [SopS 40/65] | | 17 October 1963 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | | |
|---|---|---|---|
| • | NPT | Entry into force: | 5 February 1969 |
| • | Agreement on privileges and immunities of the IAEA, in Vienna [SopS 27/60] | Entry into force: | 29 July 1960<br>1 July 1959 |
| • | Statute of the International Atomic Energy Agency, in New York [SopS 2/58, 37/63, 18/76, 13/90] | amended several times | 26 October 1955 |
| • | Convention on physical protection of nuclear material INFCIRC/274/Rev. 1 [SopS 72/89] | Entry into force: | 22 October 1989 |
| • | Convention on early notification of a nuclear accident INFCIRC/335 [SopS 98/86] | Entry into force: | 11 January 1987 |
| • | Convention on assistance in the case of a nuclear accident or radiological emergency INFCIRC/336 [SopS 83/90] | Entry into force: | 28 December 1990 |
| • | Convention on civil liability for nuclear damage in Paris 29 July 1960 [SopS 485/72, 1/90] | Accession to Paris Convention:<br>last amended: | 16 June 1972<br>16 November 1982 |
| | a) Convention Supplementary to the Paris Convention of 29 July 1960 on Third Party Liability in the Field of Nuclear Energy, in Brussels in Paris[SopS 4/77, 85/91] | last amended | 31 January 1963<br>16 November 1982 |
| | b) Convention relating to Civil Liability in the Field of Maritime, Carriage of Nuclear Material in Brussels [SopS 62/91] | | 17 December 1971 |
| • | Joint protocol | Entry into force: | 3 January 1995 |
| • | Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • | ZANGGER Committee | Member | |
| • | Nuclear Export Guidelines | Adopted | |

| | | |
|---|---|---|
| • Acceptance of NUSS Codes | Summary: Codes are considered to be useful guidance. Finnish regulations are in general consistent with revised Codes. letter | 18 May 1990 |
| • Nuclear Suppliers Group | Member | |
| • The Statute of the OECD Nuclear Energy Agency (NEA), subsequently amended | Adopted | 5 April 1978 |
| • Agreement on the OECD Halden reactor project covering the period 1st January 1994 to 31st December 1996, in Oslo | | 15 June 1993 |
| • Agreement on common Nordic guidelines on communication concerning the siting of nuclear installations in border areas, [SopS 19/1977] | | 15 November 1976 |
| • Convention on the prevention of marine pollution by dumping of wastes and other matter, [SopS 34/1979] | | 29 December 1972 |

*BILATERAL AGREEMENTS*

- Agreement between the Government of the Republic of Finland and the Government of Australia concerning the transfer of nuclear materials, in Helsinki on 20 July 1978 [SopS 2/80].
- Agreement between the Government of the Republic of Finland and the Government of Canada concerning the uses of nuclear material, equipment, facilities and information transfers, in Helsinki on 5 March 1976 [SopS 43/76].
- Agreement between the Government of the Republic of Finland and the USSR concerning co-operation in the peaceful uses of atomic energy, in Helsinki on 14 May 1969 [SopS 39/69].
- Agreement for Co-operation between the Government of the Republic of Finland and the Government of the United States of America concerning peaceful uses of nuclear energy, in Washington on 2 May 1985 [SopS 37/92].
- Agreement for co-operation between the Government of Finland and the Government of Sweden concerning peaceful uses of atomic energy, in Stockholm on 15 October 1968 [SopS 41/70].
- Agreement on the guidelines to be followed while exporting nuclear material, technology or equipment, in Helsinki on 4 March 1983 [SopS 20/83].
- Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the Republic of Finland for co-operation in the peaceful uses of atomic energy, in Helsinki 24 May 1968 [SopS 16/69].

- Agreement between Finland and Denmark on the Exchange of Information and Reporting Relative to Nuclear Plants and Nuclear Events in Finland and Denmark, in Helsinki on 25 February 1987 [SopS 27/87].

- Agreement between Finland and Sweden on the Exchange of Information and Reporting Relative to Nuclear Plants and Nuclear Events in Finland and Sweden, in Helsinki on 25 February 1987 [SopS 28/87].

- Agreement between Finland and Norway on the Exchange of Information and Reporting Relative to Nuclear Plants ad Nuclear Events in Finland and Norway, in Helsinki on 25 February 1987 [SopS 46/87].

- Agreement between the Government of Finland and the Government of the Russian Federation on the Rapid Reporting on Nuclear Accidents and the Exchange of Information Relative to Nuclear Plants, in Helsinki on 7 January 1987 [SopS 39/87].

- Agreement between the Government of the Republic of Germany and the Republic of Finland concerning the Early Notification of a Nuclear Accident and the Exchange of Information and Experience Relative to Nuclear Safety and Protection Against Radiation, in Helsinki 21 December 1992 [SopS 35/93].

- Agreement with Estonia articles 4, 6 and 7 in Helsinki 20.3.1992 and 3.1.1995 [SopS 32/92, 16/95].

## REFERENCES


[1] Analysis of the Electrical Sector in Finland. IVO International Ltd, Finland, (January 1994).

[2] Electricity in Finland, Finnish Power Council 1995, Finland.

[3] The Ministry of Trade and Industry, Energy Review 2/1995.

[4] Reuters News Service.

[5] IVO Group.

[6] Teollisuuden Voima Ltd.

[7] STUK.

[8] The Ministry of Foreign Affairs, Finland.

[9] World Bank World Tables 1995.

[10] EEDB/IAEA.

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTES AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Ministry of Trade and Industry (KTM)<br>Energy Department<br>Nuclear Energy Division<br>P.O. Box 37<br>SF-00131 Helsinki | Tel.: +358-9-1601<br>Fax: +358-9-160 2695<br>Telex: 125452 EDEPT SF |
| Finnish Centre for Radiation and<br>Nuclear Safety (STUK)<br>P.O. Box 14<br>00881 HELSINKI | Tel.: +358-9-759 881<br>Fax: +358-97598 8500 |
| Säteilyturvakeskus (STUK)<br>Finnish Centre for Radiation<br>and Nuclear Safety<br>PL/P.O. Box 268<br>FIN-00101 Helsinki | Tel.: +358 9708 21<br>Fax: +358 9 7082 392<br>Telex: 122691 STUK SF |

**Nuclear Advisory Body**

| | |
|---|---|
| Advisory Committee on Nuclear Energy<br>Ministry of Trade and Industry (KTM)<br>P. Makasiinikatu 6 | Tel.: +358-9-1601<br>Fax: +358-9-160 2695 |
| Advisory Committee on Nuclear Safety<br>Finnish Centre for Radiation<br>and Nuclear Safety (STUK)<br>P.O. Box 14<br>00881 HELSINKI | Tel.: +358-9-759 881<br>Fax: +358-9-7598 8500 |

*OTHER NUCLEAR ORGANIZATIONS*

**Nuclear Utility Companies**

| | |
|---|---|
| Imatran Voima Oy<br>00019 IVO | Tel.: +358-9-85 611<br>Fax: +358-9-8561 6961 |
| Teollisuuden Voima Oy<br>27160 OLKILUOTO | Tel. +358 2 3811<br>Fax +358 2 381 2109 |
| Posiva Oy<br>Annankatu 42 D<br>00100 HELSINKI | Tel.: +358 9 2280 3760<br>FAX: +358 9 2280 3719 |

**Research Centres**

| | |
|---|---|
| Geological Survey of Finland (GTK)<br>Betonimiehenkuja 4<br>02150 ESPOO | Tel.: +358-9-469 31<br>Fax: +358-9-462 205 |

Lappeenranta University of Technology (LTKK)
P.O. Box 20 | Fax +358 5 621 2350
53851 LAPPEENRANTA | Tel. +358 5 621 11

Meteorological Institute
P.O. Box 503 | Tel.: +358-9-192 91
00101 HELSINKI | Fax: +358-9-179 581

Technical Research Centre of Finland (VTT)
P.O. Box 1000 | Tel.: +358-9-4561
02044 VTT | Fax: +358-9-456 7000

University of Kuopio
P.O. Box 1627 | Tel. +358 17 162 211
70211 KUOPIO | Fax +358 17 163 230

University of Technology (TKK)
Otakaari 1 | Tel.: +358-9-4511
02150 ESPOO | Fax: +358-9-465 077

# FRANCE

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FRANCE

# 1. GENERAL INFORMATION

## 1.1. General Overview

France is situated in western Europe and is nearly hexagonal in shape, with an extreme length from north to south of about 965 km and a maximum width of about 935 km. The total area of metropolitan France, including the island of Corsica in the Mediterranean, is 552 000 km$^2$. In addition to European, or metropolitan France, the country includes several overseas departments, territorial "collectivises", and overseas territories. The climate of metropolitan France is generally temperate, but wide regional contrasts occur. The average annual temperature is about 10 degrees. Precipitation is evenly distributed throughout France, averaging about 760 mm annually.

France has a population of about 58 million and a population density slightly above 100 inhabitants per km$^2$ (Table 1). Population growth rate is around 0.5% per annum.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 45.7 | 50.8 | 53.9 | 56.7 | 57.5 | 57.7 | 0.5 |
| Population density (inhabitants/km$^2$) | 82.8 | 92.1 | 97.7 | 102.8 | 104.3 | 104.7 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.4 |
| Area (1000 km$^2$) | 551.5 |
| Urban population in 1993 as percent of total | 73.0 |

Source: IAEA Energy and Economic Data Base

France has sizeable deposits of various metals and some fossil fuel resources. However, owing to high recovery costs, production of fossil fuels has decreased to a rather low level and is not expected to provide a significant share of the country energy supply in the future. Most hydro power resources are already exploited. Therefore, the energy policy of France places high emphasis on increasing energy independence through the development of domestic technologies, including nuclear power, in order to alleviate the vulnerability of the country energy system to the volatility of fossil fuel international markets.

## 1.2. Economic Indicators

Table 2 shows the historical trend of Gross Domestic Product (GDP).

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 142,873 | 664,528 | 1,194,761 | 1,250,696 | 1,328,908 | 5.1 |
| GDP (millions of constant 1990 US$) | 686,491 | 950,201 | 1,194,761 | 1,206,942 | 1,241,043 | 1.9 |
| GDP per capita (current US$/capita) | 2,814 | 12,333 | 21,065 | 21,748 | 23,013 | 4.6 |

| GDP by sector : | |
|---|---|
| Agriculture | 3% |
| Industry | 29% |
| Services | 68% |

Source: IAEA Energy and Economic Data Base

The economic growth of France has been modest in the recent years, as in other Western European countries, with Gross Domestic Product (GDP) growth rates of 2.9 and 2.2% per annum in 1994 and 1995, respectively.

## 1.3. Energy Situation

The French energy reserves amounted to 43 Exajoules at the end of 1993 (Table 3).

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 6.74 | 0.80 | 1.51 | 8.33 | 25.64 | 43.02 |

[1] *This total represents essentially recoverable reserves.*
[2] *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1992) by a factor of 10.*
Source: IAEA Energy and Economic Data Base

Table 4 provides statistical data on energy and electricity supply and demand between 1960 and 1994 drawn from international statistics. It illustrates the trend to substituting nuclear power to imported fossil fuels and the progress in energy independence. National energy statistics for 1994 and 1995 confirm the trend of continuing increase of domestic share in the country energy supply. Since 1993, primary energy consumption remained stable at some 230 Mtoe and domestic production accounted for some 51.4% of that consumption in 1995. The energy balance improved in the last two decades owing mainly to the increase of electricity exports, that reached some 70 TW·h in 1995, and to the reduced imports of oil. The energy intensity has decreased owing to structural changes in the economy, i.e., reduction of the share of energy intensive industries in total Gross Domestic Product (GDP), and to a lesser extent to efficiency improvements.

## 1.4. Energy Policy

During the post World War II reconstruction period, the economic and social development of France relied mainly on the deployment of energy intensive industries. The rapidly increasing energy needs were partly met by domestic coal production and harnessing hydro power resources. However, recognising that its domestic fossil fuel resources were limited and costly, and taking into account the relatively low price of energy on international markets, France chose to rely heavily on imports for its energy supply. Nevertheless, energy independence has always been a long term objective of French energy policy. The implementation of a large nuclear power programme was a major element of this energy policy that included also energy saving measures, efficiency improvements and research and development in the field of renewable energy sources.

By 1973, imports were covering more than 75% of the energy consumption of France as compared with 38% in 1960. The two oil shocks of the 1970s stressed the importance of pursuing a policy aiming at substituting imported oil by domestic energy sources. This was successfully achieved within two decades mainly through enhanced energy efficiency and the development of nuclear energy. Nuclear power increased its share in primary energy supply of France from less than 2% in the late seventies to around one third in the mid nineties.

The macroeconomic impacts of the French energy policy include: a drastic improvement of the energy trade balance; the stability at a rather low level of domestic energy prices reinforcing the competitiveness of French industries on international markets; and the deployment of a nuclear industry sector covering reactor and fuel cycle activities.

The increasing awareness of environmental concerns has been reflected in the French choices of energy mixes aiming at reducing negative impacts of the energy sector on health and the environment. In this regard, substituting nuclear power to fossil fuel burning for electricity generation reduced drastically the atmospheric emissions from the energy sector.

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[(1)] | 3.68 | 6.56 | 8.41 | 8.73 | 9.07 | 8.78 | 4.22 | 0.31 |
| - Solids[(2)] | 2.01 | 1.79 | 1.70 | 1.10 | 0.76 | 0.77 | -0.86 | -5.50 |
| - Liquids | 1.16 | 3.79 | 4.46 | 3.51 | 3.54 | 3.29 | 6.99 | -2.14 |
| - Gases | 0.12 | 0.38 | 1.00 | 1.12 | 1.34 | 1.25 | 11.38 | 1.65 |
| - Primary electricity[(3)] | 0.39 | 0.60 | 1.25 | 2.99 | 3.44 | 3.47 | 6.02 | 7.55 |
| Energy production | | | | | | | | |
| - Total | 2.28 | 2.30 | 2.41 | 4.19 | 4.69 | 4.68 | 0.29 | 4.85 |
| - Solids | 1.67 | 1.30 | 0.81 | 0.53 | 0.43 | 0.38 | -3.52 | -5.36 |
| - Liquids | 0.10 | 0.12 | 0.09 | 0.14 | 0.14 | 0.14 | -0.74 | 3.20 |
| - Gases | 0.12 | 0.27 | 0.29 | 0.08 | 0.09 | 0.09 | 4.65 | -7.68 |
| - Primary electricity[(3)]) | 0.39 | 0.61 | 1.22 | 3.43 | 4.03 | 4.08 | 5.88 | 8.98 |
| Net import (import - export) | | | | | | | | |
| - Total | 1.54 | 4.63 | 6.39 | 5.33 | 5.18 | 4.98 | 7.37 | -1.77 |
| - Solids | 0.40 | 0.44 | 0.92 | 0.58 | 0.41 | 0.35 | 4.19 | -6.64 |
| - Liquids | 1.13 | 4.06 | 4.72 | 3.62 | 3.59 | 3.41 | 7.39 | -2.31 |
| - Gases | | 0.13 | 0.75 | 1.13 | 1.18 | 1.22 | 30.26 | 3.52 |

[(1)] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[(2)] *Solid fuels include coal, lignite and commercial wood.*
[(3)] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

The French electricity sector is highly centralised. The state-owned utility Electricité De France (EDF) has the main responsibility for production, transmission, distribution, import and export of electricity. EDF is also responsible for co-ordinating load dispatching. It owns and manages the transmission grid, and operates most nuclear, fossil-fuelled and hydro power plants. EDF has some 85-90% share in generation activities and a 95% share in electricity distribution.

The Generation and Transmission Division of EDF sells all available high-voltage electricity, either directly to 600 major customers, or to distribution networks (specialised EDF units or other private distributor), or foreign utilities. The Generation and Transmission Division of EDF buys electricity when it is proposed at prices competitive with electricity generated by the most expensive units operating at a given time. EDF is obliged by law to purchase all quantities of electricity proposed by authorized independent producers at an in advance specified price, in relation with EDF trarification rules and levels. The main independent suppliers are the French coal utility "Charbonnages de France" and manufacturers which have back-up or dual-purpose electricity-steam production units, as well as operators of small and medium size hydro-power plants.

For the time being, EDF holds a monopoly of electricity transmission and the French grid is not open to third parties. Most of the electricity consumed in France is distributed by EDF. Regarding distribution activities, local authorities grant the concession of well defined areas. There are about 200 distributing companies featuring municipality or joint ownership, with a 5% share of total electricity billing.

EDF is involved in activities abroad (e.g. in studies for Eastern European, Far Eastern and Latin American (Peru) countries) and is associated with foreign companies (e.g. with electricity distributors in Argentina (EDENOR) and thermal generators in Africa, Cote d'Ivoire).

### 2.2. Decision Making Process

The General Directorate for Energy and Raw Materials (DGEMP) which is under the Minister for Industry is responsible for implementing the French government policy on energy. It is responsible for authorising the construction and approving site licenses for power plants and transmission lines. The Minister for Finance is responsible for authorising capital expenditures and increases in electricity tariffs. The Minister for Environment and the Minister for Health are controlling health and environmental impacts of industrial facilities including energy production and transformation plants.

The state-owned utility, EDF, is the main investor in the power sector. The relationship between EDF and the State are defined in the contract "Contrat de Plan, setting the objectives to be met by EDF in a given period of time. One third of the EDF Management Board is occupied by French central administration representatives. The French government also appoints EDF's President. EDF's policy is designed by the company's experts and executives, conducted by the General Director and submitted to the Company's President and Management Board, who ascertain that it is consistent with the administration's general objectives and policy.

The central administration examines and approves EDF's investment programmes and makes decisions in connection with the technologies to be used for electricity generation; it also approves the construction of power plants and transmission lines. With regard to the costs of electricity generation by different types of power plants, a committee directed by the Minister for Industry, publishes a report every two to three years, which serve as a basis for establishing the policy of EDF in line with least cost planning.

With regard to nuclear safety, the Directorate for the Safety of Nuclear Installations (Direction de la Sureté des Installations Nucléaires - DSIN) is the main body responsible for studying, drawing up and implementing nuclear safety policy. DSIN reports to the Minister for Industry and to the Minister for Environment. With regard to radiation protection, the Board for Protection against Ionising Radiation (OPRI) under the joint supervision of the Minister for Health and the Minister for Labour, is in charge of controlling and monitoring radioactive emissions and releases in order to prevent hazards to the health of workers and population as a whole.

### 2.3. Main Indicators

Table 5 shows the historical electricity production and Table 6 the energy related ratios from EEDB. At present, over 90% of France's electricity is of nuclear and hydraulic origin, while the remaining 10% comes from coal and fuel oil. Electricity demand growth remained modest during the last two to three years; final electricity consumption increased by 3% and 1% in 1994 and 1995 respectively.

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

Historically, the development of nuclear power falls into four phases, closely corresponding with the periods of office of Presidents de Gaulle, Pompidou, Giscard d'Estaing and Mitterand, which is not coincidental, since the decisions regarding electricity system expansion rest mainly under the government responsibility.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITIES

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 72.12 | 146.79 | 245.71 | 420.13 | 471.45 | 475.62 | 6.32 | 4.83 |
| - Thermal | 31.64 | 83.86 | 118.91 | 64.10 | 53.35 | 52.81 | 6.84 | -5.63 |
| - Hydro | 40.34 | 57.22 | 68.86 | 58.32 | 67.89 | 81.02 | 2.71 | 1.17 |
| - Nuclear | 0.13 | 5.71 | 57.95 | 297.70 | 350.20 | 341.80 | 35.66 | 13.52 |
| - Geothermal | | | | | | | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 21.85 | 36.22 | 62.71 | 103.41 | 107.65 | 107.23 | 5.41 | 3.91 |
| - Thermal | 11.52 | 19.58 | 29.03 | 22.51 | 23.45 | 23.51 | 4.73 | -1.50 |
| - Hydro | 10.23 | 15.00 | 19.29 | 24.75 | 24.93 | 24.99 | 3.22 | 1.87 |
| - Nuclear | 0.10 | 1.65 | 14.39 | 55.92 | 59.03 | 58.49 | 28.40 | 10.53 |
| - Geothermal | | | | | | | | |
| - Wind | | | | 0.24 | 0.24 | 0.24 | | |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 80 | 129 | 156 | 154 | 158 | 152 |
| Electricity per capita (kW·h/capita) | 1,577 | 2,755 | 4,618 | 6,250 | 6,757 | 6,767 |
| Electricity production/Energy production (%) | 31 | 59 | 98 | 92 | 92 | 93 |
| Nuclear/Total electricity (%) | | 4 | 24 | 74 | 78 | 75 |
| Ratio of external dependency (%)[(1)] | 42 | 71 | 76 | 61 | 57 | 57 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 38 | 46 | 45 | 46 | 50 | 51 |
| - Thermal | 31 | 49 | 47 | 33 | 26 | 26 |
| - Hydro | 45 | 44 | 41 | 27 | 31 | 37 |
| - Nuclear | 15 | 40 | 46 | 61 | 68 | 67 |

[(1)] *Net import / Total energy consumption.*
Source: IAEA Energy and Economic Data Base

Under President de Gaulle, in line with the overall objective of a national policy aiming at independence and domestic technological development, indigenous reactor designs were promoted (mainly gas cooled reactors and fast breeders). However, a PWR unit (Chooz-A) was built jointly with Belgium and connected to the grid in 1967.

International developments in the nuclear industry led in the late sixties to the recognition that the French reactor designs could not compete with LWRs. In 1969, under President Pompidou, the decision was taken to build LWRs under license, whilst restructuring the domestic industry in an attempt to strengthen it and make it more competitive on international markets. Subsequently, the nuclear programme envisaged the commencement of construction of one or two PWRs every year.

From 1974 to 1981, under President Giscard d'Estaing, emphasis was put on adaptation of the American proven designs for the development of a French standardised design. The oil crisis of the 1970s accelerated the pace of the nuclear programme. The capacity of French designs increased from 900 MW(e) to 1,300 MW(e) and later to 1,450 MW(e). France developed and implemented, in parallel with the nuclear power plant programme, a strong domestic fuel cycle industry, that was built upon the infrastructure established by the CEA.

In 1981, Framatome terminated its license with Westinghouse and negotiated a new agreement which gave it greater autonomy. Framatome developed a wide range of servicing expertise and capabilities in reactor operation and maintenance services. In the same year, under President

Mitterand, France had to adapt its energy policy because of the lower than expected economic growth together with the occurrence of over capacity of the French electricity supply system. The Ministry of Research and Technology became responsible for the CEA and more emphasis was given to regional and local authorities.

In 1993, the French energy independence reached 51.8% as a result of nuclear power, compared to the energy dependence of 80% in 1970.

### 3.2. Current Policy Issues

The main objectives of the French nuclear policy at present are: optimising the utilisation of the existing equipment, i.e., power plants and fuel cycle facilities; designing and implementing a policy with regard to final disposal of high level radioactive waste; and development of the next generation of reactors.

The share of nuclear power in the French electricity system has practically reached its technical and economic maximum. At the end of the century, the number of plants installed in France could reach an output in commercial service of about 64,000 MW(e). It would be made up of sixty units, of which fifty-eight would be pressurised water reactors (34 PWR 900, 20 PWR 1300, 4 PWR 1450) and two fast breeder reactors, Phenix and Superphenix. A policy of flexible site management has been adopted in order to enable a development rate of one block per year, and, if necessary, to face up to an acceleration of this rate. To prepare decisions which could be taken in the next two to three years, EDF has already implemented procedures concerning the extension of existing sites and the search for new sites.

### 3.3. Status and Trends of Nuclear Power

Currently (year 1996), France has 54 nuclear power plants in operation, with an installed capacity of 60,000 MW(e) and generating 378.2 TW·h of electricity. The nuclear electricity generated by nuclear plants represented 77% of the total in 1996, making France the world's second largest nuclear electricity producer. There are also 3 units under construction accounting for 4,350 MW(e). Table 7 lists the status of the power plants as of yearend 1995. The nuclear electricity generation represents over one third of the total primary energy supply of the country, and over 80% of its domestic energy production.

With fifty-six units installed (end of 1995), of which thirty-four at the 900 MW(e) level and eighteen at the 1,300 MW(e) level, EDF confirmed its position as by far the number one nuclear operator in the world. The work in progress on the new 1,450 MW(e) series (as of beginning of 1997, one unit in operation and one unit under construction at the Chooz site and two units under construction on the Civaux site), vouch for the expertise of the French nuclear boiler manufacturer Framatome.

France is still the front runner for units of power output exceeding 1200 MW(e) on electric network, with nineteen units (21 PWR and one FBR), ahead of Germany (3 BWR and 11 PWR) and the United States (2 BWR and 11 PWR). Only Lithuania, in Eastern Europe, has two units on the electric network with a power output 1,500 MW(e), of type RBMK, on the site of Ignalina.

### 3.4. Organizational Chart

The main organizations responsible for the implementation of the French nuclear power programme are shown in Figure 1.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

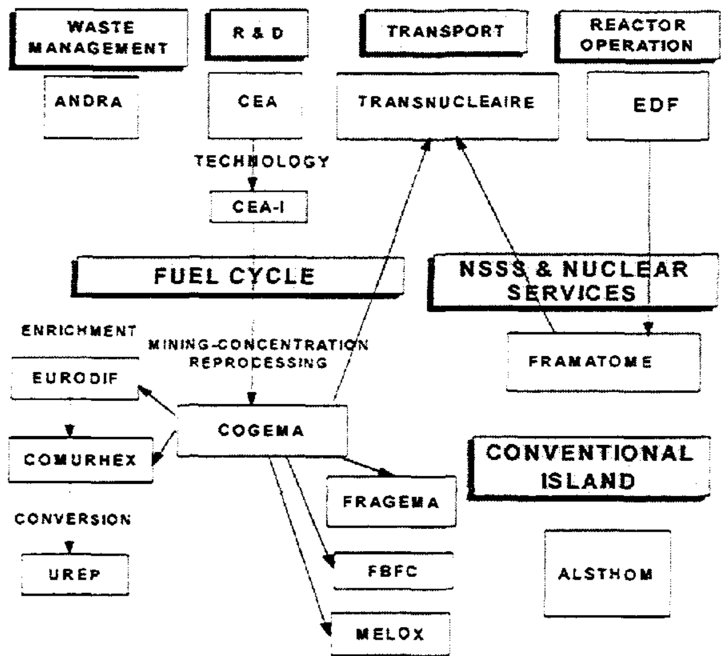
| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| BELLEVILLE-1 | PWR | 1310 | EDF | Operational | FRAM | 01-May-80 | 09-Sep-87 | 14-Oct-87 | 01-Jun-88 | |
| BELLEVILLE-2 | PWR | 1310 | EDF | Operational | FRAM | 01-Aug.-80 | 25-May-88 | 06-Jul.-88 | 01-Jan-89 | |
| BLAYAIS-1 | PWR | 910 | EDF | Operational | FRAM | 01-Jan-77 | 20-May-81 | 12-Jun-81 | 01-Dec.-81 | |
| BLAYAIS-2 | PWR | 910 | EDF | Operational | FRAM | 01-Jan-77 | 28-Jun-82 | 17-Jul.-82 | 01-Feb.-83 | |
| BLAYAIS-3 | PWR | 910 | EDF | Operational | FRAM | 01-Apr.-78 | 29-Jul.-83 | 17-Aug.-83 | 14-Nov.-83 | |
| BLAYAIS-4 | PWR | 910 | EDF | Operational | FRAM | 01-Apr.-78 | 01-May-83 | 16-May-83 | 01-Oct-83 | |
| BUGEY-2 | PWR | 920 | EDF | Operational | FRAM | 01-Nov.-72 | 20-Apr.-78 | 10-May-78 | 01-Mar-79 | |
| BUGEY-3 | PWR | 920 | EDF | Operational | FRAM | 01-Sep-73 | 31-Aug.-78 | 21-Sep-78 | 01-Mar-79 | |
| BUGEY-4 | PWR | 900 | EDF | Operational | FRAM | 01-Jun-74 | 17-Feb.-79 | 08-Mar-79 | 01-Jul.-79 | |
| BUGEY-5 | PWR | 900 | EDF | Operational | FRAM | 01-Jul.-74 | 15-Jul.-79 | 31-Jul.-79 | 03-Jan-80 | |
| CATTENOM-1 | PWR | 1300 | EDF | Operational | FRAM | 29-Oct-79 | 24-Oct-86 | 13-Nov.-86 | 01-Apr.-87 | |
| CATTENOM-2 | PWR | 1300 | EDF | Operational | FRAM | 28-Jul.-80 | 07-Aug.-87 | 17-Sep-87 | 01-Feb.-88 | |
| CATTENOM-3 | PWR | 1300 | EDF | Operational | FRAM | 15-Jun-82 | 16-Feb.-90 | 06-Jul.-90 | 01-Feb.-91 | |
| CATTENOM-4 | PWR | 1300 | EDF | Operational | FRAM | 28-Sep-83 | 04-May-91 | 27-May-91 | 01-Jan-92 | |
| CHINON-B1 | PWR | 905 | EDF | Operational | FRAM | 01-Mar-77 | 28-Oct-82 | 30-Nov.-82 | 01-Feb.-84 | |
| CHINON-B2 | PWR | 870 | EDF | Operational | FRAM | 01-Mar-77 | 23-Sep-83 | 29-Nov.-83 | 01-Aug.-84 | |
| CHINON-B3 | PWR | 905 | EDF | Operational | FRAM | 01-Oct-80 | 18-Sep-86 | 20-Oct-86 | 04-Mar-87 | |
| CHINON-B4 | PWR | 905 | EDF | Operational | FRAM | 01-Feb.-81 | 13-Oct-87 | 14-Nov.-87 | 01-Apr.-88 | |
| CREYS-MALVILLE | FBR | 1200 | NERSA | Operational | NOVATOME | 13-Dec.-76 | 07-Sep-85 | 14-Jan-86 | | |
| CRUAS-1 | PWR | 915 | EDF | Operational | FRAM | 01-Aug.-78 | 02-Apr.-83 | 29-Apr.-83 | 02-Apr.-84 | |
| CRUAS-2 | PWR | 915 | EDF | Operational | FRAM | 15-Nov.-78 | 01-Aug.-84 | 06-Sep-84 | 01-Apr.-85 | |
| CRUAS-3 | PWR | 880 | EDF | Operational | FRAM | 15-Apr.-79 | 09-Apr.-84 | 14-May-84 | 10-Sep-84 | |
| CRUAS-4 | PWR | 880 | EDF | Operational | FRAM | 01-Oct-79 | 01-Oct-84 | 27-Oct-84 | 11-Feb.-85 | |
| DAMPIERRE-1 | PWR | 890 | EDF | Operational | FRAM | 01-Feb.-75 | 15-Mar-80 | 23-Mar-80 | 10-Sep-80 | |
| DAMPIERRE-2 | PWR | 890 | EDF | Operational | FRAM | 01-Apr.-75 | 05-Dec.-80 | 10-Dec.-80 | 16-Feb.-81 | |
| DAMPIERRE-3 | PWR | 890 | EDF | Operational | FRAM | 01-Sep-75 | 25-Jan-81 | 30-Jan-81 | 27-May-81 | |
| DAMPIERRE-4 | PWR | 890 | EDF | Operational | FRAM | 01-Dec.-75 | 05-Aug.-81 | 18-Aug.-81 | 20-Nov.-81 | |
| FESSENHEIM-1 | PWR | 880 | EDF | Operational | FRAM | 01-Sep-71 | 07-Mar-77 | 06-Apr.-77 | 30-Dec.-77 | |
| FESSENHEIM-2 | PWR | 880 | EDF | Operational | FRAM | 01-Feb.-72 | 27-Jun-77 | 07-Oct-77 | 18-Mar-78 | |
| FLAMANVILLE-1 | PWR | 1330 | EDF | Operational | FRAM | 01-Dec.-79 | 29-Sep-85 | 04-Dec.-85 | 01-Dec.-86 | |
| FLAMANVILLE-2 | PWR | 1330 | EDF | Operational | FRAM | 01-May-80 | 12-Jun-86 | 18-Jul.-86 | 09-Mar-87 | |
| GOLFECH-1 | PWR | 1310 | EDF | Operational | FRAM | 17-Nov.-82 | 24-Apr.-90 | 07-Jun-90 | 01-Feb.-91 | |
| GOLFECH-2 | PWR | 1310 | EDF | Operational | FRAM | 01-Oct-84 | 21-May-93 | 18-Jun-93 | 01-Jan-94 | |
| GRAVELINES-1 | PWR | 910 | EDF | Operational | FRAM | 01-Feb.-75 | 21-Feb.-80 | 13-Mar-80 | 01-Dec.-80 | |
| GRAVELINES-2 | PWR | 910 | EDF | Operational | FRAM | 01-Mar-75 | 02-Aug.-80 | 26-Aug.-80 | 01-Dec.-80 | |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 7. CONTINUED, STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| GRAVELINES-3 | PWR | 910 | EDF | Operational | FRAM | 01-Dec.-75 | 30-Nov.-80 | 12-Dec.-80 | 01-Jun-81 | |
| GRAVELINES-4 | PWR | 910 | EDF | Operational | FRAM | 01-Apr.-76 | 31-May-81 | 14-Jun-81 | 01-Oct-81 | |
| GRAVELINES-5 | PWR | 910 | EDF | Operational | FRAM | 01-Oct-79 | 05-Aug.-84 | 28-Aug.-84 | 15-Jan-85 | |
| GRAVELINES-6 | PWR | 910 | EDF | Operational | FRAM | 01-Oct-79 | 21-Jul.-85 | 01-Aug.-85 | 25-Oct-85 | |
| NOGENT-1 | PWR | 1310 | EDF | Operational | FRAM | 26-May-81 | 12-Sep-87 | 21-Oct-87 | 24-Feb.-88 | |
| NOGENT-2 | PWR | 1310 | EDF | Operational | FRAM | 01-Jan-82 | 04-Oct-88 | 14-Dec.-88 | 01-May-89 | |
| PALUEL-1 | PWR | 1330 | EDF | Operational | FRAM | 15-Aug.-77 | 13-May-84 | 22-Jun-84 | 01-Dec.-85 | |
| PALUEL-2 | PWR | 1330 | EDF | Operational | FRAM | 01-Jan-78 | 11-Aug.-84 | 14-Sep-84 | 01-Dec.-85 | |
| PALUEL-3 | PWR | 1330 | EDF | Operational | FRAM | 01-Feb.-79 | 07-Aug.-85 | 30-Sep-85 | 01-Feb.-86 | |
| PALUEL-4 | PWR | 1330 | EDF | Operational | FRAM | 01-Feb.-80 | 29-Mar-86 | 11-Apr.-86 | 01-Jun-86 | |
| PENLY-1 | PWR | 1330 | EDF | Operational | FRAM | 01-Sep-82 | 01-Apr.-90 | 04-May-90 | 01-Dec.-90 | |
| PENLY-2 | PWR | 1330 | EDF | Operational | FRAM | 01-Aug.-84 | 10-Jan-92 | 01-Feb.-92 | 01-Nov.-92 | |
| PHENIX | FBR | 233 | CEA/EDF | Operational | CNCLNEY | 01-Nov.-68 | 31-Aug.-73 | 13-Dec.-73 | 14-Jul.-74 | |
| ST. ALBAN-1 | PWR | 1335 | EDF | Operational | FRAM | 29-Jan-79 | 04-Aug.-85 | 30-Aug.-85 | 01-May-86 | |
| ST. ALBAN-2 | PWR | 1335 | EDF | Operational | FRAM | 31-Jul.-79 | 07-Jun-86 | 03-Jul.-86 | 01-Mar-87 | |
| ST. LAURENT-B1 | PWR | 915 | EDF | Operational | FRAM | 01-May-76 | 04-Jan-81 | 21-Jan-81 | 01-Aug.-83 | |
| ST. LAURENT-B2 | PWR | 880 | EDF | Operational | FRAM | 01-Jul.-76 | 12-May-81 | 01-Jun-81 | 01-Aug.-83 | |
| TRICASTIN-1 | PWR | 915 | EDF | Operational | FRAM | 01-Nov.-74 | 21-Feb.-80 | 31-May-80 | 01-Dec.-80 | |
| TRICASTIN-2 | PWR | 915 | EDF | Operational | FRAM | 01-Dec.-74 | 22-Jul.-80 | 07-Aug.-80 | 01-Dec.-80 | |
| TRICASTIN-3 | PWR | 915 | EDF | Operational | FRAM | 01-Apr.-75 | 29-Nov.-80 | 10-Feb.-81 | 11-May-81 | |
| TRICASTIN-4 | PWR | 915 | EDF | Operational | FRAM | 01-May-75 | 31-May-81 | 12-Jun-81 | 01-Nov.-81 | |
| CHOOZ-B1 | PWR | 1455 | EDF | Operational | FRAM | 01-Jan-84 | 01-Jul.-96 | 30-Aug.-96 | 01-Jan-97 | |
| CHOOZ-B2 | PWR | 1455 | EDF | Under Construction | FRAM | 31-Dec.-85 | 01-Nov.-96 | 01-Jan-97 | 01-May-97 | |
| CIVAUX-1 | PWR | 1450 | EDF | Under Construction | FRAM | 15-Oct-88 | 01-Jun-97 | 01-Jun-97 | 01-Sep-97 | |
| CIVAUX-2 | PWR | 1450 | EDF | Under Construction | FRAM | 01-Apr.-91 | 01-Jul.-98 | 01-Nov-98 | 01-Feb.-99 | |
| BUGEY-1 | GCR | 540 | EDF | Shut Down | VARIOUS | 01-Dec.-65 | 21-Mar-72 | 15-Apr.-72 | 01-Jul.-72 | 27-May-94 |
| CHINON-A1 | GCR | 70 | EDF | Shut Down | LEVIVIER | 01-Feb.-57 | 16-Sep-62 | 14-Jun-63 | 01-Feb.-64 | 16-Apr.-73 |
| CHINON-A2 | GCR | 210 | EDF | Shut Down | LEVIVIER | 01-Aug.-59 | 17-Aug.-64 | 24-Feb.-65 | 24-Feb.-65 | 14-Jun-85 |
| CHINON-A3 | GCR | 480 | EDF | Shut Down | GTM | 01-Mar-61 | 01-Mar-66 | 04-Aug.-66 | 04-Aug.-66 | 15-Jun-90 |
| CHOOZ-A(ARDENNES) | PWR | 310 | SENA | Shut Down | A/F/W | 01-Jan-62 | 18-Oct-66 | 03-Apr.-67 | 15-Apr.-67 | 30-Oct-91 |
| EL-4 (MONTS D'ARREE) | HWGCR | 70 | EDF | Shut Down | GAAA | 01-Jul.-62 | 23-Dec.-66 | 09-Jul.-67 | 01-Jun-68 | 31-Jul.-85 |
| G-2 (MARCOULE) | GCR | 38 | COGEMA | Shut Down | SACM | 01-Mar-55 | 21-Jul.-58 | 22-Apr.-59 | 22-Apr.-59 | 02-Feb.-80 |
| G-3 (MARCOULE) | GCR | 38 | COGEMA | Shut Down | SACM | 01-Mar-56 | 11-Jun-59 | 04-Apr.-60 | 04-Apr.-60 | 20-Jun-84 |
| ST. LAURENT-A1 | GCR | 480 | EDF | Shut Down | VARIOUS | 01-Oct-63 | 07-Jan-69 | 14-Mar-69 | 01-Jun-69 | 18-Apr.-90 |
| ST. LAURENT-A2 | GCR | 515 | EDF | Shut Down | VARIOUS | 01-Jan-66 | 04-Jul.-71 | 09-Aug.-71 | 01-Nov.-71 | 27-May-92 |

Source: IAEA Power Reactor Information System, yearend 1996



[Source] D3E-GIDE 03/1993

*FIG. 1. Main actors of the French Nuclear Programme*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Suppliers of NPPs

The plant supply industry for the PWRs is based around the state-owned company Framatome, which supplies the nuclear island, and Alsthom, which supplies the conventional island. There have been changes in the ownership and scope of business of these companies as they expanded to meet the needs of the large ordering for the French programme in the last decade. Through its subsidiary Novatome (Nira/Nucléare Italiana Reattori Avanzati Novatome/Novatone), Framatome plays a similar role concerning fast breeder reactors.

Adjustments within the French nuclear industry were triggered by world recession, which depressed demand for electricity while the decrease in fossil fuel prices, reduced the competitiveness of nuclear generated electricity and reduced export orders for nuclear power plants.

In 1981, Framatome terminated its licence with Westinghouse and negotiated a new agreement which gave it greater autonomy. Framatome developed a wide range of expertise and capabilities in reactor operation and maintenance services. Framatome's ownership pattern is currently 36% by CEA, 11% by EDF, 44% by Alcatel-Alsthom, 4% by Credit-Lyonnais and 5% by Framatome staff.

### 4.2. Operators of NPPs

The French electricity supply industry is organized on the basis of a central actor, Electricité de France (EDF), which dominates the electricity sector. EDF was nationalised in 1946 (along with the national coal, oil and gas companies) and it supplies all electricity sold to final consumers. In terms of capacity of plants owned, EDF is the largest utility in the world.

EDF owns and operates all the French PWR nuclear power plants and is one of the shareholders of the French nuclear power plant designer and manufacturer, Framatome. It is worth mentioning that EDF operates fifty-six units and is the number one nuclear operator in the world.

### 4.3. Fuel Cycle and Waste Management Service Supply

The Ministry of Research and Technology became responsible for the Commissariat a l'Ėnergie Atomique (CEA). CEA is the sole owner of the Compagnie génerale des matières nucléaires (Cogema) which controls all the industrial fuel cycle activities with the exception of waste management and disposal which is under the responsibility of an independent public agency (ANDRA). CEA is an industrial and commercial leader in all phases of the fuel cycle, including prospecting and working of uranium mines, enrichment, fuel fabrication, reprocessing, and packaging and storage of waste.

### 4.4. R&D Activities

As with the other pioneers of nuclear power, such as the USA and the United Kingdom, the French government created a national body, the CEA, with wide responsibilities for developing all aspects of atomic energy including both civil and military applications. Although its responsibilities have changed through time, CEA has retained more of its early responsibilities and interests, notably the reactors' design and safety regulators; the development of the fuel cycle, which has been more comprehensive and on a larger scale than in other countries, has remained under its control through subsidiaries, such as Cogéma.

### 4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

France is member of several international organizations, including the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD) as well as other bilateral and multilateral organizations such as the World Association of Nuclear Operators (WANO).

## 5. NUCLEAR LAWS AND REGULATIONS

### 5.1. Safety Authority and the Licensing Process

Nuclear legislation in France does has developed in successive stages in line with technological advances and growth in the atomic energy field. Therefore, many of the enactments governing nuclear activities are to be found in the general French legislation on environmental protection, water supply, atmospheric pollution, public health and labour.

Nevertheless, Parliament has adopted a number of specific nuclear Acts. Examples include Act No. 68-493 of 30 October 1968 laying down special rules as to third party liability in the field of nuclear energy (different from the ordinary French law on third party liability), the Act of 19 July 1952, now embodied in the Public Health Code specifying licensing requirements for the use of radioisotopes, Act No. 80-572 of 25 July 1980 on the protection and control of nuclear materials, and more recently Act No. 91-1381 concerning research on radioactive waste management.

Although French nuclear law is characterised by its variety of sources, as in other countries where nuclear energy has developed, the original features of this legislation derive chiefly from international recommendations or regulations. For example, radiation protection standards are derived from the Recommendations of the International Commission on Radiological Protection (ICRP) and Directives issued by the European Union (formerly the European Communities). Likewise, the French Act of 1968 on the liability of nuclear operators is directly derived from the Paris Convention of 29 July 1960.

French nuclear legislation began to develop from the time the Atomic Energy Commission (*Commissariat à l'énergie atomique* - CEA), a public establishment set up by the State in 1945 [Ordinance No. 45-2563 of 18 October 1945] and formerly reporting directly to the Head of Government, no longer held a monopoly for nuclear activities, in other words from the time nuclear energy applications entered the industrialisation stage, thus requiring the involvement of other electricity-generating and industrial nuclear operators. This development had several landmarks: in 1963, a system for licensing and controlling major nuclear installations was introduced, making central government responsible for decisions taken to ensure the safety of the population and workers (Decree of 11th December 1963). Prior to this, procedures concerning the licensing and control of industrial activities had been dealt with by the *Préfet* for each *Département*. In 1973, this system was expanded to cover the development of the nuclear power programme, and the role of the authorities was clearly defined then. Finally, the Decree of 20 June 1966 made Euratom Directives part of French radiation protection legislation.

Since that time, technological advances have continued to be made in nuclear science. In the course of the 1980s, the enactments setting up the CEA were amended so as to strengthen its interministerial status and to back up the Atomic Energy Committee, which acts as a restricted interministerial committee on nuclear energy matters, by a tripartite Board of Administration including staff representatives. The CEA is now answerable to the Minister of Industry, Post and Telecommunications and foreign Trade (Minister of Industry) and to the Minister for Higher Education and Research (Minister for Research) [Decrees No. 93-1272 of 1 December 1993 and No. 93-796 of 16 April 1993]. The main task of the CEA was laid down in September 1992 by the Government: to concentrate on developing the control of the atom for purposes of energy, health, defence and industry, while remaining attentive to the requests made by its partners in industry and research.

The regulations for large nuclear installations, referred to above, have been supplemented with regard to procedures by an Instruction of 27th March 1973 and a Decision of the same date (amended by a Decision of 17th December 1976), which are internal instruments issued by the Minister for Industry. The authorities primarily involved in the licensing procedure for the setting up of large nuclear installations are the Minister for Industry and the Minister for the Environment. The consent of the Minister for Health is requested.

In 1973, within the Ministry of Industry, the Central Service for the Safety of Nuclear Installations - (SCSIN ) was set up, renamed the Directorate for the Safety of Nuclear Installations (Direction de la Sureté des Installations Nucléaires (DSIN).

DSIN is mainly responsible for:

i) studying problems raised by site selection;
ii) establishing the procedures for licensing large nuclear installations (licenses for setting up, commissioning, disposal, etc.);
iii) organizing and directing the control of these installations by the inspectors of large nuclear installations;
iv) drafting general technical regulations and following their implementation;
v) establishing plans in the event of an accident in a large nuclear installation, enabling it to intervene in the framework of the Minister of Industry's responsibilities and in accordance with the Prime Minister's instructions;
vi) proposing and organizing public information on nuclear safety.

At the local level, the DSIN's actions are relayed through the nuclear divisions of the Regional Directorates for Industry, Research and the Environment (DRIRE). These Directorates are mainly responsible for inspecting nuclear installations, monitoring reactor unit shut-downs and all pressurised components, and also provide technical support to the préfet, the Government representative, in particular in case of an accident.

The DSIN is assisted in its decisions mainly by the Institute for Protection and Nuclear Safety (Institute de protection et de sureté nucleaire - IPSN), set up in 1976 within the Atomic Energy Commission (CEA). A recent reorganization strengthened the independence of the IPSN's safety experts. The Institute may also undertake studies, research and work on protection and nuclear safety requested by all ministerial departments and agencies concerned.

The central service for protection against ionising radiation (Office de Protection contre les Rayonnements Ionisants, OPRI) is responsible for carrying out any measurement or analytical work necessary to determine the level of radioactivity or ionising radiation in the various types of environment where it might lead to hazards to the health of individuals or the population as a whole. It co-ordinates and defines controls for the radiation protection of workers and is involved in the plans to be put in effect in the event of radioactive incident.

The licensing procedure proper is governed by Decree No. 63-1128 of 11 December 1963 and aims to authorise the setting up of installations. Under this procedure the Decree authorising the setting up of an installation lays down the technical requirements and the other formalities with which its operator must comply. For nuclear reactors, for instance, there are generally two stages: firstly fuel loading and commissioning tests, and secondly the entry into operation - both conditional on approval being given jointly by the Ministers for Industry and the Environment.

### 5.2. Main National Laws and Regulations

***Organization and structure***

- Decree Nr. 68-852 of 1968 modified the composition of the Atomic Energy Committee.
- Decree Nr. 69-724 of 1969 determined the powers and duties of the Ministry of Industrial and Scientific Development.
- Decree Nr. 70-878 dated September 29,1970 establishing powers and duties and organization of the Commissariat a L'Énergie Atomique (CEA) and Regulatory
- Decree Nr. 72-11582 of 1972. Further amended in 1981, 1982 and 1984.
- Decree Nr. 71-279 of 1971 provided for the creation of the National Institute for the Physics of Nuclear Energy and Particles.
- Decree Nr. 84-667 of 1984 amended the By-laws of said Institute. Further amendments by decrees of 1981 and 1987.
- Decree of 1973 providing for the creation of the Superior Council of Nuclear Safety and Central Service of Safety for Nuclear Installations, further amended in 1977, 1981 and 1987.
- Decree of 1973 appointing a General Delegate on Energy.
- Decree of 1975 providing for the formation of an Interministerial Committee of Nuclear Safety.
- Resolution of 1975 related to the creation of an Institute of Basic Research within the CEA.
- Decree of 1975 related to basic tariffs of nuclear installations.
- Resolution of 1976 providing for the establishment of the Institute for Protection and Nuclear Safety. Further amended by resolutions dated October 29, 1981 and May 28, 1990.
- Resolution of 1979 related to the creation of a Federal Agency for Radioactive Waste Management. Amended by resolution of 1984.
- Decree Nr. 81-300 of 1981 authorising the CEA and COGEMA (Compagnie Generale de Matières Nucléaires) to intervene in matters of mineral substances and fossils.
- Decree of 1981 related to the organization of the Ministry of Research and Technology.
- Resolution of 1984 establishing a Commission on Radioactive waste management under the CEA.
- Decree related to the creation of a School of Technological Risk Prevention (1989).
- Determination of Jurisdiction of the Ministry of Industry in nuclear matters.

***Protection against radiation***

- Decree Nr. 67-228 of 1967 related to protection of workers against ionising radiation risks; substituted by Decree of 1986 on the same subject.

- Decree Nr. 66-450 of 1966 enforcing basic protection rules against Euratom radiation. Further amended by Decree of 1988.
- Resolution of 1967 providing for the creation of the Commission for Protection against Ionising Radiation.
- Resolutions of 1968 related to protection of workers against ionising radiation's and enforcement of 1967 Decree. Resolution of 1987 ratified these resolutions.
- Decree Nr. 69-50 of 1969 concerning survey procedures to determine contamination levels of surface waters.
- Decree Nr. 75-306 of 1975 related to protection of workers against ionising radiation hazards in basic nuclear installations. Regulatory decrees. Further amended by Decree of 1988.
- Decree of 1972 related to the creation of a Defence Body for Civil Protection.
- Resolution of 1977 related to professions requiring special health regulations.
- Resolutions dealing with the definition of control methods established by Decree of 1986 related to protection of workers against ionising radiation hazards (1990).

***Regulatory regime for nuclear installations***

- Resolutions dated December 6, 1966 and January 25, 1967 defining nuclear installations.
- Decree Nr. 67-964 of 1967 revised the nomenclature of hazardous, unhealthy and uncomfortable facilities.
- Decree Nr. 70-440 of 1970 revoked the authorisation regime for nuclear plants and thermoelectric plants authorised by Decree of October 30, 1935.
- Directive of 1970 related to the construction of shielding spheres in nuclear reactors.
- Decree dated December 11, 1963 related to basic nuclear installations, further amended by Decree of March 27, 1973.
- Decrees of 1974 related to refuse of liquid and gaseous radioactive effluents coming from basic nuclear installations.
- Resolution dated February 16, 1974 related to the application of regulations on pressure equipment for pressurised water nuclear reactors. Amended by Resolution dated December 6, 1974 and further amended by circular of August 5, 1977.
- Law Nr. 76-662 of 1976 related to facilities for environment protection.
- Resolution and Circular of 1984 concerning number, building concept and operation of basic nuclear installations.

***Regulatory regime for radioactive matters***

- Resolution of 1977 related to the regime of assistance to prospect uranium.
- Law of 1980 on control and protection of nuclear matters. Further amended in 1989.
- Decree of 1981 related to the control and protection of nuclear matters.
- Resolutions of 1981 related to techniques for surveillance and compatibility of nuclear matters.
- Resolution of 1984 related to nuclear elements subject to be declared.

***Radioactive waste management***

- Resolution of 1979 related to the creation of ANDRA.
- Decree of 1982 related to the publication of amendments to Annexes I and II of the 1972 London Convention.
- Law of 1991 on radioactive waste management.

***Environment Protection***

- Law Nr. 76-662 of 1976 related to classified installation for environment protection.
- Law of 1976 related to the protection of nature and its regulatory Decree.

- Decree of 1977 related to the information to be provided in respect of wastes susceptible of causing damage.
- Enforcement of the Paris Convention and Barcelona Convention related to sea contamination (1978).
- National regulation related to radioactive waste (1980).
- Decree of 1982 related to the publication of Annexes I and II of the 1972 London Convention.
- Circular of 1984 related to classified installations for environment protection.
- 1987 Circular referred to inspections of classified installations for environment protection.

*Civil Liability*

- Law Nr. 68-943 of 1968 on nuclear civil liability. Further amended in 1991.
- Decree Nr. 69-154 of 1969 related to the publication of the Paris Convention.
- Decree of 1973 related to the insurance and reinsurance of exceptional and nuclear risks by the Reinsurance Central Fund.
- Decree of 1979 concerning two decisions of exclusion from the AEN Committee of Directors.
- Decree related to the characteristics of reduced risks-safe installations (1991).

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Voluntary offer<br>INFCIRC No: 290 | Entry into force: | 12 September 1981 |

*OTHER MULTILATERAL SAFEGUARDS AGREEMENTS*:

| | | |
|---|---|---|
| • Japan/France<br>INFCIRC/171 | Entry into force: | 22 September 1972 |
| • Republic of Korea/France<br>INFCIRC/233 | Entry into force: | 22 September 1975 |
| • Pakistan/France<br>INFCIRC/239 | Entry into force: | 18 March 1976 |
| • South Africa/France<br>INFCIRC/244 | Entry into force: | 5 January 1977 |
| • Improved procedures for designation of safeguards inspector | Accepted on: | 6 April 1989 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 3 August 1992 |
| • EURATOM | Member | |
| • Agreement on privileges and immunities | Entry into force: | Non-Party |
| • Convention on physical protection of nuclear material | Entry into force: | 6 October 1991 |

| | | |
|---|---|---|
| • Convention on early notification of a nuclear accident | Entry into force: | 6 April 1989 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 6 April 1989 |
| • Conventions on civil liability for nuclear damage and joint protocol | Entry into force of<br>Paris Convention<br>Signature: | <br>9 March 1966<br>21 June 1989 |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | Summary: Generally positive; will take into account for own regulations; compatible with national regulations. letter of | 9 August 1988 |
| • Nuclear Suppliers Group | Member | |

*BILATERAL AGREEMENTS*

## REFERENCES


[1] Annual report of CEA.

[2] Annual report of COGEMA.

[3] Annual report of EdF.

[4] Annual report of FRAMATOME.

## ANNEX I. DIRECTORY OF THE MAIN ORGANISATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Commissariat a l'Énergie Atomique (CEA) | |
| 31-33 rue de la Fédération | Tel.: 4056 1000 or 4056 + Ext. |
| F-75752 Paris Cedex 15 | Telex: ENAT PARIS |
| France 200671 | Cable: ENERGAT |

The following institutes are within the CEA:

- Institute National des Sciences et des Techniques Nucléaires (INSTN)
- National Nuclear Science and Technology Institute (also under the Ministry of Education)
- Institute de Protection et de Sûreté Nucléaire (IPSN)
- Nuclear Safety Protection Institute

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Comité interministériel de la | |
| Sécurité Nucléaire | |
| 13, rue de Bourgogne | |
| 75007 Paris | Tel.: +331-4319 5678 |
| | |
| Direction de la Sûreté des | |
| Installations Nucléaires (DSIN) | |
| 99 rue de Grenelle | |
| 75353 Paris 07 | Tel.: +331-4319 3636 |
| (Under Ministry of Industry) | |
| | |
| or: 60-68 av. du Général-Leclerc | |
| B.P. 6 | Tel.: .+331-4654 7080 |
| F-92265 Fontenay aux Roses | Fax: +331-4253 6904 |
| | |
| Office de Protection contre | |
| les Rayonnements Ionisants (OPRI) | |
| 31, rue de l'Ecluse | Tel.: +331-3015 5200 |
| B.P. 35 | Fax: +331-3976 0896 |
| 78110 Le Vesinet | Telex: 696257 |
| (Under Ministry of Health) | |
| | |
| Agence Nationale pour la Gestion | |
| des Déchets Radioactifs (ANDRA) | |
| Parc de la Croix Blanche | |
| 1-7, rue Jean Monnet | Tel.: +331-4611 8000 |
| 92298 Chatenay-Malabry Cedex | Fax: +331-4611 8268 |

*OTHER ORGANIZATIONS IN THE NUCLEAR INDUSTRY*

| | |
|---|---|
| Electricité de France (EDF)<br>2 rue Louis Mural<br>75384 Paris Cedex 08 | Tel.: +331-4042 2222<br>Fax: +331-4042 1332 |
| Compagnie Générale des Matières<br>Nucléaires (COGEMA)<br>2 rue Paul Dautier<br>B.P. 4<br>F-78141 Velizy Cedex | Tel.: +331-3926 3000<br>Fax: +331-3926 2700 |
| FRAMATOME<br>Tour-Framatome<br>La Defense<br>F-92084 Paris la défense cedex<br>France | Tel.: +33 1 47 96 1414<br>Fax.: +33 1 47 96 0102 |

# GERMANY

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# 1. GENERAL INFORMATION

## 1.1. General Overview

Germany is situated in central Europe, bounded on the north by the North Sea, Denmark, and the Baltic Sea; on the east by Poland and the Czech Republic; on the south by Austria and Switzerland; and, on the west by France, Luxembourg, Belgium, and the Netherlands. It is known officially as the Federal Republic of Germany (Bundesrepublik Deutschland).

The climate of Germany is moderate and influenced by winds from the West, the eastern part of Germany stronger determined by continental character. In the lowland of the northern part of Germany the average July temperature is 16 - 18°C, the average precipitation amounting to 600 - 750 mm per annum.

Germany was a unified nation for 74 years (1871 - 1945), but was divided after World War II into the Federal Republic of Germany (FRG; commonly known as West Germany) and the German Democratic Republic (GDR; commonly known as East Germany). In October, 1990, East Germany became part of the FRG, and Germany once again became a unified nation

The German territory extends over 356,755 square kilometres. After reunification Berlin with a population of 3,420,600 (1990 estimate) became again the capital of Germany. The government, however, still largely resides in the old capital of the former West Germany, Bonn (population 289,500). The total population is about 81 million and the population density is about 225 inhabitants per square kilometer (Table 1).

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1993 |
|---|---|---|---|---|---|---|---|
| Population FRG/Germany (millions) | 55.4 | 60.7 | 61.6 | 61.3 | 80.9 | 81.3 | 2.1 |
| Population former GDR (millions) | 17.2 | 17.1 | 16.7 | 16.2 | | | |
| Pop. dens. FRG/Germany (inh./km²) | 223.0 | 244.0 | 247.7 | 246.7 | 325.3 | 327.0 | |
| Pop. dens. former GDR (inh./km²) | 159.4 | 157.7 | 154.7 | 150.2 | | | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.2 |
| Area (1000 km²) FRG | 248.6 |
| former GDR | 108.2 |
| Germany | 356.8 |
| Urban population in 1993 as percent of total | 86.0 |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

The historical Gross Domestic Product (GDP) statistics are given in Table 2. Up to 1990, they are given for the separate republics and from 1992 on for the unified republic. Reunification has been a difficult process. Germany has had to shoulder taxes to fund improvements in infrastructure, environment, and industry in the eastern part, while many eastern enterprises have collapsed in the face of western competition.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP FRG (millions of current US$) | 184,508 | 809,703 | 1,501,021 | 1,712,937 | 1,834,927 | 6.0 |
| GDP former GDR (millions of current US$) | 40,063 | 134,301 | 170,821 | | | |
| GDP FRG (millions of constant 1990 US$) | 930,978 | 1,217,099 | 1,501,021 | 1,557,328 | 1,834,927 | 1.9 |
| GDP former GDR (millions of const. 1990 US$) | 101,268 | 161,301 | 170,821 | | | |
| GDP per capita FRG (current US$/capita) | 3,042 | 13,152 | 24,477 | 21,185 | 22,576 | 3.7 |
| GDP per capita former GDR (current US$/capita) | 2,349 | 8,034 | 10,513 | | | |

| GDP by sector (1991): | |
|---|---|
| Agriculture | 1% |
| Industry | 38% |
| Services | 61% |

Source: IAEA Energy and Economic Data Base

## 1.3. Energy Situation

The Federal Republic of Germany imported 66% of its primary energy requirements in 1994, including oil, which accounts for 53% of its final energy consumption. There are substantial reserves of both hard coal (1993 proven reserves of 44,000 million Mt) and lignite (proven reserves for eastern and western Germany of 102,000 million Mt). See Table 3, as far as estimated energy reserves are concerned. However, domestic hard coal is more expensive than imported coal and expansion of open cast lignite mining is restricted by environmental considerations.

TABLE 3. ESTIMATED ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 1301.02 | 2.60 | 10.31 | 0.21 | 11.57 | 1325.71 |

[1] This total represents essentially recoverable reserves.

[2] For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.

Source: IAEA Energy and Economic Data Base

Most of the coal mines are in the western part of the country and 50% of their output is now taken by the electricity supply industry. Coal fired power stations are concentrated in the mining areas, and, most of them have a capacity below 600 MW(e). The historical energy statistics are given in Table 4.

## 1.4. Energy Policy

The central aim of the German energy policy, over the past decade, has been successful in moving electricity production away from imported oil and gas toward indigenous coal and nuclear power. The share of oil and gas in electricity production has been reduced from the peak of 30% in 1975 to 8% in 1994, while over the same period, the nuclear power share has grown from 9% to 36%, and that of coal has remained at around 50%. In 1987, the nuclear power stations provided 11% of primary energy.

During the 1980's, the rate of growth in demand for electricity fell well below that of the previous decade and in 1982 demand actually dropped. Electricity consumption was affected by reduction in economic activity, energy conservation, and political intervention (aimed at moving heating load from electricity to gas) in electricity pricing.

In the retail electricity market, current policy promotes the utilisation of renewable energy sources. The Federal Government requires electric companies to purchase the energy generated by independent producers who use renewable energy sources and determines minimum prices for these transactions.

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 6.3(2.9) | 9.9(3.1) | 11.6(3.8) | 11.5(3.7) | 13.80 | 13.45 | 3.06 | 1.07 |
| - Solids[2] | 4.9(2.8) | 4.0(2.6) | 3.5(2.5) | 3.3(2.5) | 4.20 | 3.66 | -1.68 | 0.40 |
| - Liquids | 1.3(0.1) | 5.1(0.4) | 5.4(0.8) | 4.5(0.7) | 5.30 | 5.36 | 7.41 | -0.10 |
| - Gases | 0.0(0.0 | 0.6(0.0) | 2.1(0.3) | 2.2(0.3) | 2.69 | 2.82 | 24.78 | 2.24 |
| - Primary electricity[3] | 0.2(0.0) | 0.3(0.0) | 0.6(0.1) | 1.5(0.1) | 1.61 | 1.62 | 6.85 | 7.06 |
| Energy production | | | | | | | | |
| - Total | 5.6(2.6) | 5.2(2.4) | 5.2(2.5) | 5.4(2.7) | 6.08 | 5.80 | -0.42 | 0.80 |
| - Solids | 5.3(2.6) | 4.3(2.3) | 3.7(2.3) | 3.2(2.5) | 3.73 | 3.44 | -1.69 | -0.59 |
| - Liquids | 0.2(0.0) | 0.3(0.0) | 0.2(0.0) | 0.2(0.0) | 0.13 | 0.12 | -0.34 | -4.00 |
| - Gases | 0.0(0.0) | 0.5(0.0) | 0.7(0.1) | 0.5(0.1) | 0.63 | 0.63 | 16.68 | -0.36 |
| - Primary electricity[3]) | 0.1(0.0) | 0.2(0.0) | 0.6(0.1) | 1.5(0.1) | 1.60 | 1.61 | 7.85 | 7.73 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.6(0.3) | 4.8(0.7) | 6.8(1.2) | 6.4(1.0) | 8.08 | 8.24 | 12.54 | 1.36 |
| - Solids | -0.5(0.2) | -0.4(0.3) | -0.2(0.2) | 0.1(0.1) | 0.38 | 0.42 | -3.80 | -3.97 |
| - Liquids | 1.2(0.1) | 5.1(0.4) | 5.6(0.8) | 4.5(0.7) | 5.49 | 5.51 | 8.13 | -0.17 |
| - Gases | | 0.1(0.0) | 1.4(0.2) | 1.7(0.2) | 2.20 | 2.31 | -31.80 | 3.52 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
* *Numbers in brackets refer to former GDR data*
Source: IAEA Energy and Economic Data Base

Direct government subsidies for the installation of aero-generators and photovoltaic generators with the guarantee of a minimum purchase price for produced electricity, at the present time, are not viable options for a the large scale generation of electricity. Large scale electricity production will continue to come from Germany's coal and nuclear power plants.

In the past, the government encouraged the electric utilities to enter into contracts to increase amounts of hard coal for electricity generation, which rose to 45 million tons per year in 1995. Up to July 1994, there was a specific help for hard coal through a levy on electricity consumers which amounted to approximately 10 billion DM per annum. Now it is replaced by subsidies from the federation and the states which will be reduced continuously in the forthcoming years.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Germany's federal political organization, distinguished by the autonomy of regional and local governments (states and municipalities) together with the historical development process of the country's electricity supply industry have created a complex institutional framework. The apparent fragmentation of the electricity supply industry and the intricate network of facility ownerships are the key elements in this complex framework.

Electricity services are provided primarily by four different types of entities:

- Nine supraregional companies (Verbundunternehmen) account for the majority of power generation, own and operate the high voltage transmission network, have direct supply contracts with large industrial customers, but formally have almost no participation in electricity distribution to small users.

- 60 regional companies (Regionalunternehmen) throughout Germany are mainly devoted to electricity distribution acquired from the supraregional companies. In many cases, they take care of other public services rendered through networks (telecommunications, gas, distributed heat).

- 900 local companies (Stadtwerke) distribute electricity in urban areas, although they might have self-generation from co-generation power plants (electricity and heat) using urban waste.

- Companies devoted solely to power generation (three in 1991) are established by association with the above electricity companies, to construct and operate new power plants.

Among the group of electricity suppliers are a number of self-producers, co-generators and independent producers using renewable power sources, which are specifically promoted and whose generation surplus must be purchased by the companies providing the public service.

Germany has private, mixed (private and state), and state-owned companies. In 1990, the Federal Government owned most of the distribution companies (438) holding 95% of their capital stock. These companies make up only 23% of the country's electricity sales. The most significant companies are those with mixed private and state-owned capital with 63% share of the total sales. Least significant are private companies (at least 75% of their capital stock held by private investors) with 15% of total sales.

The institutional framework consists of regulatory entities at federal, provincial (Länder) and municipal levels. There are three Ministries at the federal level: Ministry for Economy, responsible for the energy policy; Ministry for the Environment, Nature Conservation and Nuclear Safety, in charge of regulating environmental and safety standards; and, Ministry for Education, Science, Research and Technology. Electric companies are also subject to the control of Antitrust Commission, which oversees that the companies do not use their monopoly status for the detriment of their customers. The electricity and gas companies were initially, in 1957, excluded from antitrust regulations. However, in light of the monopolistic nature of the networks, legislation was amended in 1980 and 1990 to control the companies' possible abuse resulting from their monopoly position in the market place.

Regional governments participate in regulating and controlling electricity companies, and are autonomous to some extent, to establish their own energy and environmental policies. Regional and local governments have a wide range of participation in the electricity supply industry from fulfillment of their regulatory activities to active involvement in the ownership and management of electricity companies. Municipalities also participate in environmental protection. From the very beginning, municipalities have been involved in electricity supply.

Germany's legal framework recognises the uniqueness of network distributing industries, such as electricity and gas. The law applicable to these industries was enacted in 1935. It grants to government agencies a supervisory function over electricity development and marketing.

At the provincial level, the states (Länder) play a significant role in regulating electricity services, although the federal government is in charge of national policies. The Länder grant licenses to companies interested in providing electricity service within their jurisdiction. These companies are given monopolistic rights in exchange for their commitments to meet electricity demand and ensure public safety. Licenses are granted by local governments for 20 year periods.

Supraregional companies (responsible for 75% of electricity generation and 100% of the high voltage transmission network) have developed a cooperation strategy of creating subsidiaries for construction of large investment projects, thus reducing business risks. Nevertheless, implementation of company decisions is subject to the government authorisation designed to enforce company compliance with energy and environmental regulations.

Use of land is regulated by the states (Länder) and municipalities as pertains to the location of new generating plants, the use of certain fuels and the installation of new transmission lines. To comply with environmental regulations, German electric companies have used state-of-the-art technologies to control emissions from electricity generation and have invested heavily in underground transmission networks. This policy has impacted the companies' costs and electricity prices in Germany.

Given the organizational structure of Germany's electricity supply, large wholesale market exists consisting of transactions between companies and from third party producers. Transactions are directly coordinated by the companies in the DVS (Deutsches Verbundsystem) without participation of any official agency. Transactions between companies are defined by private agreements, through the execution of long term supply contracts. There is no direct state supervision over contract terms. However, because of the active participation of local and regional authorities in distribution companies, the authorities exercise some influence on these contracts.

An early 1980's regulation terminated, as of 1994, all supply contracts to distributors and obliged renegotiations for a subsequent 20 year period. Consequently, many disputes between distributors and suppliers arose. Another portion of the wholesale market is made up of purchases from independent generators and self-producers. Prices paid to self-producers are based on agreements between electric companies, self-producers and the association of German industrial businessmen (BDI- Bundesverband der Deutschen Industrie). These agreements generally account for the electric companies' long run avoided costs.

The retail electricity market is made up of large industrial users who negotiate the price and supply conditions with the companies. Small users are charged regulated tariffs. Although there is no government control over the prices established with large industrial users, current legislation does not discriminate between customers.

Regulation of the electric companies' activities is, in general, carried out by the Länder authorities. Local communities, however, control the use of land in their jurisdictions and public safety when distribution works are undertaken. An exception to this practice is the regulation of nuclear power plants, which is subject to federal law, see chapter 5.1. Radioactive waste management is supervised by the Federal Office for Radiation Protection, established in 1989.

In the past few years Germany's electricity supply industry has faced two challenges: the reorganization of the electric sector due to Germany's reunification; and, the establishment of a unified electricity market within the European Economic Community. In 1990, an agreement was executed enabling electricity companies of the former West Germany to participate in restructuring the electricity supply industry of the former East Germany.

The electricity sector was regulated by different systems during the years of the political and territorial division, and this is still reflected in their current organizational structures and performance. In the former West Germany, fragmentation of the electricity supply industry continues to exist, with a high participation of local communities in power distribution, even though large private companies and others with private and state-owned capital prevail in generation and transmission. In the former East Germany, the state-owned monopoly is disappearing with national reunification.

Current generating facilities in the former East Germany, would have to either adjust before July 1996 to the existing operating conditions in the former West Germany, or be closed down. The former East German nuclear power plants at Greifswald and Rheinsberg, with a total installed capacity of 1,830 MW(e), ceased operation in 1990.

Electric companies in the former West Germany have performed quite well in recent years and have not suffered financial shocks similar to those experienced in other countries. The electricity supply industry has adjusted to the strict German environmental standards, and regulation has enabled it to transfer higher costs to tariffs. In spite of the intensive use of coal (50% of electricity generation), emission controls make it a clean industry.

The current position of the German government with respect to $CO_2$ emissions creates a new challenge for the electricity supply industry. Connected with the climate debate, the German government is committed to a reduction of its $CO_2$ emissions by 25% by the year 2005, with respect to the year 1990. It no longer suffices to add new devices to existing technologies. A strong reduction in the burning of hydrocarbon fuels is now necessary. The options for the electricity supply industry are to increase energy efficiency, both in electricity generation and end-use consumption, and/or turn to generating technologies which do not burn fossil fuels. Both options require concerted action between the utilities, the equipment suppliers and the political sector.

In the current German and European situation, electric companies are also actively participating in the debate over the country's energy and environmental policies. The adjustment of the tariff structure, from a very high fixed charge to a more "linear" structure, promotes a more efficient use of electricity and avoids unnecessary capacity increases.

Reduction in the electricity sector's environmental impacts and its high quality service standards have led to a gradual increase in the price of electricity in Germany. Compared with OECD countries, the average price of electricity in Germany is 14% higher for industrial customers and 30% higher for residential customers.

Electricity subsidies in the former East Germany were revoked between 1990 and 1992. Today's prices reflecting actual service costs have brought about significant price increases for many eastern end-users.

### 2.2. Decision Making Process

Germany's policies on energy, environment and technology pertaining to the development of the electricity supply industry are administered by the Federal Government through Ministries for Economy; Environment, Nature Conservation and Nuclear Safety; and, Education, Science, Research and Technology. These policies are established with the concurrence of state governments which participate in defining and implementing the policies.

The Federal Ministry for Economy (BMWi) is responsible for the national energy policy. It does not make energy forecasts, but relies on those prepared by private economic institutes. Changes in energy production and demand are largely achieved by using market forces and price mechanisms. According to these policies companies are responsible for planning and making decisions on their system expansion needs, and making the required investments. This is done on an individual basis, with limited intercompany co-ordination by the electric companies at other levels (supraregional and regional). The commitment of company decisions depends on the duration of its wholesale market supply agreements. Long-term commitments reduce the economic uncertainties for utilities.

## 2.3. Main Indicators

Table 5 shows the historical electricity production statistics and installed capacities. In Table 6, energy related ratios are shown.

As of 1990, socio-economic conditions have had their impact on the electricity end-use consumption. A reduction in the electricity consumption in the former East Germany of 18% in 1990 affected particularly the industrial sector (- 30%). The result was a net decrease in total electricity consumption in Germany, irrespective of the differences in scale between the western and eastern German systems. Until 1989, electricity consumption in the former East Germany amounted to 20% of the country's total electricity consumption, but decreased to under 15% by 1991.

The economic recession also had an impact upon the former West Germany, although to a lesser extent. It affected energy consumption in general, without reducing the share of electricity, which continues to be below 16%. In the former West Germany, electricity has a 50% higher share than the one in the former East Germany, even though it is only about 20% of the total end-use energy consumption.

Electricity generation in Germany has been based on locally produced coal. However, in the last 20 years the trend has been to replace liquid and gaseous hydrocarbons - and to a lesser degree coal - with nuclear power. The closing down of nuclear plants in the former East Germany in 1990, increased the dependence of the electricity supply in locally produced lignite, which in 1992 accounted for about 95% of electricity generation there. The policy in the Eastern territory, is to refurbish power plants with cleaner and more efficient lignite fired generating units.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITIES

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 118.99 | 237.81 | 365.27 | 444.50 | 525.72 | 528.22 | 5.77 | 2.67 |
| - Thermal | 105.99 | 218.82 | 306.42 | 285.93 | 359.53 | 361.22 | 5.45 | 1.18 |
| - Hydro | 12.99 | 16.25 | 17.41 | 19.20 | 21.47 | 22.46 | 1.47 | 1.84 |
| - Nuclear | | 2.73 | 41.44 | 139.37 | 144.60 | 143.12 | | 9.26 |
| Electricity prod. former GDR (TW·h) | | | | | | | | |
| - Total [(1)] | 40.3 | 67.7 | 98.8 | 117.3 | | | | |
| - Thermal | 39.7 | 65.9 | 85.3 | 103.5 | | | | |
| - Hydro | 0.6 | 1.3 | 1.7 | 2.0 | | | | |
| - Nuclear | | 0.5 | 11.9 | 11.8 | | | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 28.39 | 47.58 | 82.60 | 106.36 | 114.29 | 114.36 | 5.48 | 2.35 |
| - Thermal | 25.04 | 41.95 | 67.50 | 76.60 | 82.83 | 82.67 | 5.08 | 1.46 |
| - Hydro | 3.35 | 4.70 | 6.45 | 7.10 | 8.80 | 8.84 | 3.33 | 2.28 |
| - Nuclear | | 0.93 | 8.65 | 22.66 | 22.66 | 22.66 | | 7.12 |
| - Wind | | | | | | 0.19 | | |
| Cap. of el. pl. former GDR (GW(e)) | | | | | | | | |
| - Total | 7.9 | 12.1 | 19.7 | 23.4 | | | | |
| - Thermal | 7.6 | 11.3 | 16.5 | 19.7 | | | | |
| - Hydro | 0.3 | 0.7 | 1.5 | 1.8 | | | | |
| - Nuclear | | 0.1 | 1.7 | 1.8 | | | | |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS*

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 114(167) | 164(180) | 188(224) | 188(227) | 171 | 165 |
| Electricity per capita (kW·h/capita) | 2,222 (2,316) | 3,790 (3,603) | 5,673 (5,391) | 6,785 (6,603) | 6,042 | 6,057 |
| Electricity production/Energy production (%) | 20(15) | 41(25) | 64(34) | 74(38) | 77 | 81 |
| Nuclear/Total electricity (%) | | 1(1) | 12(13) | 34(11) | 30 | 29 |
| Ratio of external dependency (%)[(1)] | 10(10) | 49(22) | 59(33) | 55(28) | 59 | 61 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 48(58) | 57(64) | 50(57) | 51(57) | 53 | 53 |
| - Thermal | 48(60) | 60(66) | 52(59) | 47(60) | 50 | 50 |
| - Hydro | 44(22) | 39(22) | 31(13) | 31(12) | 28 | 29 |
| - Nuclear | | 34(85) | 55(80) | 70(74) | 73 | 72 |

[(1)] *Total net import / Total energy consumption*
* *Numbers in brackets refer to the former GDR*
Source: IAEA Energy and Economic Data Base

The growth of nuclear generation, now approaching 29% of electricity production, was sustained from the mid 1970's up to the late 1980's by the erection of 21 units with combined capacity of 22.6 GW(e). The latest nuclear power plant began commercial operation in May 1989.

Since differences in conventional fuel quality affect the efficiency and the own consumption share of power plants, the efforts of German authorities and electric utilities are directed to alleviate these differences by refurbishing the facilities in the former East Germany. Germany's electricity system is self-supplied with domestic generation, but makes use of the provided interconnections to improve the economic operation of its facilities.

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

After World War II, allied regulations prohibited any activity in nuclear physics research and nuclear industrial development in the divided Germany. After West Germany had relinquished all rights to produce, possess and use nuclear weapons, it was admitted, in 1955, to the western community of nations as a sovereign state and could begin with research and development for the peaceful use of nuclear energy.

By this time, some countries already had ten years nuclear technology advantage. To close the gap, an agreement was reached between scientific, economic and political sectors to organize an extensive international cooperation. German Atomic Programme was formulated to coordinate the work, including the construction of a series of prototype reactors, formulating the concept of a closed nuclear fuel cycle, and the disposal of radioactive waste in deep geological formations.

In 1955, the Federal Government established an atomic ministry (Federal Ministry on Atomic Affairs, Bundesministerium für Atomfragen) and began to set up nuclear standards. Nuclear research centres and university institutes with reactors for the purpose of instruction, research and material testing were founded. Germany became a founding member of EURATOM and the present Nuclear Energy Agency (NEA) of OECD. Agreements of cooperation with France, Great Britain and the USA were signed. With the assistance of the U.S. firms (Siemens/Westinghouse for pressurized water reactors - PWR; AEG/General Electric for boiling water reactors - BWR) Germany began development of commercial nuclear power plants. The German electric utilities (Energieversorgungsunternehmen, EVU) supported this development.

In 1958, the 15 MW(e)-Kahl experimental nuclear power plant (Versuchsatomkraftwerk Kahl, VAK) - U.S. designed - was ordered and put into operation in 1961. With a 15 MW(e) high temperature reactor ordered by the Jülich Experimental Reactor Study Group (Arbeitsgemeinschaft Versuchsreaktor in Jülich, AVR), German nuclear programme development began in 1961. Power reactors with 250-350 MW(e) and 600-700 MW(e) were ordered between 1965 and 1970. After about 15 years, the gap between the German and the international technical state of art was closed. German nuclear industry received the first orders from abroad, from the Netherlands (Borssele) and from Argentina (Atucha). In 1972, construction of the then world's largest reactor, Biblis-A, began in Germany. Between 1970 and 1975 on average three units were ordered annually.

Also in 1955, in the former East Germany, development of nuclear power began with the assistance of the Soviet Union. Research was conducted in nuclear physics and in the peaceful utilisation of nuclear energy. In 1956, the Central Institute for Nuclear Physics was founded at Rossendorf near Dresden. There, in 1957, a research reactor supplied by the Soviet Union was placed in operation. First East German nuclear power plant was connected to the grid in 1966. This Rheinsberg nuclear power plant had an electrical capacity of 70 MW and was equipped with a Russian type PWR (i.e. WWER).

In 1969, Siemens and AEG founded the Kraftwerk Union (KWU). To do this, the license contract with one of the U.S. firms had to be discontinued. Since a large worldwide market for PWRs had opened up, the contract with Westinghouse was canceled and development of Siemens/KWU nuclear power plants with PWRs started (KWU-PWR). The concept of "basic safety" was introduced to the reactor design systems in the late 1970's. On the basis of several years of operational experience, a standardized 1,300 MW(e) PWR, the so-called convoy-facility, was produced, mainly, to speed up the licensing process. However, after some "pre-convoy" units, the construction of only three convoy-units was actually realized (Isar-2, Neckarwestheim-2, and Emsland). These convoy units were ordered in 1982 and put into operation in 1988/89. They were the last NPP projects in Germany and for the German industry.

In the former East Germany, between 1974 and 1979, the Greifswald NPP units 1-4 were connected to the electric grid, all equipped with Russian WWER-440/W-230 reactors with an electrical capacity of 440 MW(e) each. In 1989, unit 5, a WWER-440/W-213 reactor, went into operation.

Two 300 MW(e) prototypes of advanced reactor design were also developed in Germany: the Thorium high-temperature reactor (Thorium-Hochtemperaturreaktor, THTR) and the fast sodium-cooled reactor (Schneller Natriumgekühlter Reaktor, SNR-300). Neither project, however, was completed due to economical and political reasons.

All facilities currently in operation in Germany were built by KWU, Siemens or AEG. The Mülheim-Kärlich nuclear power plant (1,300 MW(e)-PWR), shut down in 1988 for procedural reasons, was the only nuclear power plant in Germany constructed by Babcock & Wilcox, although it bears many characteristics of a "typical German" design.

After the German unification a comprehensive safety assessment of Soviet type NPPs in East Germany was conducted. This analysis showed severe safety deficiencies compared to the German nuclear safety requirements. Due to technical and economic reasons (especially uncertainties in the licensing process and a diminishing demand for electricity), it was decided not to upgrade these nuclear power plants. Instead, they were taken out of service and prepared for decommissioning. Additionally, work on nuclear plants under construction (units 6, 7 and 8 at Greifswald with WWER-440/W-213 reactors and a WWER-1000-NPP near Stendal) was stopped. The partially completed facilities are now being demolished.

In the early 1970's, the already successful German nuclear power programme was faced with a steadily increasing opposition against the use of nuclear power. Several demonstrations and site occupations occurred, like those at Brokdorf and Wyhl. Furthermore, concerned citizens raised objections in administrative courts. Consequently, construction and licensing of nuclear power plants were considerably delayed due to ongoing litigations.

By the mid 1970's, Germany increased its efforts to close the fuel cycle and to set up an effective programme for radioactive waste, including final disposal. In 1979, an understanding on the "principles of making provisions for NPP waste disposal" ("Grundsätze zur Entsorgungsvorsorge für KKW") was reached. The Federal Government, the states, and the government of Lower Saxony agreed to assess the Gorleben site's suitability as a repository for high-level wastes. The salt dome of Gorleben is now envisaged as a repository for spent fuel and its vitrified high level wastes. Extensive experience resulting from the disposal of low- and medium-level waste and from experiments simulating high level waste disposal in the former salt mine Asse near Wolfenbüttel is being used. According to present plans, Gorleben could go into operation in 2008.

The former iron-ore mine Konrad at Salzgitter is being considered as a repository for low and medium-level radioactive waste. Preliminary investigation on the suitability of Konrad as a repository started in 1976. Technical assessment of its suitability is nearly complete.

In the late 1960's, former East German studies on final disposal of radioactive waste resulted in the decision to use an abandoned salt mine as a repository for short lived low and medium level waste with low concentrations of alpha emitters. In 1972, the Morsleben rock salt mine was chosen for this purpose. In 1981, after extensive investigations, the first license for final disposal was granted. With the German unification in 1990, the operation license was to remain effective until 30 June 2000. After several court decisions, the operation for final disposal was resumed in January 1994. The intention is to store 25,000 $m^3$ of low level waste from nuclear facilities, 5,000 $m^3$ from collecting depots of the Länder and other waste producers, and about 10,000 $m^3$ of low level waste from the decommissioning of the Greifswald and Rheinsberg nuclear power plants.

A project for a reprocessing plant at Wackersdorf was abandoned in 1988 due to strong public opposition and economic reasons. Until 1994, the fuel cycle policy was based on reprocessing spent fuel. Therefore, the German utilities made contracts for reprocessing spent fuel with COGEMA (France) and BNFL (Great Britain). Radioactive wastes resulting from reprocessing spent fuel in foreign facilities will be brought back to Germany starting in 1997. The plutonium from the reprocessing will be used to produce MOX fuel elements. At Hanau (Hesse), a new MOX fuel fabrication plant was almost completed. Its commissioning was delayed because of pending court decision and finally given up because of economic reasons in July 1995.

### 3.2. Current Policy Issues

In 1986, after the Chernobyl nuclear disaster, political consensus on energy was lost. Social Democratic Party (SPD) adopted a resolution to phase out nuclear power by 1996. Today, both in opposition to the Federal Government and as the leading party in "red-green" coalition governments in several Länder, the SPD maintains its position.

Despite of "energy consensus" talks in 1993 among the leading German political parties and other groups, no common position on the future use of nuclear energy has been reached. After the elections of Federal parliament in October 1994, the confirmed coalition government of the parties CDU, CSU and FDP continues to keep to its position of a secure, cost-effective and environmentally friendly energy supply. This includes the peaceful use of nuclear energy as part of the energy mix. A further attempt aimed at reaching a national consensus on energy policy and future use of nuclear power was undertaken in March 1995. But the negotiations were abandoned on June 21 because no consensus could be reached between the parties involved. The opposing Social Democrats do not support the development of a new generation of nuclear power reactors. The coalition government plans to address national energy issues without participation of the opposition.

### 3.3. Status and Trends of Nuclear Power

In 1996, the total gross and net capacities of the 20 operating German nuclear power plants amount to 22.2 GW(e) and 21.5 GW(e), respectively, and the generated nuclear electricity amounted to 152.8 TW·h, i.e. 30% of the electricity supplied by the public utilities. Table 7 shows the status of the German nuclear power plants. Note, the Muelheim-Kaerlich NPP began trial operation in 1987 but has been out of operation since 1988 because of a long-lasting legal dispute over the validity of its license. The Wuergasse NPP was shut down because of economic reasons, in June 1995.

The relevant German nuclear fuel cycle facilities are listed in Table 8. Locations of the German nuclear power plants, nuclear fuel cycle facilities, and repositories are shown in Figures 1 and 2, respectively.

In the Federal Republic of Germany the development and use of nuclear energy for peaceful purposes is based on the Atomic Energy Act, enacted in 1954 and last amended in July 1994. Two important changes were introduced by the last amendment:

- An additional safety goal is defined for future nuclear power plants: Radioactive releases to the environment in case of severe accidents with core meltdown have to be limited to such an amount that stringent protective measures outside the immediate vicinity of the plant will not become necessary.
- In future, besides reprocessing of spent fuel, direct disposal is allowed as an equivalent option for the waste management of spent fuel.

German utilities together with the nuclear industry (Siemens) in close cooperation with its French counterparts (EdF and Framatome) are developing an advanced PWR within the European Pressurized Water Reactor (EPR) project. The reactor design is "evolutionary" and shows enhanced safety features. The design includes provisions to control core meltdown accidents and is expected to comply with the safety requirements specified in the amendment to the Atomic Energy Act. The basic design phase of the EPR project started in February 1995. German utilities support the Siemens research and development activities with a contribution of about 200 million DM including a minor budget devoted to the development of a 600 MW(e) BWR.

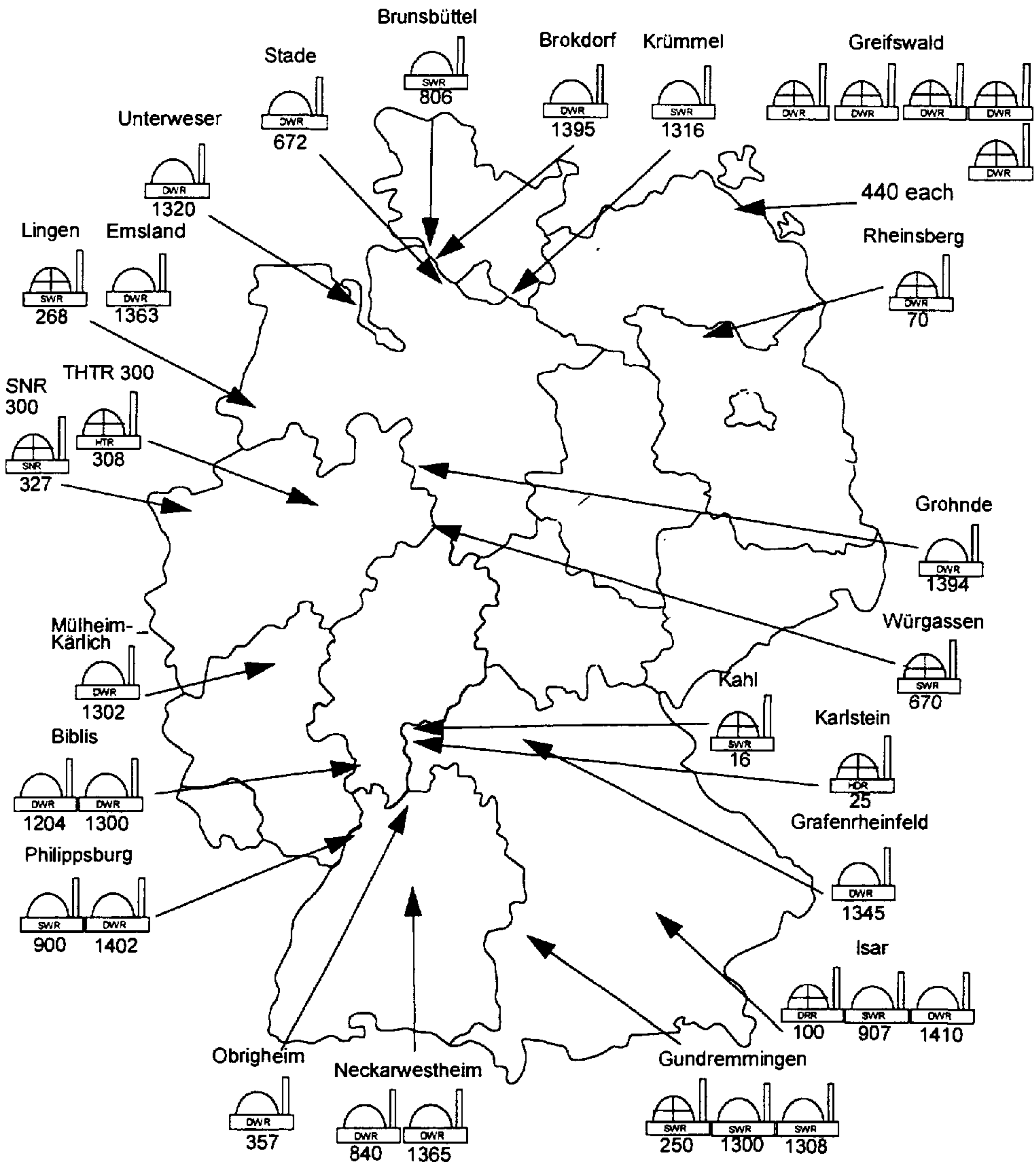
TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| BIBLIS-A (KWB A) | PWR | 1167 | RWE | Operational | KWU | 01-Jan-70 | 16-Jul.-74 | 25-Aug.-74 | 26-Feb.-75 | |
| BIBLIS-B (KWB B) | PWR | 1240 | RWE | Operational | KWU | 01-Feb.-72 | 25-Mar-76 | 06-Apr.-76 | 31-Jan-77 | |
| BROKDORF (KBR) | PWR | 1326 | KBR | Operational | KWU | 01-Jan-76 | 08-Oct.-86 | 14-Oct.-86 | 22-Dec.-86 | |
| BRUNSBUETTEL (KKB) | BWR | 771 | KKB | Operational | KWU | 15-Apr.-70 | 23-Jun.-76 | 13-Jul.-76 | 09-Feb.-77 | |
| EMSLAND (KKE) | PWR | 1290 | KLE | Operational | SIEM,KWU | 10-Aug.-82 | 14-Apr.-88 | 19-Apr.-88 | 20-Jun.-88 | |
| GRAFENRHEINFELD (KKG) | PWR | 1275 | BAG | Operational | KWU | 01-Jan-75 | 09-Dec.-81 | 21-Dec.-81 | 17-Jun.-82 | |
| GROHNDE (KWG) | PWR | 1360 | KWG | Operational | KWU | 01-Jun.-76 | 01-Sept.-84 | 04-Sept.-84 | 01-Feb.-85 | |
| GUNDREMMINGEN-B (KRB B) | BWR | 1284 | KGB | Operational | KWU | 20-Jul.-76 | 09-Mar-84 | 16-Mar-84 | 19-Jul.-84 | |
| GUNDREMMINGEN-C (KRB C) | BWR | 1288 | KGB | Operational | KWU | 20-Jul.-76 | 26-Oct.-84 | 02-Nov.-84 | 18-Jan-85 | |
| ISAR-1 (KKI 1) | BWR | 870 | KKI | Operational | KWU | 01-May-72 | 20-Nov.-77 | 03-Dec.-77 | 17-Mar-79 | |
| ISAR-2 (KKI 2) | PWR | 1365 | KKI 2 | Operational | SIEM,KWU | 15-Sept.-82 | 15-Jan-88 | 22-Jan-88 | 09-Apr.-88 | |
| KRUEMMEL (KKK) | BWR | 1260 | KKK | Operational | KWU | 05-Apr.-74 | 14-Sept.-83 | 28-Sept.-83 | 28-Mar-84 | |
| MUELHEIM-KAERLICH (KMK) | PWR | 1219 | RWE | Operational | BBR | 15-Jan-75 | 01-Mar-86 | 14-Mar-86 | 01-Aug.-87 | |
| NECKARWESTHEIM-1 (GKN 1) | PWR | 785 | GKN | Operational | KWU | 01-Feb.-72 | 26-May-76 | 03-Jun.-76 | 01-Dec.-76 | |
| NECKARWESTHEIM-2 (GKN 2) | PWR | 1269 | GKN | Operational | SIEM,KWU | 09-Nov.-82 | 29-Dec.-88 | 03-Jan-89 | 15-Apr.-89 | |
| OBRIGHEIM (KWO) | PWR | 340 | KWO | Operational | SIEM,KWU | 15-Mar-65 | 22-Sept.-68 | 29-Oct.-68 | 31-Mar-69 | |
| PHILIPPSBURG-1 (KKP 1) | BWR | 890 | KKP | Operational | KWU | 01-Oct.-70 | 09-Mar-79 | 07-May-79 | 18-Feb.-80 | |
| PHILIPPSBURG-2 (KKP 2) | PWR | 1358 | KKP | Operational | KWU | 07-Jul.-77 | 13-Dec.-84 | 17-Dec.-84 | 17-Apr.-85 | |
| STADE (KKS) | PWR | 640 | KKS | Operational | SIEM,KWU | 01-Dec.-67 | 08-Jan-72 | 29-Jan-72 | 19-May-72 | |
| UNTERWESER (KKU) | PWR | 1285 | KKU | Operational | KWU | 01-Jul.-72 | 16-Sept.-78 | 29-Sept.-78 | 06-Sept.-79 | |
| AVR JUELICH (AVR) | HTGR | 13 | AVR | Shut Down | BBK | 01-Aug.-61 | 16-Aug.-66 | 17-Dec.-67 | 19-May-69 | 31-Dec.-88 |
| GREIFSWALD-1(KGR 1) | WWER | 408 | EWN | Shut Down | AEE,KAB | 01-Mar-70 | 15-Dec.-73 | 17-Dec.-73 | 12-Jul.-74 | 15-Dec.-90 |
| GREIFSWALD-2 (KGR 2) | WWER | 408 | EWN | Shut Down | AEE,KAB | 01-Mar-70 | 03-Dec.-74 | 23-Dec.-74 | 16-Apr.-75 | 14-Feb.-90 |
| GREIFSWALD-3 (KGR 3) | WWER | 408 | EWN | Shut Down | AEE,KAB | 01-Apr.-72 | 16-Oct.-77 | 24-Oct.-77 | 01-May-78 | 28-Feb.-90 |
| GREIFSWALD-4 (KGR 4) | WWER | 408 | EWN | Shut Down | AEE,KAB | 01-Apr.-72 | 22-Jul.-79 | 03-Sept.-79 | 01-Nov.-79 | 02-Jun.-90 |
| GREIFSWALD-5 (KGR 5) | WWER | 408 | EWN | Shut Down | AEE,KAB | 01-Dec.-76 | 26-Mar-89 | 24-Apr.-89 | 01-Nov.-89 | 01-Nov.-90 |
| GUNDREMMINGEN-A (KRB A) | BWR | 237 | KGB | Shut Down | AEG,GE | 12-Dec.-62 | 14-Aug.-66 | 01-Dec.-66 | 12-Apr.-67 | 08-Jan-80 |
| HDR GROSSWELZHEIM | BWR | 23 | HDR | Shut Down | AEG,KWU | 01-Jan-65 | 14-Oct.-69 | 14-Oct.-69 | 02-Aug.-70 | 20-Jul.-71 |
| KNK II | FBR | 17 | KBG | Shut Down | IA | 01-Sept.-74 | 10-Oct.-77 | 09-Apr.-78 | 03-Mar-79 | 23-Aug.-90 |
| LINGEN (KWL) | BWR | 250 | KWL | Shut Down | AEG | 01-Oct.-64 | 31-Jan-68 | 01-Jul.-68 | 01-Oct.-68 | 05-Jan-79 |
| MZFR | PHWR | 52 | KBG | Shut Down | SIEMENS | 01-Dec.-61 | 01-Sept.-65 | 09-Mar-66 | 19-Dec.-66 | 03-May-84 |
| NIEDERAICHBACH (KKN) | HWGCR | 100 | KKN | Shut Down | SIEM,KWU | 01-Jun.-66 | 17-Dec.-72 | 01-Jan-73 | 01-Jan-73 | 21-Jul.-74 |
| RHEINSBERG (KKR) | PWR | 62 | EWN | Shut Down | AEE,KAB | 01-Jan-60 | 01-Mar-66 | 06-May-66 | 11-Oct.-66 | 01-Jun.-90 |
| THTR-300 | HTGR | 296 | HKG | Shut Down | HRB | 01-May-71 | 13-Sept.-83 | 16-Nov.-85 | 01-Jun.-87 | 01-Sept.-90 |
| VAK KAHL | BWR | 15 | VAK | Shut Down | GE,AEG | 01-Jul.-58 | 13-Nov.-60 | 17-Jun.-61 | 01-Feb.-62 | 25-Nov.-85 |
| WUERGASSEN (KWW) | BWR | 640 | PE | Shut Down | AEG,KWU | 26-Jan-68 | 20-Oct.-71 | 18-Dec.-71 | 11-Nov.-75 | 01-Jun.-95 |

Source: IAEA Power Reactor System, yearend 1996

TABLE 8. SELECTED NUCLEAR FUEL CYCLE PLANTS AND REPOSITORIES

| No. | Name and Site of the Plant | Operator | Type of Plant | Capacity | Start of Operation |
|---|---|---|---|---|---|
| 1 | Urananreicherungsanlage Gronau<br>Grohnau<br>North Rhine-Westphalia | Urenco-Deutschland | enrichment plant | 1,000 t SWU/a | 15.08.85 |
| 2 | Advanced Nuclear Fuels GmbH<br>Lingen<br>Lower Saxony | Advanced Nuclear Fuels GmbH | uranium fuel, element fabrication plant | 400 t HM/a | January 1979 |
| 3 | Zwischenlager für abgebrannte Brennelemente<br>Gorleben<br>Lower Saxony | BLG (Brennelementelager Gorleben GmbH) | external interim storage facility for spent fuel elements | 1,500 t HM | ready for operation since 07.02.91 |
| 4 | Pilot-Konditionierungsanlage (PKA)<br>Gorleben<br>Lower Saxony | BLG and GNS (Gesellschaft für Nuklearservice mbH) | conditioning of spent fuel and rad-waste | 35 t HM/a | presumably 1996 |
| 5 | Endlager für radioaktive Abfälle bei Gorleben<br>Gorleben<br>Lower Saxony | BfS (Bundesamt für Strahlenschutz) together with DBE (Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH) | repository,<br>for high-active radwaste<br>(HAW) | | envisaged 2008 |
| 6 | Schachtanlage Konrad<br>Salzgitter<br>Lower Saxony | BfS together with DBE | repository for MAW and LAW, with negligible heat production | | around 1997 |
| 7 | Endlager für radioaktive Abfälle Morsleben (ERAM)<br>Morsleben<br>Saxony-Anhalt | BfS together with DBE | repository for MAW and LAW,<br>with prevalent short half-life | 55,000 $m^3$ | 1978 |




legend:

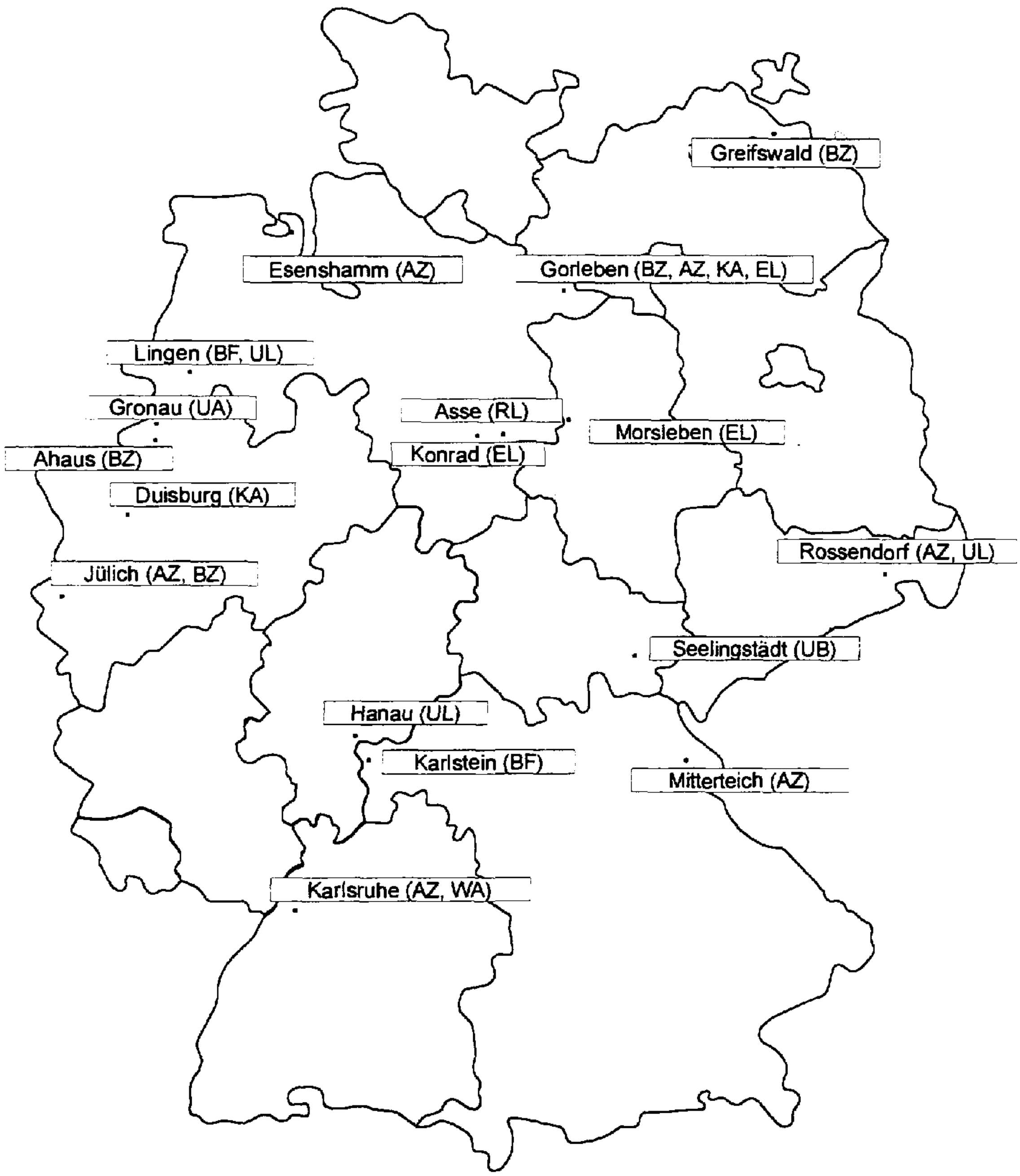
DWR: pressurized water reactor PWR
SWR: boiling water reactor BWR
SNR: fast reactor (Kalkar)
HTR: high temperatur reactor (Hamm-Uentrop)
DRR: pressure tube reactor (Niederaichbach)
HDR: overheated steam testing reactor (Karlstein)

figures: gross capacity in MW(e)

in operation

out of operation for decommissioning

*FIG. 1. Nuclear Power Plants in the Federal Republic of Germany*



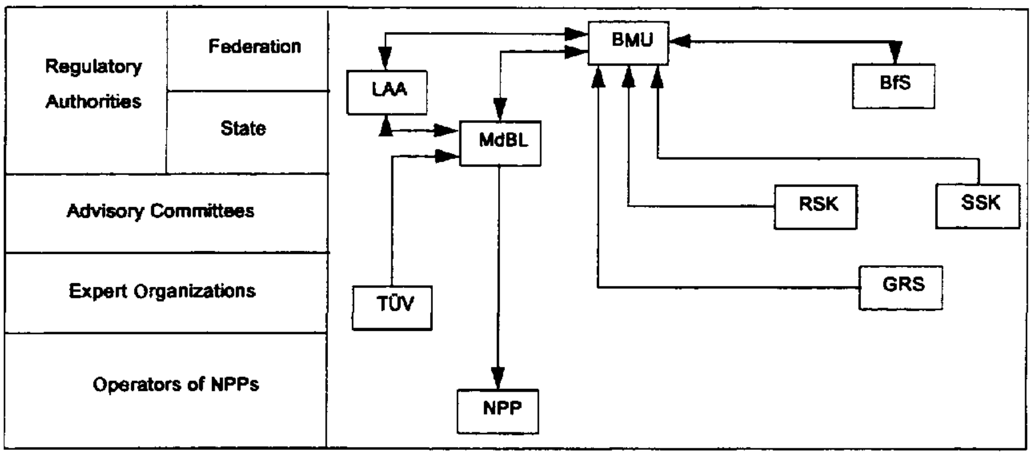

legend:

1. UB: uranium mining
2. UL: uranium storage facility
3. UA: uranium enrichment facility at Gronau
4. BF: fuel element fabrication plant
5. BZ: external interim storage of fuel elements
6. AZ: intermediate radwaste storage
7. WA: fuel reprocessing pilot plant (WAK Karlsruhe)
8. KA: pilot conditioning plant
9.. EL: radwaste repository
10. RL: underground research laboratory

*FIG. 2. Nuclear Fuel Cycle Plants in the Federal Republic of Germany*

### 3.4. Organizational Charts

The general structure of the German nuclear sector is shown in Figure 3. All the institutions mentioned on the right hand side of Figure 3 are explained in chapter 5.1 in detail.




BMU Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BfS Federal Office for Radiation Protection
LAA States' Committee on Atomic Energy
MdBL Ministry of the individual State
RSK Reactor Safety Commission
SSK Commission on Radiological Protection
GRS Company for Plant and Reactor Safety
TÜV Technical Inspection Agency

*FIG. 3. Structural Scheme of Regulatory Authorities, Committees and Expert Organizations involved in the Licensing Procedure*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of NPPS

Because of increasing costs and decreasing electricity growth rate, the German nuclear power industry has undergone a process of concentration. Only Siemens and ABB Reaktor have remained as vendors for potential new nuclear power plants. Addresses of Siemens, ABB and other manufacturers are given in the annex.

### 4.2. Operation of NPPs

Large German utilities are the main shareholders of the nuclear power plant operator companies. There are 13 different companies which operate nuclear power plants with one or two units at the same site. The operators must provide the financial resources for interim storage of spent fuel, construction and operation of repositories for final disposal, and decommissioning of nuclear power plants.

In order to maintain a high level of technical qualification, nuclear power plant operations personnel must attend regular training courses at the simulator training centre GfS. Addresses of the main utilities operating NPPs and of GfS are given in the annex.

### 4.3. Fuel Cycle and Waste Management Service Supply

Germany has several companies engaged in fuel enrichment, fuel element manufacturing, external interim storage of spent fuel, and radwaste management. Addresses of involved firms are given in the annex.

### 4.4. Research and Development Activities

Fundamental nuclear safety research is supported by the Federal Ministry for Education, Science, Research and Technology (Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie, BMBF) and conducted mainly by research centres, universities and by various institutions in industry and in the public sector.

The Federal Government supports research and development activities on final repositories. Projects are carried out on behalf of two ministries, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU), and BMBF. Addresses of the federal ministries and of important research centres are given in the annex.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Germany is a member of the European Union (EU), OECD/NEA, and IAEA. The German Federal Government supports EU programmes in the field of nuclear safety and nuclear waste management and participates in many OECD/NEA and IAEA projects.

Industrial cooperation takes place between Germany (Siemens) and France (Framatome) in order to develop the European Pressurized Water Reactor, EPR. For this purpose both companies established the joint subsidiary NPI.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

Construction of new fossil or nuclear power plants requires a license granted by the corresponding state. Hydroelectric plants are under regional jurisdiction.

Environmental considerations play an important role in the authorization for new nuclear facilities, and all jurisdictional levels are involved. Every project with a capacity greater than 200 MW(e) must include an acceptable environmental impact statement before the authorization for its construction is granted by the government.

The Federal Constitution (Grundgesetz) contains detailed provisions on the legislative and administrative competence of the Federation (Bund) and the individual States (Bundesländer or Länder).

The legal basis for the peaceful use of nuclear power in the Federal Republic of Germany is the Atomic Energy Act (Atomgesetz, AtG of 1959, at last amended in 1994). With the unification in October 1990, the Atomic Energy Act became also effective on the territory of the former East Germany.

The Federal Ministry of the Environment, Nature Conservation and Reactor Safety (BMU) is the supreme Federal authority for all matters pertaining to nuclear safety.

Acting on behalf of BMU, the Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS) is responsible - inter alia - for the construction and operation of nuclear waste repositories. The BfS - a subordinate authority of the BMU - was founded by federal Act for the

Establishing of the Federal Office of Radiation Protection, issued in October 1989. To perform its task BfS subcontracts with third parties. The subcontractor for the construction and operation of repositories for radioactive waste materials is Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH.

Pursuant to the Atomic Energy Act, the authorities of the states grant, withdraw and revoke licenses for all nuclear installations on their territory. These authorities exercise control over the construction and operation of nuclear installations.

The Atomic Energy Act and the ordinances form the legal basis by which the individual states act on behalf of the Federation. The states have established licensing and supervisory authorities in the form of Ministries (Ministerium des Bundeslandes, MdBL). Addresses of these authorities are given in the annex.

In case of conflicting opinions between the supreme Federal authority and the authorities of individual states, the authority of the state is subject to BMU directives. Usually BMU supervises actions taken by state authorities on issues of legal and technical importance to all states.

The Federal Government has set up a States' Committee of Atomic Energy (Länderausschuss für Atomkernenergie, LAA) to address issues of nuclear safety uniformly in all of the states.

In matters of nuclear safety and radiation protection, BMU is advised by the Reactor Safety Commission (Reaktor-Sicherheitskommission, RSK) and by the Commission on Radiological Protection (Strahlenschutzkommission, SSK). These commissions are composed of independent experts to deal with issues of general importance. To prepare their recommendations, the commissions have a number of sub-committees to carry out detailed examinations.

On detailed technical questions, BMU is assisted by the Company for Plant and Reactor Safety (Gesellschaft für Anlagen- und Reaktorsicherheit mbH, GRS) established by the Federation, the states and their Technical Inspection Agencies (Technische Überwachungsvereine, TÜV).

For technical matters in the licensing procedure and the supervision of nuclear facilities, the regulatory authorities of the states are supported by independent expert organizations. For this purpose the Technical Inspection Agencies have established nuclear energy departments.

The application for licensing of a nuclear power plant must be accompanied by documents which are necessary to examine the compliance with the licensing requirements, in particular:

i) explanatory plans, drawings and descriptions;
ii) safety report describing the installation and its operation, specifying design, safety design principles and functioning of the installation;
iii) data about the competence and reliability of the applicant's responsible persons;
iv) data on physical protection of the installation and its operation;
v) proposals of provisions for financial security to cover third party liability for nuclear damage.

A license is also required for the decommissioning of a nuclear installation, for safe enclosure of decommissioned installations and for dismantling, unless the measures planned are already subject to a nuclear installation license. Usually the granting of a license occurs in several stages: provisional site approval (Standortvorbescheid); provisional design approval; construction permit; and operating license. The licensing authority has to announce the project officially in order to enable public participation.

In the licensing procedure, the state authority usually consults the Technical Inspection Agency for independent assessment of the safety of the facility. When granting a preliminary decision or a provisional license, the authority must either reject public interventions, or impose corresponding conditions upon the license. The decision is served both on the applicant and on the interveners who may challenge it in the administrative courts whose decisions may be further appealed. Moreover, the operative part of the decisions and any conditions attached thereto, as well as notice of right to appeal, must be declared publicly.

Once the licensing authority's decision becomes effective and final, third parties are precluded, in any subsequent proceedings, from raising objections on the basis of facts which have already been put forward.

Construction and operation of nuclear installations are subject to continuous regulatory supervision. The supreme authorities of the states are responsible for exercising supervisory functions. In exercising their control functions the authorities may delegate specific tasks to subordinate agencies. In general, experts of the Technical Inspection Agencies carry out inspections and quality controls. Controls during the construction of a nuclear installation are designed to ensure that all safety systems and components comply with the requirements of the license.

After the nuclear installation has commenced operation, inspections are carried out at regular intervals. Authorised inspectors have access to nuclear installations at all times and may carry out necessary examinations and request pertinent information. The emphasis of the regulatory inspections is on the safety related systems and components with special attention toward the systems functions. Other objectives are plant operation, operator behavior and periodic maintenance. Licensees are required to shut down their nuclear installations at regular intervals for inspection and maintenance. One year is a typical interval between two successive plant shutdowns.

The supervisory authority may order discontinuance of an operation, which is not in compliance with the Atomic Energy Act and constitutes a considerable hazard. Before halting the operations, the regulatory authority can notify the licensee through warning letters, that certain operational procedures are not being properly executed or that irregularities were discovered. Operational restrictions may be imposed in the case of violations or abnormal occurrences.

The nuclear power plant operators are liable for damages caused by accidents. The maximum amount of financial security of 500 million DM is provided by a system consisting of two layers. Up to 200 million DM financial security is furnished by a third party liability insurance taken out by each operator. Between this amount and 500 million DM, the financial security is provided jointly by all nuclear power plant operators.

### 5.2. Main National Laws and Regulations

The Atomic Energy Act forms the legal basis for the peaceful utilization of nuclear energy. After the severe reactor accident of Chernobyl the "Precautionary Radiological Protection Act" was added:

- Atomic Energy Act (Gesetz über die friedliche Verwendung der Kernenergie und den Schutz gegen ihre Gefahren - Atomgesetz - AtG), enacted in December, 1959, revised in July, 1985, last amendment in July, 1994.

- Precautionary Radiological Protection Act (Gesetz zum vorsorgenden Schutz der Bevölkerung gegen Strahlenbelastung - Strahlenschutzvorsorgegesetz - StrVG), enacted in December, 1986, last amendment by the Fifth Competence Adoption Ordinance (5. Zuständigkeitsanpasssungs-Verordnung) of February, 1993.

The provisions of the Atomic Energy Act are supplemented and specified by ordinances. The most important ordinances include:

- Radiological Protection Ordinance (Verordnung über den Schutz vor Schäden durch ionisierende Strahlen - Strahlenschutzverordnung - StrSchV), enacted October, 1976, revised October, 1989, last amendment in July, 1996.

- Ordinance Relating to the Procedure for the Licensing of Facilities in Accordance with Section 7 of the Atomic Energy Act - Nuclear Licensing Procedures Ordinance (Verordnung über das Verfahren bei der Genehmigung von Anlagen nach §7 des Atomgesetzes - Atomrechtliche Verfahrensverordnung - AtVfV), enacted in February, 1977, revised in February, 1995.

- X-ray Ordinance (Verordnung über den Schutz vor Schäden durch Röntgenstrahlen - Röntgen Verordnung - RöV), enacted in January, 1987, last amendment in July, 1996.

- Nuclear Financial Security Ordinance (Verordnung über die Deckungsvorsorge nach dem Atomgesetz - Atomrechtliche Deckungsvorsorge-Verordnung - AtDeckV), enacted in January, 1977, last amendment by the 6th Transitory Law (6. Überleitungsgesetz) of September, 1990.

- Repository Financing Ordinance (Verordnung über Vorausleistungen für die Einrichtung von Anlagen des Bundes zur Sicherstellung und zur Endlagerung radioaktiver Abfälle - Endlagervorausleistungs-Verordnung - EndlagerVlV), enacted in April, 1982, last amendment by the 6th Transitory Law (6. Überleitungsgesetz) of September, 1990.

Along with the acts and ordinances, there is a large number of regulations related to nuclear safety, e.g., safety guidelines and recommendations by RSK and SSK, nuclear safety standards of the Nuclear Safety Standards Committee (Kerntechnischer Ausschuss, KTA) and other technical rules.

**5.3. International, Multilateral and Bilateral Agreements**

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related safeguards agreement INFCIRC/193 | Entry into force | 21 February 1977 |
| • Improved procedures for designation of safeguards inspectors | Proposal rejected by EURATOM but special procedures agreed upon | letter of 16 February 1989 |

*OTHER MULTILATERAL SAFEGUARDS AGREEMENTS*

| | | |
|---|---|---|
| • Brazil/Germany INFCIRC/237 | Entry into force | 26 February 1976 |
| • Spain/Germany INFCIRC/305 (application suspended) | Entry into force | 29 September 1982 |

*OTHER RELEVANT INTERNATIONAL TREATIES*

| | | |
|---|---|---|
| • NPT | Entry into force | 2 May 1975 |
| • EURATOM | | |
| • Agreement on privileges and immunities | Entry into force | 4 August 1960 |

| | | |
|---|---|---|
| • Convention on physical protection of nuclear material | Entry into force | 6 October 1991 |
| • Convention on early notification of a nuclear accident | Entry into force | 15 October 1989 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force | 15 October 1989 |
| • Conventions on nuclear damage and civil liability for joint protocol | Entry into force of<br>Paris Convention<br>Signature | <br>30 September 1975<br>21 September 1988 |
| • Convention on nuclear safety | Signature:<br>and | 20 September 1994<br>5 October 1994 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted; Acceptance of NUSS Codes: Summary New Codes are proof of common commitment. Revised codes are valuable. National regulations are generally consistent with codes | letter of 6 March 1989 |
| • Nuclear Suppliers Group | Member | |

*BILATERAL AGREEMENTS*

Germany has bilateral agreements with about 25 countries on the exchange of experience and information in the field of nuclear safety and radiation protection including early notification in case of a nuclear accident with transboundary impact (Table 9).

## REFERENCES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[2] Jahrbuch der Atomwirtschaft 1994, Hrsg. W.-M. Liebholz, Verlagsgruppe Handelsblatt GmbH, Düsseldorf.

[3] Handbuch Reaktorsicherheit und Strahlenschutz, 3 Teile, Hrsg. Der Bundesminister des Innern.

[4] Country Profile of Germany 1995 - 96, Economist Intelligence Unit.

[5] United Nations Energy Statistics Yearbook 1993.

TABLE 9. GERMAN BILATERAL AGREEMENTS ON THE SAFETY OF NUCLEAR INSTALLATIONS (N.I.) AND RADIATION PROTECTION

| Agreement with | Major agreement content | Signature, citation |
|---|---|---|
| Argentina | Exchange of information; co-operation | 8 October 1981<br>BGBI. II 1981, p..958 |
| Austria | Exchange of information | 3 August 1993<br>BGBI. II 1995, p. 482 |
| Brazil | Exchange of information; co-operation | 10 March 1978<br>BGBI. II 1978, p.950 |
| Bulgaria | Exchange of information | 26 March 1993<br>BGBI. II, 1993, No. 29 |
| Canada | Exchange of information; co-operation | 23 May 1991<br>not published |
| China | Promotion of co-operation | 12 April 1992<br>BGBI. II 1993, No. 29 |
| Czechoslovakia (former) | Exchange of information | 30 May 1990<br>BGBI. II 1990, p. 1307 |
| Denmark | Mutual informing on the construction of n.i. close to the border;<br>Exchange of information | 4 July 1977<br>not published<br>13 October 1987<br>BGBI. II 1988, p. 1099 |
| Finland | Early notification in case of nuclear accidents;<br>Exchange of information | 21 December 1992<br>BGBI. II 1993, No. 29 |
| France | Exchange of information in case of events and accidents;<br>R & D on management and final disposal of radwaste | 28 January 1981<br>BGBI. II 1981, p. 885<br>6 May 1991<br>BGBI. II 1992, No. 36 |
| Hungary | Exchange of information | 26 September 1990<br>BGBI. II 1991, p. 889 |
| Japan | Exchange of information | 1 September 1989<br>not published |
| The Netherlands | Mutual informing on n.i. close to the border, within the frames of a Dutch-German Commission (NDKK); exchange of information on events in NPPs;<br>Mutual aid in case of catastrophes, nuclear accidents included | 28 October 1977 and 21 May 1981<br>not published<br>7 June 1988<br>BGBI. II 1992, No. 9 |
| Norway | Exchange of information | 10 May 1988<br>BGBI. II 1988, p. 1097 |
| Spain | co-operation | 14 March 1988<br>not published |
| Sweden | Early notification in case of nuclear accidents; exchange of information | 25 September 1990<br>BGBI. II 1991, p. 421 |
| Switzerland | Radiological emergency preparedness;<br>Mutual informing on the construction and operation of n.i. close to the border;<br>Third party liability, regarding the peaceful use of nuclear energy | 31 May 1978<br>BGBI. II 1980, p. 563<br>10 August 1982<br>BGBI. II 1983, p. 734<br>22 October 1986<br>BGBI. II 1988, p. 598 |
| UK | Important nuclear safety issues; elaboration of safety standards | 4 April 1979<br>BGBI. II 1979, p. 434 |
| Ukraine | Exchange of information | 10 jUNE 1993<br>BGBI. II 1994, No. 12 |
| USA | Exchange of information;<br>co-operation | 6 July 1981<br>BGBI. II 1981, p. 657 and<br>BGBI. II 1987, p. 197 and<br>BGBI.II 1996, No. 9 |
| USSR(former) | Early notification in case of a nuclear accident;<br>Exchange of information | 25 October 1988<br>BGBI. II 1990, p. 165 |

# ANNEX I. DIRECTORY OF THE MAIN ORGANISATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*FEDERAL AUTHORITIES*

| | |
|---|---|
| Bundesministerium für Wirtschaft (BMWi)<br>Villemombler Str. 76<br>D-53123 Bonn | Tel.: +49-228-615-0<br>Fax: +49-228-615-4436 |
| Bundesministerium für Umwelt, Naturschutz<br>und Reaktorsicherheit (BMU)<br>Postfach 12 06 29<br>D-53048 Bonn | Tel.: +49-228-305-0<br>Fax: +49-305-2899 |
| Bundesministerium für Bildung,<br>Wissenschaft, Forschung und<br>Technologie (BMBF)<br>Heinemannstr. 2<br>D-53175 Bonn | Tel.: +49-228-57-0<br>Fax: +49-228-57-3601 |
| Bundesamt für Strahlenschutz (BfS)<br>Postfach 10 01 49<br>D-38201 Salzgitter | Tel.: +49-5341-188-0<br>Fax: +49-5341-188-188 |

*STATE AUTHORITIES*

| | |
|---|---|
| **Baden-Württemberg**<br>Wirtschaftsministerium des Landes Baden-Württemberg<br>Theodor-Heuss-Str. 4<br>D-70174 Stuttgart | Tel.: +49-711-123-0<br>Fax: +49-711-123-2126 |
| Ministerium für Umwelt und Verkehr<br>des Landes Baden-Württemberg<br>Kernerplatz 9<br>D-70182 Stuttgart | Tel.: +49-711-126-0<br>Fax: +49-711-126-2880 |
| Innenministerium des Landes Baden-Württemberg<br>Dorotheenstr. 6<br>D-70173 Stuttgart | Tel.: +49-711-2072-1<br>Fax: +49-711-2072-3779 |
| **Bavaria**<br>Bayerisches Staatsministerium für Landesentwicklung und<br>Umweltfragen<br>Postfach 81 01 40<br>D-81901 München | Tel.: +49-89-9214-0<br>Fax: +49-89-9214-2266 |
| Bayerisches Staatsministerium für Wirtschaft,<br>Verkehr und Technologie<br>Prinzregentenstr. 28<br>D-80538 München | Tel.: +49-89-2162-01<br>Fax: +49-89-2162-2760 |
| **Berlin**<br>Senatsverwaltung für Stadtentwicklung,<br>Umweltschutz und Technologie Berlin<br>Brückenstr. 6<br>D-10179 Berlin | Tel: +49-30-2471-0<br>Fax: +49-30-2471-2920 |
| **Brandenburg**<br>Ministerium für Umwelt, Naturschutz und Raumordnung<br>Postfach 60 11 64<br>D-14411 Potsdam | Tel: +49-331-866-0<br>Fax: +49-331-866-7240 |

**Bremen**
Senator für Frauen, Gesundheit, Jugend,
Soziales und Umweltschutz der Freien
Hansestadt Bremen
Hanseatenhof 5 — Tel: +49-421-361-0
D-28195 Bremen — Fax: +49-421-361-6013

Senator für Arbeit
der Freien Hansestadt Bremen
Contrescarpe 73 — Tel: +49-421-361-0
D-28195 Bremen — Fax: +49-421-361-2072

**Hamburg**
Umweltbehörde der Freien Hansestadt Hamburg
Billstr. 84 — Tel: +49-40-7880-0
D-20539 Hamburg — Fax: +49-40-7880-3293

**Hessen**
Hessisches Ministerium für Umwelt, Energie,
Jugend, Familie und Gesundheit
Mainzer Str. 80 — Tel: +49-611-815-0
D-65189 Wiesbaden — Fax: +49-611-815-1941

**Mecklenburg-Vorpommern**
Innenministerium des Landes Mecklenburg-Vorpommern
Abteilung Reaktorsicherheit und Strahlenschutz
Wismarsche Str. 133 — Tel: +49-385-588-0
D-19053 Schwerin — Fax: +49-385-588-2972

**Lower Saxony**
Niedersächsisches Umweltministerium
Postfach 41 07 — Tel: +49-511-104-0
D-30041 Hannover — Fax: +49-511-104-3399

**North Rhine-Westphalia**
Ministerium für Wirtschaft, Mittelstand, Technologie
und Verkehr des Landes Nordrhein-Westfalen — Tel: +49-211-837-02
D-40190 Düsseldorf — Fax: +49-211-837-2200

**Rhineland-Palatinate**
Ministerium für Umwelt und Forsten
des Landes Rheinland-Pfalz
Postfach 31 60 — Tel: +49-6131-16-0
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**Saarland**
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D-66024 Saarbrücken — Fax: +49-681-501-4521

**Saxony**
Sächsisches Staatsministerium für Umwelt und
Landesentwicklung
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D-01002 Dresden — Fax: +49-351-486-2209

**Saxony-Anhalt**
Ministerium für Umwelt, Naturschutz
und Raumordnung des Landes Sachsen-Anhalt
Postfach 37 69 — Tel: +49-391-567-01
D-39012 Magdeburg — Fax: +49-391-567-3368

**Schleswig-Holstein**
Ministerium für Finanzen und Energie des Landes
Schleswig-Holstein
Postfach 20 09 — Tel: +49-431-988-0
D-24019 Kiel — Fax: +49-431-988-4202

**Thuringia**
Thüringisches Ministerium für Landwirtschaft,
Naturschutz und Umwelt
Postfach 13 03 — Tel: +49-3612-144-0
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*NUCLEAR EXPERT ORGANIZATIONS*

Gesellschaft für Anlagen-
und Reaktorsicherheit (GRS) mbH
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D-50667 Köln — Fax: +49-221-2068-888

TÜV Energie- und Systemtechnik GmbH
Unternehmensgruppe TÜV Bayern — Tel.: +49-89-5791-0
D-80684 München — Fax: +49-89-5791-1551

Technischer Überwachungs-Verein
Berlin-Brandenburg e.V. — Tel.: +49-30-7562-0
D-10882 Berlin — Fax: +49-30-7562-298

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D-30505 Hannover — Fax: +49-511-986-1237

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D-22502 Hamburg — Fax: +49-40-8557-2295

Technischer Überwachungs-Verein Südwest e.V.
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D-68032 Mannheim — Fax: +49-621-395-454

Technischer Überwachungs-Verein Rheinland e.V. — Tel.: +49-221-806-0
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*MAIN RESEARCH CENTRES*

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D-52425 Jülich — Fax: +49-2461-61-5327

Forschungszentrum Karlsruhe GmbH (KfK)
Postfach 36 40 — Tel.: +49-7247-82-1
D-76201 Karlsruhe — Fax: +49-7247-82-5070

*OPERATION OF NPPs*

**Main utilities**

Bayernwerk AG (BAG)
Nymphenburger Str. 39 — Tel.: +49-89-1254-1
D-80335 München — Fax: +49-89-1254-3906

Hamburgische Electricitätswerke AG (HEW)
Überseering 12 — Tel.: +49-40-6396-0
D-22297 Hamburg — Fax: +49-40-6396-5182

Isar-Amperwerke AG
Brienner Str. 40 — Tel.: +49-89-5208-0
D-80333 München — Fax: +49-89-5280-2203

PreussenElektra AG
Tresckowstr. 5 — Tel.: +49-511-439-0
D-30457 Hannover — Fax: +49-511-439-2375

RWE Energie AG
Kruppstr. 5 — Tel.: +49-201-12-01
D-45128 Essen — Fax: +49-201-12-24313

Vereinigte Elektrizitätswerke Westfalen AG (VEW)
Rheinlanddamm 24
Postfach 10 50 56 — Tel.: +49-231-438-1
D-44139 Dortmund — Fax: +49-231-438-2147

**Simulator training centre**

Gesellschaft für Simulatorschulung
Postfach 15 02 51 — Tel.: +49-201-4862-0
D-45242 Essen — Fax: +49-201-4862-199

*MANUFACTURERS OF NPPs*

Siemens AG
Bereich Energieerzeugung (KWU)
Freyeslebenstr. 1 — Tel.: +49-9131-18-0
D-91058 Erlangen — Fax: +49-9131-18-3815

ABB Reaktor GmbH
Dudenstr. 44
Postfach 10 05 63 — Tel.: +49-621-388-2007
D-68167 Mannheim — Fax: +49-621-388-2010

*MANUFACTURERS OF COMPONENTS; SERVICES*

Babcock Rohrleitungsbau GmbH
Duisburgerstr. 375
Postfach 10 02 67 — Tel.: +49-208-833-0
D-46002 Oberhausen — Fax: +49-208-24561

Dornier GmbH — Tel.: +49-7545-84572
D-88039 Friedrichshafen — Fax: +49-7545-85513

KSB Aktiengesellschaft
Postfach 1360 — Tel.: +49-9241-71-1641
D-91253 Pegnitz — Fax: +49-9241-71-1761

Nukem GmbH
Industriestr. 13 — Tel.: +49-6023-91-1384
D-63754 Alzenau — Fax: +49-6023-91-1486

Siempelkamp Gießerei Gesellschaft für Guss-
und Reaktortechnik mbH
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D-47803 Krefeld — Fax: +49-2151-894-345

Steag Kernenergie GmbH
Rüttenscheider Straße 1-3 — Tel.: +49-201-801-0
D-45128 Essen — Fax: +49-201-801-2349

Sulzer Weise GmbH
Ernst-Blickle-Str. 29 — Tel.: +49-7251-76-0
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*FUEL CYCLE*

**Radwaste management**

Brennelementlager Gorleben GmbH (BLG)
Lüchower Str. 8 — Tel.: +49-5882-10-0
D-29475 Gorleben — Fax: +49-5882-10-130

Brennelement-Zwischenlager Ahaus GmbH (BZA)
Ammeln 59 — Tel.: +49-2561-426-0
D-48683 Ahaus — Fax: +49-2561-426-99

Deutsche Gesellschaft zum Bau und Betrieb
von Endlagern für Abfallstoffe mbH (DBE)
Woltorfer Str. 74 — Tel.: +49-5171-43-1
D-31201 Peine — Fax: +49-5171-43-218

GNB Gesellschaft für Nuklear-Behälter mbH
Hollestr. 7A — Tel.: +49-201-109-0
D-45127 Essen — Fax: +49-201-109-1100

GNS Gesellschaft für Nuklearservice mbH
Hollestr. 7A — Tel.: +49-201-109-0
D-45127 Essen — Fax: +49-201-109-1100

**Enrichment, fuel elements, transportation**

Advanced Nuclear Fuels GmbH
Postfach 14 65 — Tel.: +49-591-9145-0
D-49784 Lingen — Fax: +49-591-9145-383

Urangesellschaft mbH (UG)
Solmsstr. 2-26 — Tel.: +49-69-795005-0
D-60486 Frankfurt am Main — Fax: +49-69-795005-55

Urenco Deutschland GmbH
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Röntgenstr. 4 — Tel.: +49-2562-711-0
D-48580 Gronau — Fax: +49-2562-711-178

# HUNGARY

## HUNGARY

# 1. GENERAL INFORMATION

## 1.1. General overview

Hungary is a landlocked central European country. It has borders with Austria, the Slovak Republic, Ukraine, Romania, Yugoslavia, Croatia and Slovenia. It is strategically located astride main land routes between Western Europe and the Balkan peninsula as well as between Ukraine and the Mediterranean basin. Hungary covers an area of 93,032 square kilometers.

Hungary has a continental climate with Mediterranean and Atlantic influences with humid winters and warm summers. The average temperature in January is 2°C (28°F) and in July 23°C (73°F). In 1993, the population in Hungary was 10.2 million of which 64% lived in urban areas. The population growth rate from 1980 to 1993 was -0.4% (decreasing) and the population density 110 inhabitants per square kilometre (Table 1).

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 10.0 | 10.3 | 10.7 | 10.4 | 10.2 | 10.2 | -0.4 |
| Population density (inhabitants/km²) | 107.3 | 111.1 | 115.1 | 111.4 | 109.8 | 109.2 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | -0.4 |
| Area (1000 km²) | 93.0 |
| Urban population in 1994 as percent of total | 64.0 |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

Hungary is still in the midst of a difficult transition from a centralised to a market economy. Its economic reforms during the communist era gave a head start on this process, particularly in terms of attracting foreign investors. Although, the privatisation process has lagged. Overall, about half of Gross Domestic Product (GDP) now originates in the private sector. The unemployment rate rose to about 13% in 1993, while inflation remained just above 20%. Falling exports pushed the trade deficit to about $3 billion. Total Gross Domestic Product (GDP) amounted to 36 billion US$ in 1993 (Table 2). The GDP real growth rate was -1% and the national product per capita about 3,500 US$ in 1993.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1993 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 5,663 | 22,649 | 33,056 | 36,113 | | 3.7 |
| GDP (millions of constant 1990 US$) | 18,569 | 29,517 | 33,056 | 26,614 | 27,146 | -0.8 |
| GDP per capita (current US$/capita) | 548 | 2,115 | 3,189 | 3,535 | | 4.0 |

| GDP by sector (1990): | |
|---|---|
| Agriculture | 10% |
| Industry | 34% |
| Services | 55% |

Source: IAEA Energy and Economic Data Base

### 1.3. Energy Situation

Hungary has various energy resources, but mainly coal and lignite (Table 3). Coal mining has been in a critical situation for a long time. Difficult geological conditions, poor heating value and low quality of Hungarian lignites, together with the current low prices of the other energy sources, have resulted in a declining annual production. In recent years, Hungary produced about 20-22 million tonnes of coal, including 5-6 million tonnes of poor quality lignite. Hungary is a producer of crude oil. The present production of approximately 2 million tons/year covers less than a quarter of the national demand and is decreasing. About 6 billion m3/year of natural gases are produced in Hungary, covering roughly half of the total demand. Gas production is also decreasing. The mining of uranium began in Hungary in the 1950s. Under a special arrangement, the total production was exported to the former USSR and hence did not play a role in the national energy balance. The share of domestic energy resources in energy production in 1993 was 24% for nuclear, 31% for coal, 16% for oil and 29% for gas. The basic energy statistics are given in Table 4. The share of the final energy consumption by sector in 1993 was 38.2% in industry, 34.8% in household and 26.9% in others.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 49.13 | 0.80 | 3.15 | 0.00 | 0.67 | 83.44 |

[1] *This total represents essentially recoverable reserves.*
[2] *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.*
Source: IAEA Energy and Economic Data Base

TABLE 4. BASIC ENERGY SITUATION

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 0.53 | 0.94 | 1.29 | 1.27 | 1.03 | 1.02 | 4.49 | -1.63 |
| - Solids[2] | 0.39 | 0.52 | 0.40 | 0.32 | 0.24 | 0.22 | 0.08 | -4.29 |
| - Liquids | 0.12 | 0.26 | 0.45 | 0.34 | 0.30 | 0.32 | 7.03 | -2.48 |
| - Gases | 0.02 | 0.13 | 0.36 | 0.37 | 0.34 | 0.34 | 15.45 | -0.50 |
| - Primary electricity[3] | 0.01 | 0.03 | 0.07 | 0.23 | 0.15 | 0.15 | 13.18 | 5.29 |
| Energy production | | | | | | | | |
| - Total | 0.38 | 0.64 | 0.67 | 0.62 | 0.55 | 0.53 | 2.81 | -1.58 |
| - Solids | 0.32 | 0.43 | 0.31 | 0.23 | 0.17 | 0.16 | -0.07 | -4.50 |
| - Liquids | 0.05 | 0.09 | 0.12 | 0.11 | 0.09 | 0.08 | 4.10 | -2.39 |
| - Gases | 0.01 | 0.12 | 0.24 | 0.16 | 0.16 | 0.16 | 15.66 | -2.88 |
| - Primary electricity[3]) | | | | 0.13 | 0.13 | 0.13 | 0.88 | 40.73 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.15 | 0.27 | 0.56 | 0.56 | 0.50 | 0.47 | 6.96 | -1.27 |
| - Solids | 0.08 | 0.09 | 0.09 | 0.06 | 0.05 | 0.05 | 0.84 | -4.23 |
| - Liquids | 0.06 | 0.17 | 0.33 | 0.28 | 0.26 | 0.23 | 8.64 | -2.54 |
| - Gases | 0.01 | 0.01 | 0.14 | 0.22 | 0.20 | 0.19 | 15.64 | 2.15 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

The main strategic goals of the Hungarian energy policy are:

i) exemption of the unilateral import-dependency of the country;
ii) restraint of the environmental damages of energetics;
iii) helping of thrift and more efficient consuming;
iv) extension of social-acceptance system;
v) flexible system-development;
vi) creating of the development sources (capital investment).

## 2. ELECTRICITY SECTOR

### 2.1 Structure of the Electricity Sector

The Hungarian national utility, the Hungarian Power Company Ltd. (MVM Rt.), is owned by State Asset Management Ltd. (AV Rt.) (99,82%) and by local municipalities 0,18%. The AV Rt. is responsible for the long-term strategic asset administration, maintenance of the state majority (50%+1 vote) and implementation of the national asset policy guidelines (value based sale of shares). The MVM Rt. is responsible for wholesale trading, imports/exports, the basic network, system dispatching and system development. There are four different company groups in the ownership structure belonging to MVM Rt, AV Rt. and the local municipalities:

- Power Plant Ltd
- Power Plant Ltd with coal mines
- Distribution LTD's
- National Grid Operating Company

The national grid is a part of the former Comecon power system, with 750 kV and 400 kV international interconnection lines with neighbouring countries. Hungary has only limited island operation with Austria, which is synchronised with the Western European grid of the Union for Co-ordination Production and Transport of Electric Energy (UCPTE)

Currently, the Hungarian government is making a decision on the privatisation of the electricity sector which implies that the above mentioned will be subject to changes in the near future.

### 2.2. Decision Making Process

The Minister of Industry and Trade is responsible for making proposals to construct new power plants. If the installed capacity is more than 600 MWe, the parliament has to approve the proposal for construction and if the installed capacity is between 200 and 600 MWe, the Government is responsible for taking the decision. However, electric energy demand is decreasing and projections show that the Hungarian system does not require any additional large baseload power plant before the turn of the century. Where additional generating capacity is required, this can be provided by combined cycle units, with combustion turbines installed as part of a repowering programme for existing combined heat and power stations.

### 2.3. Main Indicators

At the end of 1993 the total installed capacity was 6,735 MWe of which 73.6% fossil fired, 25.7% nuclear, 16.3% coal, 0.7% hydro. The nuclear share in total electric power generation was 39.6%, fossil 59.9% and hydro 0.5%. Of total electricity consumption, about 7% was imported and

3% provided by autoproducers. Table 5 shows the historical electricity production and installed capacity data and Table 6 the energy related ratios.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 7.62 | 14.54 | 23.88 | 28.41 | 32.78 | 33.49 | 5.88 | 2.45 |
| - Thermal | 7.52 | 14.45 | 23.76 | 15.34 | 19.63 | 20.10 | 5.92 | -1.19 |
| - Hydro | 0.09 | 0.09 | 0.11 | 0.18 | 0.17 | 0.16 | 0.88 | 2.63 |
| - Nuclear | | | | 12.89 | 12.99 | 13.23 | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 1.47 | 2.48 | 4.98 | 6.60 | 6.86 | 6.98 | 6.31 | 2.44 |
| - Thermal | 1.45 | 2.46 | 4.93 | 4.83 | 5.08 | 5.20 | 6.33 | 0.38 |
| - Hydro | 0.02 | 0.02 | 0.05 | 0.05 | 0.05 | 0.05 | 4.52 | 0.30 |
| - Nuclear | | | | 1.73 | 1.73 | 1.73 | | |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Database

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 54 | 91 | 120 | 122 | 101 | 100 |
| Electricity per capita (kW·h/capita) | 817 | 1,598 | 2,736 | 3,569 | 3,198 | 3,251 |
| Electricity production/Energy production (%) | 19 | 20 | 32 | 40 | 53 | 56 |
| Nuclear/Total electricity (%) | | | | 50 | 43 | 43 |
| Ratio of external dependency (%)[(1)] | 27 | 29 | 44 | 44 | 49 | 46 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 59 | 67 | 55 | 49 | 55 | 55 |
| - Thermal | 59 | 67 | 55 | 36 | 44 | 44 |
| - Hydro | 56 | 50 | 28 | 42 | 39 | 38 |
| - Nuclear | | | | 85 | 86 | 87 |

[(1)] *Net import / Total energy consumption.*
Source: IAEA Energy and Economic Database

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

The first Hungarian reactor (of soviet-type) was built for research purposes at Csillebercon the outskirts of Budapest in 1959. The reactor, refurbished by Hungarian experts after 30 years of operation, was put into operation again by the Nuclear Energy Research Institute in 1993. In 1966, it was decided to construct a large nuclear power plant in Hungary . The decision concerned two reactors of the VVER-440 type, 230 model. The construction work started in 1968, but was interrupted in 1970 because, at that time, the oil-fired stations were considered to be more economic. The actual construction work started after the oil crisis in 1975. The final decision included four second generation reactors, i.e. VVERs-440/213, all to be part of one nuclear power plant. The plant is located about 5 km south of the town Paks, on the right bank of the river Danube. Since 1987, these four reactors have been generating electricity to the Hungarian electric energy system. The installed capacity of the reactors was 4 times 440 MWe. As a result of modifications, the electrical output was increased by 20 MWe at the same nominal capacity of the reactors. At present , the total capacity per unit is 460 MWe, hence the total power of the plant is 1,840 MWe.

In 1986, a preliminary decision was made by the government to continue the nuclear power programme by extending the Paks site with two further Soviet PWRs, of 1,000 MWe each. Under a very different economic environment, the project was cancelled in 1989. Reasons for this cancellation were amongst others, a lower demand growth forecast and problems in providing the funds for such a large project.

### 3.2. Current Policy Issues

There has not been made any decision on new power plant construction for baseload mode operation, so no provisions have been made to start a new nuclear power project in the near future. On a long-term basis, nuclear power and, to a limited extend, domestic coal are the only alternatives for electricity supply. As a former communist-controlled country, the public involvement in nuclear power development has been minimal, i.e. there is not much experience with public acceptance. Hungary is studying the experience of various western utilities. However, it is clear that Hungary must develop its own policy, tailored to the needs of the Hungarian society, but using western experience and support. The Paks NPP should take an active role according to the established traditions in other fields such as judgement of the nuclear industry, the degree of the public acceptance; general safety upgrading efforts and implementation of new nuclear power plants.

### 3.3. Status and Trends of Nuclear Power

As mentioned above there is only one nuclear power plant in operation with four VVER reactors. For the time being, there are no plans regarding new units at the same site or new power plants. Table 7 shows the status of the nuclear reactors. The nuclear electricity generation was about 14.2 TW.h in 1996 and the nuclear electricity share in electricity generation was 40.8%.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| PAKS-1 | WWER | 430 | PAKS RT. | Operational | AEE |
| PAKS-2 | WWER | 433 | PAKS RT. | Operational | AEE |
| PAKS-3 | WWER | 433 | PAKS RT. | Operational | AEE |
| PAKS-4 | WWER | 433 | PAKS RT. | Operational | AEE |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| PAKS-1 | 01-Aug.-74 | 14-Dec.-82 | 28-Dec.-82 | 10-Aug.-83 | |
| PAKS-2 | 01-Aug.-74 | 26-Aug.-84 | 06-Sept.-84 | 14-Nov.-84 | |
| PAKS-3 | 01-Oct.-79 | 15-Sept.-86 | 28-Sept.-86 | 01-Dec.-86 | |
| PAKS-4 | 01-Oct.-79 | 09-Aug.-87 | 16-Aug.-87 | 01-Nov.-87 | |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organizational Chart

The structure of the Hungarian nuclear energy sector is shown in Figure 1.

## 4. NUCLEAR POWER INDUSTRY

The Hungarian Atomic Energy Commission (HAEC) is responsible for policy making in nuclear energy, R&D in nuclear safety, international relations (such as IAEA), bilateral and multilateral agreements, public information, nuclear safety inspectorate, nuclear export/import, safeguards, accountancy of radioactive materials and co-ordination of regulatory activities.

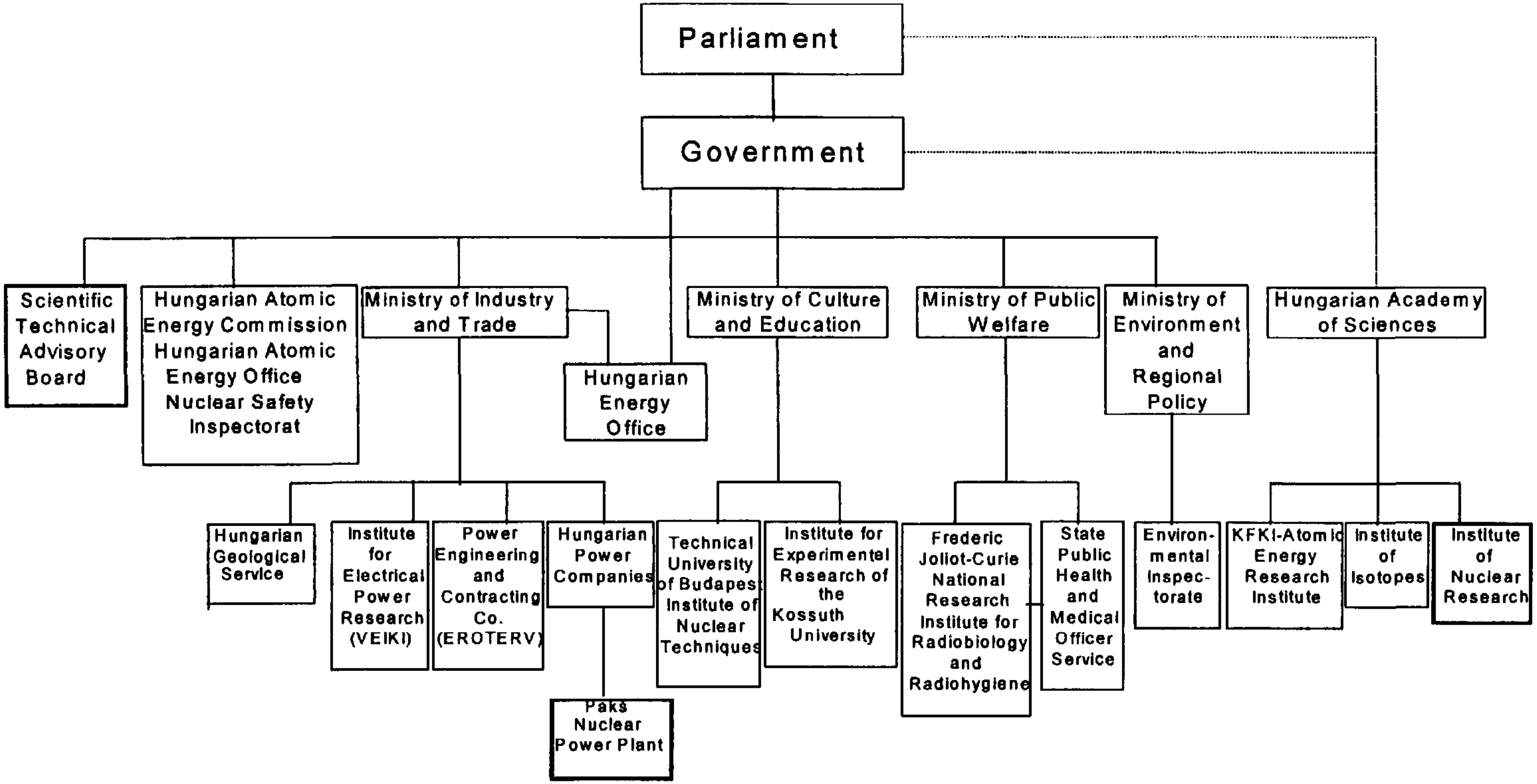


*Fig. 1. Organizational Chart of the Hungarian Nuclear Energy Sector*

The main responsibilities of the Hungarian Energy Office are the following:

i) licensing of the electric power production, supply and distribution;
ii) quality control of the services and the satisfaction of the consumer needs;
iii) consumer protection.

The office sets the electric energy prices and tariffs to be paid by the different consumers.

The Hungarian Power Companies Ltd. (MVM Rt.) is responsible for the overall electricity production. The Power Engineering and Contracting Co. (EROTERV) is the Hungarian construction and engineering company most involved in nuclear power development in Hungary. The Institute for Electrical Power Research (VEIKI) performs all kind of research related to the electric power production. It includes both the conventional and nuclear energy production. The Mecsek Ore Mining Company was established in 1954 and became a wholly state-owned company in 1956.

The Ministry of Public Welfare is taking a role in the licensing procedure and is the agency responsible for health protection rules in relation to nuclear power plant operations. The State Public Health and Medical Officer Service is responsible for the collection, treatment, and storage of solid and liquid radioactive wastes. The Frederic Joliot-Curie National Research Institute for Radiobiology and Radiohygiene provides expert advice and technical assistance to the Ministry of Public Welfare.

The Institute of Isotopes is responsible for the production of radioisotope sources for industrial, medical and research purposes. The Central Research Institute for Physics (KFKI) operates a 10 MWe reactor and a critical assembly for research purposes and is performing R&D in the field of nuclear measurement and process control technology. The Institute of Nuclear Research (ATOMKI) at Debrecen, operates a cyclotron. The Technical University of Budapest is operating a nuclear training reactor. The Ministry for the Environmental and Regional Policy is responsible for establishing air and water quality standards, limits in radioactive releases from nuclear facilities, as well as for controlling the releases at the facilities to the environment.

### 4.1. Supply of NPPs

There are no NPP suppliers in the country, the main components of the Paks NPP were made abroad. (i.e. in Russia and Czech Republic). The main constructor was AEE (Atomenergoexport) and the main architect ERBE -EROTERV (Hungary).

The main component suppliers are:

| | |
|---|---|
| – reactor system | AEE/SSSR |
| – reactor vessel | Skoda |
| – fuel | AEE |
| – steam raising | AEE |
| – turbine | AEE |
| – generator | GANZ. |

The manufacture of many components of the Russian-designed VVERs was done in the former COMECON countries under a multilateral agreement.

### 4.2. Operation of NPPs

The Paks NPP is owned by the Hungarian Power Companies Ltd (50%), State Asset Management Ltd (49%) and local municipalities (1%). Operation and maintenance is performed by

Paks Nuclear Power Ltd (PARt). In the past, the operator's training was done in Greifswald and in Novovoronezh, but nowadays Paks NPP has a full-scope simulator at the on-site training centre.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management Service Supply

*Fuel Cycle*

Hungary has 20,000 metric tons of exploitable uranium resources and 10,000 metric tons of additional reserves. There are three areas in Hungary where uranium occurrences are known, but only one region in Mecsek Mountains has been exploited. Hungary was mining uranium ore which was processed to yellowcake at Mecsek and then shipped to Russia. Fuel cycle services were guaranteed by the former USSR when Hungary purchased Soviet reactors including the fabrication of fuel assemblies, the shipping of the fabricated fuel assemblies to Hungary, and the return of spent fuel to the former USSR. Hungary does not have other fuel cycle capabilities such as fuel conversion, enrichment, and fabrication.

There are no reprocessing capabilities in Hungary, and no plans to develop any. Hungarian spent fuel has been reprocessed in Russia and the recovered plutonium does not have to be returned to Hungary. Hungary has at present no plans for recycling plutonium as fuel.

*Spent Fuel*

The Hungarian policy on spent fuel storage is to store the spent fuel in the pools at the Paks reactor site for 5 years and then transport the spent fuel to the former USSR under an existing agreement. In spring 1992, the Russian parliament passed an environmental law forbidding the import of foreign spent fuel. However, Paks was able to send a few spent fuel shipments up until February 1995.

The Hungarian Atomic Energy Commission issued a license on 4 February 1995 to the Hungarian Power Companies Ltd. for the construction of a spent fuel interim dry storage facility at the Paks site. The Paks NPP management has already chosen GEC Alsthom's modular dry storage technology. In an agreement last year with the Paks local government, Paks NPP guaranteed that no spent fuel would be placed in the dry storage facility as long as the Russians accepted the spent fuel. The dry storage facility is designed to hold fuel for 50 years and should be commissioned in 1996.

*Waste Management*

Hungary producers radioactive waste from the Paks nuclear reactors - (non-disposable in the existing off-site repository) and from medical and industrial nuclear activities (disposable in the existing off-site repository). The strategy on LLW/ILW disposal in Hungary is that these wastes will be buried in cemented form in steel drums in a shallow-ground disposal site, maintained for 600 years. Since 1986, ILW/LLW from the Paks nuclear power station has been stored at Paks, due to public opposition to its continued burial at the existing disposal site at Puspokszilagy. Public opposition also prevented disposal of Paks-generated ILW/LLW at the alternative site at Ofalu. Until this situation is resolved, ILW/LLW generated at Paks is cemented and stored on-site at Paks.

### 4.4. Research and Development Activities

There are no institutes or research centres independent from the companies listed above.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

A four year safety project with a 7 million US$ budget has just started at the Paks NPP. The project is partly funded by the US Government and the PHARE assistance programme of the European Commission, with the IAEA providing technical assistance. The project will establish a maintenance training centre, introduce international training techniques and help to enhance safety at the plant.

An operator reliability experiment project is carried out with participants from the Institute for Electrical Power Research (VEIKI), EPRI and Paks NPP. The project is supported by the US Government.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and Licensing Process

The Hungarian Atomic Energy Commission (HAEC) is an organization on the level of ministries lead by a minister without portfolio. The HAEC became independent from the Ministry of Industry and Trade in 1990. Formerly, regulation and production functions were both under the same Ministry authority. HAEC manages most of the nuclear aspects which are related to international relations, preparation for legislation, internal relations, nuclear regulatory and licensing activities.

The Nuclear Safety Inspectorate (NSI) and the Nuclear Safety Supreme Inspectorate (NSSI), i.e., the authorities of the first and second level respectively, work under HAEC. The license holder can appeal to NSSI against any decision of NSI.

A general development of regulation and licensing procedures is in progress. The Atomic Energy Act and the Guides of Nuclear Regulations (GNR) give only general principles to licensing procedures (at present these reports on nuclear regulation are being updated). The detailed licensing procedures will be described in the Quality Assurance Manual (QAM). QAM is being developed at present and will contain the operating rules and other activities of HAEC.

There are two types of licensing procedures. Nuclear safety licenses are required for nuclear facilities for the following phases: selection of the site, construction, commissioning, operation, modification and decommissioning of the facility. Nuclear safety licenses for nuclear equipment and devices are required for their fabrication, import, installation, commissioning and operation, modification or reconstruction, reparation and removal.

The licensing of a nuclear facility is performed step by step. It means that the whole process of licensing consists of subsequent licensing procedures according to the mentioned phases. The sequence of phases is fixed and the licensing procedure of a phase may not be started before completing the previous one. The licensing procedures are similar for different nuclear facilities, but every type of nuclear facility requires a set of special directives.

### 5.2. Main National Laws and Regulations

*List of the essential legal laws and decrees regulating nuclear power in Hungary*

- Decree of the Ministry of Heavy Industry 5/1979. (III.31) on Technical Safety Questions of the Nuclear Power Station.

  The Annex of Decree contains the following:

  - Technical safety regulation of the nuclear power plant;
  - Quality proving regulation of the nuclear power plant;
  - Technical safety regulation of the pressure vessels of the nuclear power reactors;
  - Stability calculating regulation of the pressure vessels of the nuclear power reactors;
  - Welding regulation of the structures of the nuclear power plant;
  - Control regulation of the welding of the structures of the nuclear power plant;

- Electric and technical safety regulations of the nuclear power plant;
- Regulation of handling radioactive wastes arising in the nuclear power plant.

- The Act on Nuclear Energy, Law No. 1/1980, and its associated Executive Order was passed by the Parliament in 1980 and established the legal basis for nuclear energy and the nuclear fuel cycle and confirmed previous laws. The nuclear regulatory tasks are carried out under the Ministry of Industry (formerly the Ministry of Heavy Industry) Decree 5/1979, which deals primarily with the safety aspects of nuclear plants and delegates nuclear regulatory authority to the state Supervisory of Energetics and Energy Safety.

  The Act on Nuclear Energy provides that:

  - Nuclear energy is to be used in a manner prescribed by law;
  - Nuclear energy applications are subject to regular State surveillance;
  - License is required for construction, commissioning, operation, alternation, and decommissioning of nuclear power plants;
  - The licensing authority is required to enforce the provision of the Act on Nuclear Energy;
  - The Act also defines that compensation payments for nuclear accident damage shall be the responsibility of the State and voids any other legal provisions which exclude or limit liability.

- Law Decree No. 15 of 1987 amended the Act I.

- Governmental Decree 104/1990 (XII.15.) on the tasks and competency of the Hungarian Atomic Energy Commission and Hungarian Atomic Energy Office. The nuclear regulatory and licensing activity came to the authority of the Hungarian Atomic Energy Commission.

- Decree of Minister without Department 1/1990. (XII.25.) on fixing the fees of official procedures concerning nuclear facilities

- Decree of Minister without Department in 1993 on the Safety Technical Regulation of the nuclear facilities. It updated the decree from 1979 extending nuclear regulations to the whole nuclear technology that is to zero power and research reactors and other nuclear facilities too.

*The mechanisms in place for financing decommissioning and waste disposal*

No nuclear facilities in Hungary have reached the stage of decommissioning and no policy has been decided on this topic yet. Waste management and disposal activities are mainly regulated by the Act I. 1/1980 as amended by the Decrees of Legal Force (DLF) No.1987 . Act I. 1/1980 states the responsibilities of the various ministries involved in the regulatory and licensing processes for nuclear facilities. The Departmental Order No. 7/1988, issued by the Ministry of Public Welfare, contains some stipulations concerning the radiation protection requirements for the final disposal of radioactive wastes. Some other aspects, such as the shielding and packing of radioactive materials, transportation are also recovered by Departmental Orders. In 1990, the Hungarian Atomic Energy Commission was charged with the responsibility for evaluating and proposing a more comprehensive basis for nuclear legislation. This process may lead to a revised law. This law incorporate provisions and will address such issues as financing, long-term responsibilities for waste management, siting procedures, etc. The creation of a fund for financing the future costs of radioactive waste management is foreseen.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related agreement INFCIRC/174 | Entry into force: | 30 March 1972 |
| • Improved procedures for designation of safeguards inspectors | Accepted: | 9 May 1988 |
| • Agreement concerning provision of a dose assurance service by IAEA to irradiation facilities in its Member States | Entry into force: | 4 November 1985 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 12 June 1989 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • Treaty banning nuclear weapon testing in the atmosphere, in outer space and under water | Entry into force: | 5 August 1963 |
| • Agreement on privileges and immunities | Entry into force: | 14 July 1967 |
| • NPT | Entry into force: | 27 May 1969 |
| • Treaty of the prohibition of the emplacement of nuclear weapons and other weapons of mass destruction on the seabed and the ocean floor and in the subsoil thereof | Entry into force: | 13 August 1971 |
| • Convention on physical protection of nuclear material | Entry into force: | 8 February 1987 |
| • Convention on early notification of a nuclear accident | Entry into force: | 10 April 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 10 April 1987 |
| • Joint protocol relating to the application of the Vienna Convention and the Paris Convention | Entry into force: | 27 April 1992 |
| • Convention on nuclear safety | Signature : | 20 September 1994 |
| • ZANGGER Committee | Member | |

| | | |
|---|---|---|
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | No reply | |
| • Nuclear Suppliers Group | Member | |
| • Standard agreements concerning technical assistance to Hungary | Parties:<br>– United Nations Organization<br>– International Labour Organization<br>– Food and Agriculture Organization of the United Nations<br>– International Civil Aviation Organization<br>– World Health Organization<br>– International Telecommunications Union<br>– International Atomic Energy Agency | |

*BILATERAL AGREEMENTS*

| | | |
|---|---|---|
| • Agreement for Co-operation in the Peaceful Uses of Nuclear Energy<br>Parties: Hungary/Canada | Entry into force: | 27 November 1987 |
| • Agreement for Co-operation in the Peaceful Uses of Nuclear Energy<br>Parties: Hungary/USA | Entry into force: | 13 February 1992 |

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITIES*

| | |
|---|---|
| Ministry of Industry and Trade<br>Martirok utja 85.<br>1024 Budapest | <br>Tel.: (361) 156-6491<br>Fax: (361) 175-0219 |
| Hungarian Atomic Energy Commission<br>P.O. Box 676<br>H-1359 Budapest<br>Hungary | <br><br>Tel: (361)175 35 86<br>Fax: (361)175 74 02 |
| Ordögh Hungarian Atomic Energy Commission<br>Hungarian Atomic Energy Office<br>P.O. Box 565<br>1374 Budapest | <br><br><br>Tel.: (361) 327-172 |
| Hungarian Atomic Energy Commission<br>Nuclear Safety Supreme Inspectorate<br>P.O. Box 565<br>1374 Budapest<br>Head of Nuclear Safety | <br><br><br>Tel.: (361) 122-3286<br>Fax: (361) 142-7598 |
| Hungarian Atomic Energy Commission<br>Nuclear Safety Inspectorate<br>P.O. Box 676<br>1539 Budapest | <br><br>Tel.: (361) 155-0493<br>Fax: (361) 155-7693 |
| Hungarian Energy Office<br>Electricity Licensing<br>Koztarsasagter 7<br>1081 Budapest | <br><br>Tel.: (361) 210-0361<br>Fax: (361) 210-0351 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Hungarian Power Companies Ltd.<br>Power Plant Planning and Investment<br>Vam utca 5-7<br>1011 Budapest | <br><br>Tel.: (361) 202-0456<br>Fax: (361) 202-14643 |
| Paks Nuclear Power Plant<br>P.O. Box 71<br>7031 Paks | <br>Tel.: (3675) 311222<br>Fax: (361) 155-1332 |

Power Engineering and Contracting Co.
ETV-EROTERV-RT
P.O. Box 111 — Tel.: (361) 215-6810
1450 Budapest — Fax: (361) 218-5585

Institute for Electrical Power Research
VEIKI
Zrinyi utca 1.
1368 Budapest — Tel.: (361) 118 3233/204

Mecsek ore Mining Co.
P.O. Box 121 — Tel.: (3672) 313055/315777
7633 Pecs — Fax: (3672) 336 044

State Public Health and Medical Officer Service
2166 Puspokszilagy — Tel.: (3627) 311-748

Frederic Joliot-Curie National Research
Institute for Radiobiology and Radiohygiene
Pentz K. utca 5
1221 Budapest — Tel.: (361) 126-4160

Central Research Institute for Physics of
the Hungarian Academy of Sciences
Institute of Atomic Energy Research
P.O. Box 49 — Tel.: (361) 169-6762
1525 Budapest 114 — Fax: (361) 155-2530

Institute of Isotopes of the Hungarian Academy of Sciences
P.O. Box 77 — Tel.: (361) 169-7922
1525 Budapest — Fax: (361) 156-5045

Technical University of Budapest
Faculty of Natural and Social Sciences
Institute of Nuclear Techniques
Muegyetem Rkp. 9. — Tel.: (361) 181-2754
1521 Budapest — Fax: (361) 181-2564

# INDIA

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# 1. GENERAL INFORMATION

## 1.1. General Overview

India occupies a strategic position in Asia. It lies north of the equator between 8°4' and 37°6' North latitude and 68°7' and 97°25' East longitude. It is bounded on the South West by the Arabian Sea and on the South East by the Bay of Bengal. On the North, North East and North West lie the Himalayan Ranges. In the Southern tip lies the Indian Ocean. India measures 3 214 kilometres from north to south and 2 993 kilometres from east to west. It has a total land area of 3 287 263 square kilometres. According to 1991 census India's population was 846.3 million with a ten year population growth of about 23.5% (Table 1).

India has seven major physiographic regions: Northern Mountains viz. the Himalayas; The Indo Gangetic Plain; Central Highlands; Peninsular Plateau; East Coast; West Coast; Bordering Seas; and, Islands. Major part of the land surface is plateau.

Indian climate is varying from cold in the north, hot in the middle of the country to tropical in the south.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 442.3 | 554.9 | 688.9 | 850.8 | 898.0 | 913.5 | 2.0 |
| Population density (inhabitants/km²) | 134.5 | 168.8 | 209.5 | 258.8 | 273.2 | 277.9 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 1.8 |
| Area (1000 km²) | 3287.6 |
| Urban population in 1994 as percent of total | 27.0 |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

Due to wide ranging economic reforms the annual GNP growth has reached a level of 5.4% during 1994. Average annual growth rate of Gross Domestic Product (GDP) 5.4% percent (1994/95). Per capita Gross Domestic Product (GDP) was 256 US dollars in 1993. The historical GDP data are given in Table 2.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1993 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 57,551 | 172,979 | 303,282 | 258,928 | | 3.2 |
| GDP (millions of constant 1990 US$) | 129,087 | 173,216 | 303,282 | 332,563 | 350,521 | 5.1 |
| GDP per capita (current US$/capita) | 104 | 251 | 356 | 288 | | 1.0 |

| GDP by sector : | |
|---|---|
| Agriculture | 31% |
| Industry | 27% |
| Services | 42% |

Source: IAEA Energy and Economic Data Base

## 1.3. Energy Situation

Table 3 shows the energy reserves according to EEDB, however, the energy resources are unevenly distributed. Hydro resources are mainly located in the northern and north eastern regions while most coal resources are located in the eastern region. A major portion of the hydroelectric potential is concentrated in the northern and north eastern regions of India with major sites in remote and comparatively inaccessible locations. Hydro power potential is estimated at 84,000 MW(e).

India has substantial reserves of high grade coal primarily in Bengal Bihar area in the Eastern Region, Singrauli and Central Coal fields in Northern and Western Regions, and Singreni Coal Fields in Southern Region. Total coal potential is estimated at 196.9 billion tonnes.

Uranium reserves found at Singhbhum district in Bihar (Eastern Region) have been developed to a full fledged mine. In the same province, uranium mining at Narwapahar, Bhatin, and Turamdih have also been established. One of the largest resources of Thorium in the world is contained in monazite deposits in India mainly along the Indian sea coast. Uranium reserves are estimated at 78,000 tonnes and thorium deposits at 360,000 tonnes. In 1993, India produced 182 metric tonnes of uranium.

Ocean thermal energy potential exists along the coast line of India. Viable sites for tidal power development are found in Gulf of Kutch. India's ocean energy potential is estimated to be 9,000 MW(e). Wind power potential is greatest in the hilly regions and coastal areas of India, and in the desert regions of Western Rajasthan. Wind energy potential is calculated to be 20,000 MW(e).

Oil reserves with a potential of 779 billion tonnes are mostly available on shore in Western and North Eastern Regions whereas most gas reserves are found off the West Coast. Gas potential is estimated at 717,950 billion cubic metres. Historical energy statistics are shown in Table 4.

## 1.4. Energy Policy

According to present energy policy, coal will remain a significant source for power generation, followed by hydro. For economic reasons, thermal power stations of the capacity range of 500 MW(e) are build close to pit heads, and a HVDC transmission system is planned. To supply coal to the thermal power stations around the country, a rapid expansion of the railroad system will also be taken up. Import of higher quality of coal, oil and natural gas, and the establishment of coastal thermal power stations are being examined as alternatives for meeting the energy requirements in the near future. However, it is debatable whether imported sources of fuel would provide energy security for the country.

Therefore, nuclear power is expected to play an increasing role in the long term. The energy policy of the country calls for increasing electricity generation by coal and oil or gas fuelled thermal power plants in the public and private sectors as well as encouraging foreign power development; (ii) maximum utilisation of existing Hydro resources; and, (iii) continuing to pursue the goal of a self-reliant nuclear power programme.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium | Hydro [1] | Total |
| Total amount in place | 1106.08 | 31.79 | 31.58 | | 254.28 | 1423.73 |

[1] *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.*

Source: IAEA Energy and Economic Data Base

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 1.43 | 4.15 | 6.62 | 11.22 | 12.85 | 13.72 | 7.94 | 5.34 |
| - Solids[2] | 1.07 | 3.10 | 4.78 | 7.80 | 8.86 | 9.40 | 7.75 | 4.95 |
| - Liquids | 0.29 | 0.77 | 1.31 | 2.28 | 2.78 | 2.91 | 7.91 | 5.86 |
| - Gases | | 0.02 | 0.05 | 0.39 | 0.46 | 0.66 | | 20.19 |
| - Primary electricity[3] | 0.08 | 0.27 | 0.48 | 0.75 | 0.75 | 0.74 | 9.65 | 3.19 |
| Energy production | | | | | | | | |
| - Total | 1.20 | 3.74 | 5.61 | 10.09 | 11.12 | 11.77 | 8.03 | 5.44 |
| - Solids | 1.10 | 3.17 | 4.69 | 7.53 | 8.76 | 9.04 | 7.51 | 4.81 |
| - Liquids | 0.02 | 0.29 | 0.39 | 1.43 | 1.16 | 1.34 | 16.36 | 9.14 |
| - Gases | | 0.02 | 0.05 | 0.39 | 0.46 | 0.66 | | 20.19 |
| - Primary electricity[3]) | 0.08 | 0.27 | 0.48 | 0.74 | 0.73 | 0.73 | 9.65 | 3.05 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.26 | 0.50 | 0.97 | 1.22 | 1.88 | 1.89 | 6.76 | 4.86 |
| - Solids | -0.03 | -0.01 | 0.01 | 0.15 | 0.18 | 0.23 | 6.57 | 27.95 |
| - Liquids | 0.29 | 0.51 | 0.96 | 1.07 | 1.70 | 1.66 | 6.17 | 3.95 |
| - Gases | | | | | | | | |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

The structure of the electricity sector derives its character and composition from the Indian constitution and is defined by the following Acts:

- Indian Electricity Act of 1910 legislates over the supply and use of electrical energy in India. It regulates license procedures for electricity undertakings. It prescribes requirements for execution of works and delivering of the supplies. It regulates relations between licensees and consumers. The Act empowers the Government to intervene in cases where a licensee fails to comply with safety requirements prescribed under the Act.

- Indian Electricity Supply Act of 1948 was enacted in order to secure a fully co-ordinated development of electricity on a regional basis. This act deals with the rationalisation for production and supply of electricity and for taking measures conducive to electrical development, i.e., to operate as a "Grid System". The Act enables establishment of autonomous bodies, like the State Electricity Boards, to administrate the Grid System.

The responsibility for electric power production and supply is vested in both the Central and the 26 State Governments. The electricity generating companies in the Central Sector are:

- The National Thermal Power Corporation (NTPC) is responsible for construction and operation of coal and gas fired thermal power plants in the various power regions controlled by Ministry of Power.
- The National Hydroelectric Power Corporation (NHPC) is responsible for establishing and operating regional hydroelectric power plants controlled by Ministry of Power.
- Northeastern Electric Power Corporation (NEEPCO) is responsible for establishing and operating thermal and hydro power plants in the Northeastern Region controlled by Ministry of Power.

- Neyveli Lignite Corporation (NCL) is responsible for establishing and operating thermal power plants based on lignite reserves at Neyveli in the Southern region controlled by Ministry of Coal.
- Nuclear Power Corporation (NPC) has responsibility for nuclear power generation controlled by Department of Atomic Energy.

The Government of India has also taken up two joint ventures:

- Nathpa-Jhakri Power Corporation (NJPC), responsible for the execution of the Nathpa-Jhakri Hydroelectric Project which is being developed as a joint project of the Central Government and the Government of Himachal Pradesh.
- Tehri Hydro Development Corporation (THDC), a joint venture of the Central Government and the Government of Uttar Pradesh to execute the Tehri Hydro Power Project.

Many states have established electricity generating companies under their ownership to attract more investment in the electric power sector. These include:

Karnataka Power Corporation (KPC)
Uttar Pradesh Vidyut Utpadan Nigam
Orissa Power Corporation
Durgapur Projects Ltd., West Bengal (DPL)
West Bengal Power Corporation
Gujarat Power Corporation.

The State Electricity Boards assign power supply generation, transmission and distribution; consolidate power system and sale of electrical energy to consumers; rationalise power supply by development of transmission and distribution systems in the state; purchase bulk power from state generating companies and Central Sector generating companies; and, operate the state load dispatch centres securely and economically.

India is divided into five Electrical Regions; namely, Northern, North Eastern, Eastern, Western and Southern. For each region, a Regional Electricity Board is constituted as shown in Figure 1. The Power Grid was established by the Central Government to promote integrated distribution grid operation through bulk transmission of electricity, i.e., intra and inter regional transfer of electric power. All transmission facilities originally under Central Sector organisations were transferred to Power Grid. Operation of Regional Load Dispatch Centres (RLDC's), which are presently under CEA's control, will also be transferred to Power Grid.

Although private sector participation, at present, is limited to a few cities (Ahmedabad, Bombay and Calcutta) it is expected to play a significant role in the coming years. Investment Promotion Cell (IPC) has been set up to interact with participating private entrants into the electric power sector. A number of incentives have been provided to encourage private sector participation, such as:

i) a debt equity ratio of up to 4 to 1 for all prospective companies entering the power sector;
ii) foreign equity participation up to 100% is permitted for projects set up by foreign private investors;
iii) generating companies are allowed to sell power on the basis of two part tariff to recover their fixed and running costs;
iv) agreement by the generating company to sell bulk power at special rates to a state electricity board.

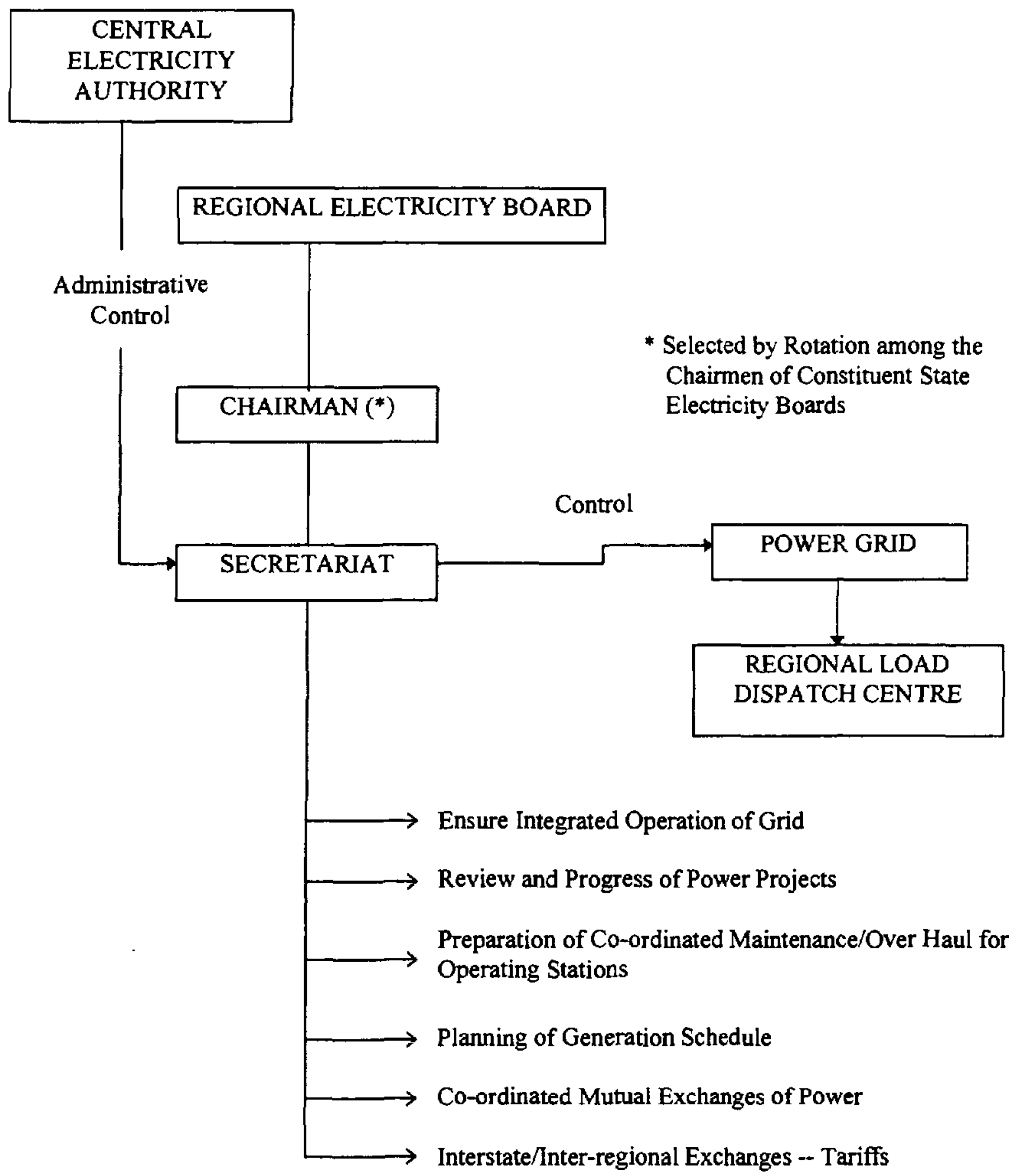


*FIG. 1. **Regional Electricity Board***

### 2.2. Policy and Decision Making Process

The Central Electricity Authority (CEA) is a statutory organisation constituted under the Electricity Supply Act of 1948. The CEA's functions and responsibilities are wide ranging and embrace areas of policy making, regulation, performance monitoring, technical advice and consultancy, tariff formulation and fixation, financial monitoring, arbitration and performance data collection and dissemination.

CEA prepares national short and long term power plans covering both electricity generation and bulk transmission. It interacts with State Electricity Boards, generating companies and the Planning Commission to ensure consensus. CEA has the responsibility of technical and economical review and approval of all power projects before implementation. It also facilitates training of persons in the generation and distribution of electricity. Moreover, CEA has tariff setting authority, including approval of normative values of tariffs which are proposed by Central Sector generating companies. Under the Atomic Energy Act, CEA also approves tariffs for nuclear power. CEA oversees contracts and tariffs associated with private generating companies, and it is consulted in the allocation of Central Sector power.

## 2.3. Main Indicators

The share of commercial energy consumption has gone up from about 26% in 1950/51 to the present level of 60%. Per capita commercial energy consumption in India increased from 113 kg OE in 1970 to 235 kg OE in 1991. Total electricity consumption in 1993 was 357.8 TW·h with per capita consumption of 397 kW·h. The total installed electric power capacity of only 1 360 MW(e) in 1947 has made an impressive growth to about 85 314 MW(e) in March, 1995. Of the total net electricity generating capacity, thermal accounted for 63 270 MW, hydro 19 904 MW, nuclear 2 100 MW, and geothermal 40 MW. In another 15 years the demand for electricity is expected to be of the order of 181 000 MW(e). Table 5 shows the historical electricity production and installed capacity and Table 6 the energy related ratios.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 20.12 | 61.21 | 119.26 | 289.44 | 356.34 | 384.42 | 9.31 | 8.72 |
| - Thermal | 12.28 | 33.53 | 69.70 | 212.65 | 280.37 | 308.98 | 9.07 | 11.22 |
| - Hydro | 7.85 | 25.26 | 46.56 | 71.66 | 70.48 | 71.07 | 9.31 | 3.07 |
| - Nuclear | | 2.42 | 3.00 | 5.11 | 5.43 | 4.32 | | 2.63 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 5.58 | 16.27 | 33.32 | 74.70 | 87.48 | 91.56 | 9.35 | 7.49 |
| - Thermal | 3.73 | 9.47 | 20.66 | 54.82 | 65.55 | 69.11 | 8.93 | 9.01 |
| - Hydro | 1.85 | 6.39 | 11.79 | 18.76 | 20.38 | 20.90 | 9.72 | 4.17 |
| - Nuclear | | 0.42 | 0.86 | 1.09 | 1.49 | 1.49 | | 4.02 |
| - Wind | | | | 0.03 | 0.05 | 0.05 | | |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 3 | 7 | 10 | 13 | 14 | 14 |
| Electricity per capita (kW·h/capita) | 45 | 104 | 161 | 315 | 349 | 367 |
| Electricity production/Energy production (%) | 16 | 15 | 19 | 26 | 27 | 29 |
| Nuclear/Total electricity (%) | | 4 | 3 | 2 | 2 | 2 |
| Ratio of external dependency (%)[(1)] | 18 | 12 | 15 | 11 | 15 | 15 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 41 | 43 | 41 | 44 | 46 | 48 |
| - Thermal | 38 | 40 | 39 | 44 | 48 | 50 |
| - Hydro | 49 | 45 | 45 | 44 | 41 | 41 |
| - Nuclear | | 66 | 40 | 54 | 43 | 42 |

Source: IAEA Energy and Economic Data Base

# 3. NUCLEAR POWER SITUATION

## 3.1. Historical Development

A major step in the formation of the Atomic Energy Programme in India was the passing of the Atomic Energy Act in 1948 (subsequently replaced by the Atomic Energy Act of 1962). Under the terms of the Atomic Energy Act, an Atomic Energy Commission (AEC) was constituted in 1948. Uranium exploration and mining required for the nuclear power programme were some of the initial activities undertaken.

The Department of Atomic Energy (DAE) was established in August 1954. It is responsible for execution of policies laid down by the Atomic Energy Commission. The key policy has been self-reliance. The importance of developing a strong research and development base for the nuclear power programme was recognised early on. Thus, a decision was made, in 1954, to set up a separate research and development centre, now called Bhabha Atomic Research Centre at Trombay. Research reactors like Apsar (1956), Cirus (1960), and Zerlina (1961) were set up at the centre. A number of additional facilities and laboratories were built at the centre to support the nuclear power programme and related nuclear fuel cycle activities.

Realising the importance of having well trained scientists and engineers in achieving success in the programme, a training school at BARC was instituted, in August 1957. During later stages when the training needs for the operating nuclear power stations arose, the Nuclear Training Centre (NTC) was founded by the Nuclear Power Corporation. Thus human resource development relating to the nuclear power programme was given the appropriate importance.

By the late 1950's, AEC had worked out the economics of generating electricity from atomic power reactors. Based on this experience, the Government decided to set up a series of nuclear power plants strategically located far away from coal mines.

India's nuclear power programme is based on the use of thorium produced by fast breeder reactors (FBR) fuelled by the plutonium generated pressurised heavy water reactors (PHWR). However, India's first nuclear power station (two BWR's using imported enriched uranium) at Tarapur was constructed initially in the 1960's to establish the technical and economic viability of nuclear power in India and to gain valuable operating experience. Concomitantly, with setting up of these BWR units, the current programme based on PHWR's began. Eight PHWR units of 220 MW(e) each at Rawatbhata, Kalpakkam, Narora and Kakrapar are in operation. Four 220 MW(e) units at Kaiga and Rawatbhata are in advanced stage of construction. Additionally, plans for designed Indian 500 MW(e) PHWR's have also been worked out. Advance procurement of critical equipment for six units and infrastructure facilities for the first two units (Tarapur 3 and 4) have been completed.

### 3.2. Current Policy Issues

The nuclear power profile prepared in 1984 envisaged setting up a 10 000 MW(e) total capacity PHWR programme with a series of 220 MW(e) and 500 MW(e) units. However, the 1980's was a critical period for nuclear power programmes world wide because of the Three Mile Island and Chernobyl accidents. At the same time, due to perceived financial risks, financial resources for future nuclear power projects were practically unavailable.

Nuclear power projects have been set up and operated directly under the Government of India since the late 1960's, when the construction of the first nuclear power station was commenced, until September 1987, when NPCIL was formed. Formation of NPCIL was a step to give the required degree of operational freedom and to mobilise funds from the Indian capital market to finance new nuclear power projects. However, due to inadequate budgetary support from the Government because of financial constraints coupled with fewer and higher interest rate loans from financial institutions, the earlier targeted nuclear power capacity had to be curtailed.

### 3.3. Status and Trends of Nuclear Power

Table 7 shows the status of the nuclear power plants and Tables 8 and 9 the performance of the operating plants. At present, the nuclear share of total electricity generation is about 2%.

TABLE 8. PERFORMANCE OF NPPs OF OLDER DESIGN

| Unit 1 | Capacity MW(e) | Capacity Factor Jan. 1985 to July 1995 | % Life time (to July 1995) |
|---|---|---|---|
| TAPS-1 | 160 | 89 | 54 |
| TAPS-2 | 160 | 74 | 56 |
| RAPS-2 | 200 | 63 | 58 |
| MAPS-1 | 220 | 56* | 57 |
| MAPS-2 | 220 | 57* | 57 |

* MAPS-1 &- MAPS-2 are operating at a maximum operating power level of 170 MW from the first of Nov. 1989.

TABLE 9. PERFORMANCE OF NPPs OF LATER DESIGN

| Unit 1 | Capacity MW(e) | Capacity Factor % | | | | |
|---|---|---|---|---|---|---|
| | | 1991 | 1992 | 1993 | 1994 | 1995* |
| NAPS-1 | 220 | 28 | 46 | ** | ** | 59 |
| NAPS-2 | 220 | -- | 67 | ** | 46 | 50 |
| KAPS-1 | 220 | -- | -- | 44 | @ | 58 |
| KAPS-2 | 220 | -- | -- | -- | -- | 39 |

* up to July
** NAPS-1, from March 1993 to January 1995, and NAPS-2, from Dec. 1992 to Nov. 1993, were shut down for rehabilitation after NAPS fire incident.
@ KAPS-was shut down from February to October 1994 for inspection and modification of turbine due to the lessons learnt from NAPS fire incident and other maintenance jobs.

### 3.4. Organisational Chart

The Indian Atomic Energy Organisational Structure is shown in Figure 2. Development of nuclear power and related nuclear fuel cycle and research and development activities have been separately organised under the Department of Atomic Energy due to the special requirements and close interaction needed between the production and R&D units.

The organisational framework is broadly divided into research and development sector, industrial sector, public sector, services and support sector:

i) Research and development sector involves BARC, IGCAR, CAT, TIFR and other aided research institutes;
ii) Industrial sector includes Government owned units manufacturing heavy water, nuclear fuel, and radioisotopes;
iii) Public sector units are enterprises under the control of DAE as follows:
  - NPCIL is responsible for design, construction, commissioning and operating the nuclear power plants;
  - UCIL is responsible for mining and milling of uranium ore;
  - IRE is responsible for supply of rare earth elements, thorium and zirconium;
  - ECIL supplies commercial electronics, controls and instrumentation related to atomic energy;
iv) The Construction and Services Group is responsible for construction of residential housing and other related facilities;
v) The Directorate of Purchase and Stores is responsible for centralised purchases and store;
vi) AERB, Atomic Energy Regulatory Board comes directly under the Atomic Energy Commission as an independent Regulatory Authority.

## TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| KAKRAPAR-1 | PHWR | 202 | NPCIL | Operational | DAE/NPCI | 01-Dec-84 | 03-Sep-92 | 24-Nov-92 | 06-May-93 | |
| KAKRAPAR-2 | PHWR | 202 | NPCIL | Operational | DAE/NPCI | 01-Apr-85 | 08-Jan-95 | 04-Mar-95 | 01-Sep-95 | |
| KALPAKKAM-1 | PHWR | 155 | NPCIL | Operational | DAE | 01-Jan-71 | 02-Jul-83 | 23-Jul-83 | 27-Jan-84 | |
| KALPAKKAM-2 | PHWR | 155 | NPCIL | Operational | DAE | 01-Oct-72 | 12-Aug-85 | 20-Sep-85 | 21-Mar-86 | |
| NARORA-1 | PHWR | 202 | NPCIL | Operational | DAE/NPCI | 01-Dec-76 | 12-Mar-89 | 29-Jul-89 | 01-Jan-91 | |
| NARORA-2 | PHWR | 202 | NPCIL | Operational | DAE/NPCI | 01-Nov-77 | 24-Oct-91 | 05-Jan-92 | 01-Jul-92 | |
| RAJASTHAN-1 | PHWR | 90 | NPCIL | Operational | AECL | 01-Aug-65 | 11-Aug-72 | 30-Nov-72 | 16-Dec-73 | |
| RAJASTHAN-2 | PHWR | 187 | NPCIL | Operational | AECL/DAE | 01-Apr-68 | 08-Oct-80 | 01-Nov-80 | 01-Apr-81 | |
| TARAPUR-1 | BWR | 150 | NPCIL | Operational | GE | 01-Oct-64 | 01-Feb-69 | 01-Apr-69 | 28-Oct-69 | |
| TARAPUR-2 | BWR | 150 | NPCIL | Operational | GE | 01-Oct-64 | 28-Feb-69 | 05-May-69 | 28-Oct-69 | |
| KAIGA-1 | PHWR | 202 | NPCIL | Under Construction | NPCIL | 01-Sep-89 | 01-May-98 | 01-Jul-98 | 01-Nov-98 | |
| KAIGA-2 | PHWR | 202 | NPCIL | Under Construction | NPCIL | 01-Dec-89 | 01-May-98 | 01-Jul-98 | 01-Nov-98 | |
| RAJASTHAN-3 | PHWR | 202 | NPCIL | Under Construction | NPCIL | 01-Feb-90 | 01-May-98 | 01-Jul-98 | 01-Nov-98 | |
| RAJASTHAN-4 | PHWR | 202 | NPCIL | Under Construction | NPCIL | 01-Oct-90 | 01-May-98 | 01-Jan-99 | 01-May-99 | |
| KAIGA-3 | PHWR | 202 | NPCIL | Planned | NPCIL | | | | | |
| KAIGA-4 | PHWR | 202 | NPCIL | Planned | NPCIL | | | | | |
| KAIGA-5 | PHWR | 202 | NPCIL | Planned | NPCIL | | | | | |
| KAIGA-6 | PHWR | 202 | NPCIL | Planned | NPCIL | | | | | |
| RAJASTHAN-5 | PHWR | 450 | NPCIL | Planned | NPCIL | | | | | |
| RAJASTHAN-6 | PHWR | 450 | NPCIL | Planned | NPCIL | | | | | |
| RAJASTHAN-7 | PHWR | 450 | NPCIL | Planned | NPCIL | | | | | |
| RAJASTHAN-8 | PHWR | 450 | NPCIL | Planned | NPCIL | | | | | |
| TARAPUR-3 | PHWR | 450 | NPCIL | Planned | NPCIL | | | | | |
| TARAPUR-4 | PHWR | 450 | NPCIL | Planned | NPCIL | | | | | |

Source: IAEA Power Reactor Information System, yearend 1996

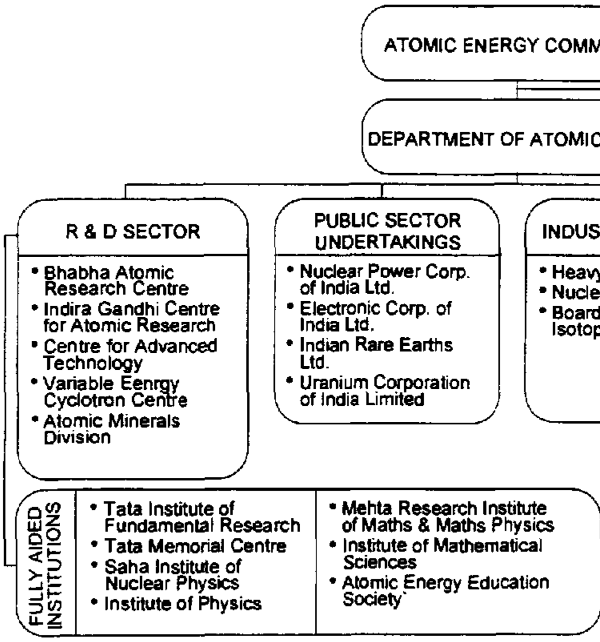


*FIG. 2. Organizational Structure*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

India's first nuclear power station, Tarapur, was constructed based on a turn-key contract. The second nuclear power station at Rajasthan was built as a collaborative venture with AECL Canada. For all subsequent nuclear power stations, DAE/NPCIL assumed total responsibility for design, manufacture, construction, commissioning and operation. The organisational structure of NPCIL is shown in Figure 3. NPCIL carries out the nuclear design. Balance of plant engineering is done by consultants who have expertise in the thermal plant engineering. Containment buildings are designed by consultants experienced with pre-stressed concrete structures.

Manufacturing of most materials, components and equipment required for nuclear power plants is organised indigenously. India has heavy engineering plants in both public and private sectors, manufacturing large steam generators, turbines, electrical equipment, heat exchangers, pumps, pressure vessels and other industrial equipment. The Indian Nuclear Power Programme utilises these facilities for manufacture of nuclear equipment augmented, whenever necessary, with balancing machinery and technical inputs to meet nuclear quality assurance requirements. Quality surveillance representatives of NPCIL are posted at the manufacturer's shops for this purpose.

### 4.2. Operation of Nuclear Power Plants

Operation and maintenance services are rendered by specially trained and qualified operating and maintenance personnel at each nuclear power station. Nuclear facilities include reactor components and processes, turbine generators, electrical switch gear, motor control centres (MCC), instrumentation and control systems (I&C), cooling water intake and out fall structures, heavy water upgrading plant (at PHWR stations) and waste management facilities. Three groups of technical and scientific personnel are required for the nuclear power programme: qualified professionals, i.e., engineers and scientists who later become senior engineers and managers; semi-professionals having engineering diplomas or advanced trade certificates who constitute the supervisory personnel; and, technicians like operators and maintainers with high school education and trade certificates.

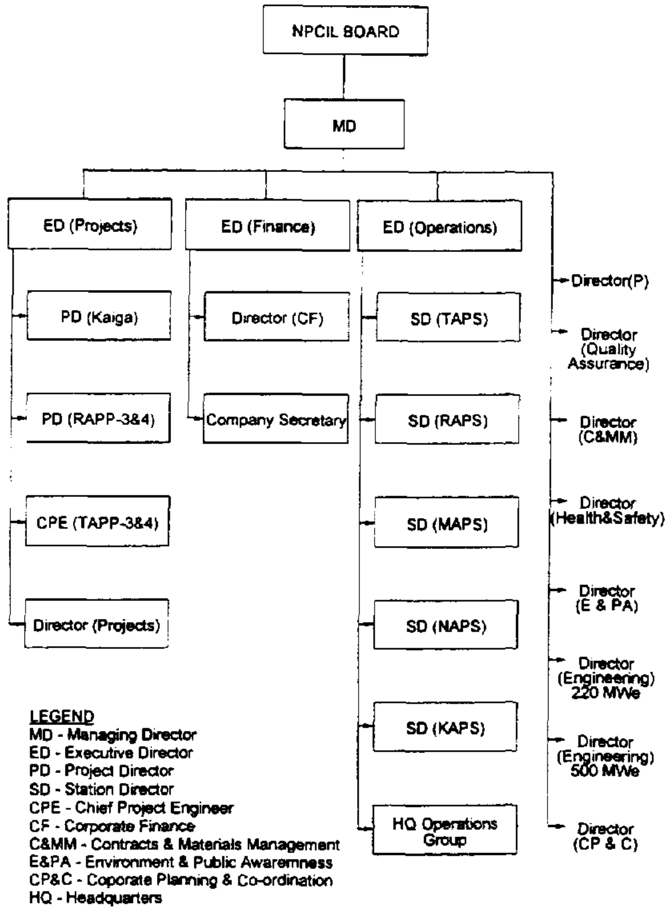


*FIG. 3. Nuclear Power Corporation of India Ltd. (NPCIL)*

Professionals get inducted into the Atomic Energy Organisation by completing one year training course at the BARC training school in Trombay. Separate training programmes at different levels are conducted at the NPCIL training centres of operating stations for quality and licensing of operating personnel, as per the regulatory requirements.

### 4.3. Fuel Cycle and Waste Management Service Supply

Fuel cycle and waste management services are provided by various units of the Department of Atomic Energy (DAE). Uranium Corporation of India Ltd., (UCIL), a public sector company of DAE, carries out mining and processing of uranium deposits surveyed by the Atomic Minerals Division (AMD) of DAE. Nuclear Fuel Complex (NFC), an industrial unit of DAE, utilises the uranium concentrates supplied by UCIL to fabricate PHWR's nuclear fuel assemblies. For the BWR's in Tarapur, NFC manufactures the fuel assemblies from imported UF6.

Spent fuel from the PHWR's is reprocessed to extract the plutonium contained in it. Plutonium base is vital for development of the second stage of the Indian nuclear power programme consisting of fast breeder reactors. The fuel reprocessing plants are set up by the Bhabha Atomic Research Centre based on the technology developed by it.

Processes for treating reactor produced wastes have been established and plants meeting regulatory requirements have been in operation during the past several decades. This is also the case with waste generated from fuel reprocessing plants. The first waste immobilisation plant at Tarapur is in service and the process of immobilisation of high level wastes has also been developed. For R&D work, ultimate disposal of high level and alpha bearing wastes in a repository is in progress.

### 4.4. Research and Development Activities

All research and development is centred around BARC, IGCAR, CAT, VECC, AMD and associated institutions.

- BARC, Bhabha Atomic Research Centre, is the national research centre for multidisciplinary R&D work in nuclear sciences, research reactors, nuclear fuel, control and instrumentation, reactor safety, engineering laboratories, radioactive isotopes, spent fuel reprocessing and radioactive waste management, etc.

- IGCAR, Indira Gandhi Centre for Atomic Research at Kalpakkam, is responsible for R&D related to development of FBR technology.

- CAT, Centre for Advanced Research at Indore, conducts R&D in high-tech areas, such as accelerators, lasers and other advanced research.

- VECC, Variable Energy Cyclotron Centre at Calcutta, is for advanced research in nuclear physics, nuclear chemistry, production of isotopes for various applications and radiation damage studies.

- AMD, Atomic Mineral Division at Hyderabad, is responsible for survey, exploration and prospecting of atomic minerals, etc.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

International co-operation is through multilateral mechanism with IAEA as well as through bilateral mechanisms. Under the above, India trains a large number of personnel, particularly from the developing countries. India has also hosted a number of workshops, seminars and training courses under the auspices of IAEA. The expertise of India's scientists and engineers is made available to other countries through IAEA.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Procedures

Enforcement of safety related regulations at all nuclear facilities lies with the Atomic Energy Regulatory Board, empowered by the Government of India. The regulatory framework is shown in Figure 4. No activity related to atomic energy can be carried out by any agency or utility without authorisation by the Regulatory Board.

Before granting authorisations, the Regulatory Body conducts an in-depth review so that no undue radiological risk is introduced by running nuclear facilities. The review process is shown in Figure 5. The authorisation process involves various major activities like site approval, construction, commissioning, operation and decommissioning. The authorisation process is an ongoing process starting with site selection and feasibility study and continuing through decommissioning of the plant. The applicant is required to provide all relevant information, such as safety principle analysis, criteria and standards proposed for each major stages, and quality assurance demonstrating that the plant will not pose any undue radiological risks to site personnel and for the public.

AERB has advisory committees for site selection, design review and authorisation, and licenses for commissioning. The advisory committees are assisted by unit level safety committees which undertake detailed safety assessments at the design and commissioning stages of nuclear facilities. AERB then issues its authorisation based on the recommendations of the advisory committee. Safety assessments during plant operation are done by the Safety Committee for

Operating Plants (SARCOP). Authorisation is granted only for a limited period and further authorisation is required beyond that period. Authorisation also includes explicit conditions that the applicant must adhere to.

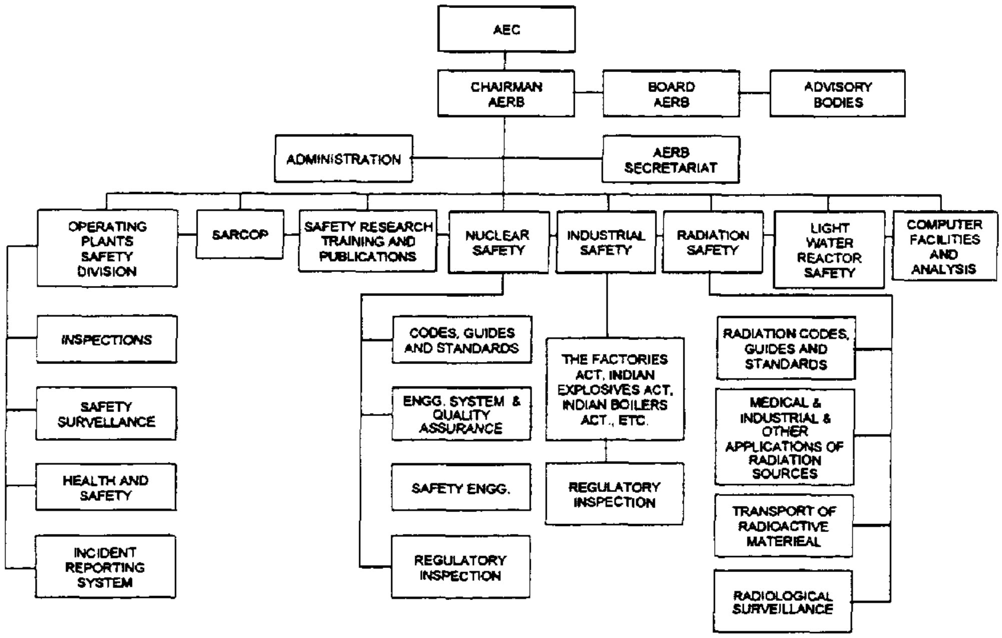


*FIG. 4. **Regulatory Framework***

### 5.2. Main National Laws and Regulations

The Atomic Energy Regulatory Board (AERB) was formed in November 1983 by the Government of India in exercise of the powers conferred by the Atomic Energy Act of 1962, to carry out regulatory and safety functions as envisaged in the Act. As per its constitution, AERB has the power of the Competent Authority to enforce rules and regulations framed under the Atomic Energy Act for radiation safety in the country. AERB also has the authority to administer the provisions of the Factories Act, for industrial safety of the units of DAE. AERB has been delegated with power to enforce some of the provisions of the Environmental Protection Act, at DAE installations.

The central government, through DAE, has framed rules and other provisions of the Act as, for instance:

The Radiation Protection Rules, 1971;
The Atomic Energy Rules (operation of mines, minerals and handling of prescribed substances), 1984;
The Atomic Energy Rules (factories), 1984;
The Atomic Energy Rules (arbitration procedure), 1984;
The Atomic Energy Rules (safe disposal of radioactive waste), 1987;
The Atomic Energy Rules (control of irradiation of foods), 1991.

The main legislation regulating nuclear power in the country is the Atomic Energy Act of 1962, under which an independent Atomic Energy Regulatory Board (AERB) was created to regulate the nuclear installations. A number of rules, codes, and regulations covering the entire nuclear fuel cycle have been defined by AERB as well as the Department of Atomic Energy (DAE) under the Atomic Energy Act of 1962.

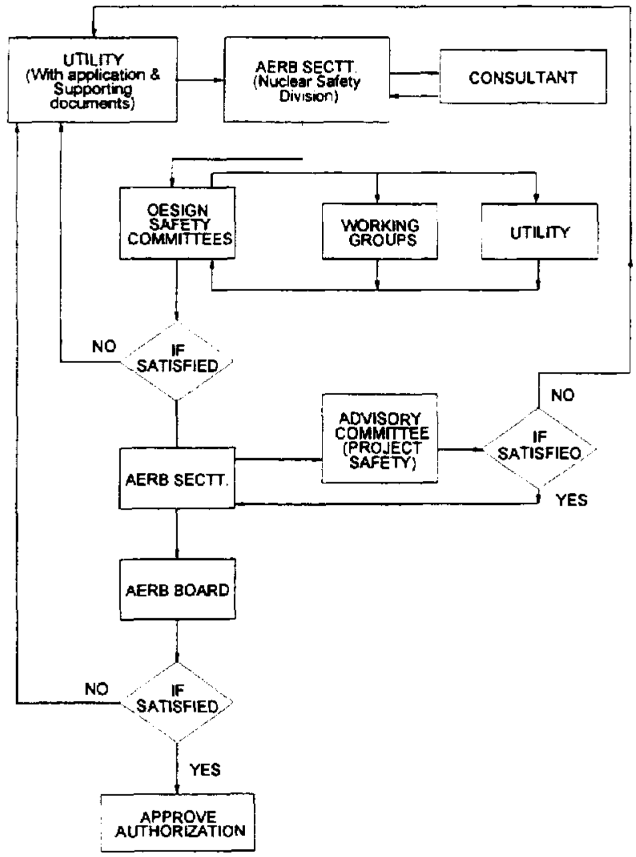


*FIG. 5. ERB Regulatory Review Process for Authorisation*

## 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • The Agency's assistance in furthering projects by the supply of materials | Entry into force: | 9 December 1966 |
| • Safeguards transfer relating to the bilateral agreement with the United States of America | Entry into force: | 27 January 1971 |
| • Safeguards transfer relating to the bilateral agreement with Canada | Entry into force: | 6 November 1974 |
| • Application of safeguards in connection with the supply of heavy water from the Soviet Union | Entry into force: | 17 November 1977 |
| • Agreement establishing the Asian Regional Co-operative Project on Food Irradiation | Entry into force: | 23 May 1980 |

| | | |
|---|---|---|
| • Application of safeguards in connection with the supply of a nuclear power station from the USSR | Entry into force: | 27 September 1988 |
| • Application of safeguards in connection with the supply of nuclear material from France | Entry into force: | 11 October 1989 |
| • Agreement for the application of safeguards to all nuclear material subject to Agency Safeguards under INFCIRC/154, Part 1 | Entry into force: | 1 March 1994 |
| • Amendment to the Article VI of the IAEA Statute | | |
| • Improved procedures for designation of safeguards inspectors | Accepted on: | 9 January 1989 |
| • Unilateral safeguards submission | | |
| INFCIRC/260 | Entry into force: | 17 November 1977 |
| /360 | | 27 September 1988 |
| /374 | | 11 October 1989 |
| /433 | | 1 March 1994 |
| /433/Mod.1 | | 12 September 1994 |

*OTHER MULTILATERAL SAFEGUARDS AGREEMENTS*

| | | |
|---|---|---|
| • India/Canada INFCIRC/211 | Entry into force: | 30 September 1971 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force:<br>Text of agreement | Non-Party<br>6 October 1993 |
| • RCA | Entry into force: | 6 July 1987 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | Non-Party |
| • Agreement on privileges and immunities | Entry into force: | 10 March 1961 |
| • Convention on physical protection of nuclear material | Entry into force: | Non-Party |
| • Convention on early notification of a nuclear accident | Entry into force: | 28 February 1988 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 28 February 1988 |

| | | |
|---|---|---|
| • Conventions on civil liability for nuclear damage and joint protocol | Non-Party | |
| • Convention on nuclear safety | Signature: | 20 September 1994 |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines | Not adopted | |
| • Acceptance of NUSS Codes | Summary: Valuable guidance for national regulatory requirements. Useful reference in safety assessments. India's regulatory requirements are generally consistent with codes. Aims to meet requirements although they are not binding. | |
| | Letter of: | 17 June 1988 |
| • ILO Convention | | 17 November 1975 |

*BILATERAL AGREEMENTS*

| | | |
|---|---|---|
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Egypt | 10 July 1962 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Belgium | 30 January 1965 |
| • Setting up of an Isotope Afghanistan Dispensation Unit at Kabul University | Afghanistan | 14 May 1966 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Czech Republic | 9 November 1966 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Germany | 5 October 1971 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Iraq | 28 March 1974 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Poland | 9 September 1977 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Russian Federation | 22 January 1979 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Syria | 1 May 1980 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Indonesia | 9 January 1981 |

| | | |
|---|---|---|
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Cuba | 18 May 1985 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Viet Nam | 25 May 1986 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Algeria | 25 September 1990 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Philippines | 29 April 1991 |
| • Co-operation Agreement Concerning Peaceful Uses of Nuclear Energy | Peru | 12 February 1992 |

## REFERENCES


[1] Country Profile of India 1995 - 96, Economist Intelligence Unit.

[2] Worldbank World Tables 1995.

[3] United Nations Energy Statistics Yearbook 1993.

[4] EEDB/IAEA.

## ANNEX I. DIRECTORY OF THE MAIN ORGANISATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

| | |
|---|---|
| Calendria: | (i) Walchandnagar Industries Ltd. (WIL)<br>(ii) Larsen and Toubro Ltd. (L&T)<br>(iii) GR Engineering Works Ltd. (GR) |
| End Shields: | (I) L&T, WIL,<br>(ii) Bharat Heavy Electricals Ltd.(BHEL) |
| Steam Generators: | (i) BHEL, (ii) L&T |
| Fuelling Machines: | (i) Central Workshops, BARC (CWS)<br>(ii) Kirloskar Brothers Ltd. (KBL)<br>(iii) Cooper Engineering Ltd. (CEL)<br>(iv) Machine Tool Aids &, Reconditioning (MTAR) |
| Reactivity Mechanisms: | (i) KBL, (ii) CEL, (iii) MTAR<br>(iv) Reactor Control Division (RCnD) |
| Heavy Water Heat Exchangers: | (i) L&T, (ii) BHEL, (iii) WIL<br>(iv) GR Engineering<br>(v) Bharat Heavy Plates & Vessels (BHPV) |
| Primary Coolant Pumps: | KSB (India) Pumps Ltd. |
| Turbine Generators: | BHEL |
| Condensers: | (i) L&T, (ii) BHPV<br>(iii) Industrial Agricultural Engineering Company (IAEC) |
| Circulating Water: | (i) KBL, (ii) Jyoti Ltd.<br>(iii) Worthigton Pumps (I) Ltd. |
| Boiler Feed Pumps: | (i) Mather & Platt (India) Ltd.<br>(ii) BHEL, (iii) KSP |
| Main Generators: | (i) BHEL, (ii) Transformer & Electricals Kerala Ltd. (TELK) |
| Large Motors: | (i) New Government Electric Factory (NGEF)<br>(ii) Kirloskar Electric Co. Ltd. (KEC)<br>(iii) BHEL |
| Electrical Switches: | (i) L&T<br>(ii) Asea Brown Bovari (ABB)<br>(iii) Siemens (India) |
| Reactor Controls: | Electronics Corporation Ltd. (ECIL) |
| Process Instruments: | (i) Instrumentation Ltd. Palghat Systems (IL-P)<br>(ii) Instrumentation Ltd. Kota (IL-K) |

| | |
|---|---|
| Main Plant Civil Works: | (i) L&T - Engineering Construction Works Co. (L&T-ECC)<br>(ii) Hindustan Construction Co. Ltd. (HCC) |
| Nuclear Piping: | (i) Dodsal Ltd.<br>(ii) Mukund Ltd. (Eng. Construction, Dn)<br>(iii) Western India Enterprises Ltd.<br>(iv) Presteel Engineering Services Pvt. Ltd.<br>(v) Engineers India (P) Ltd.<br>(vi) Stewards & Lloyds (India) Ltd.<br>(vii) L&T - ECC<br>(viii) Bharat Steel Tubes Pvt. Ltd. |

# ITALY

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# 1. GENERAL INFORMATION

## 1.1. General Overview

A republic of Southern Europe, Italy is a peninsula set in the Mediterranean sea. It extends from the Alps, its northern border, southward for 960 kilometres; it has a maximum width of 240 kilometres. To the east lies the Adriatic Sea, to the south the Ionian Sea and to the west the Tyrrhenian and Ligurian seas. Starting from north-west and moving to north-east Italy is bounded by France, Switzerland, Austria and the Republic of Slovenia. The Apennines, a recent mountain chain, created by the collision of the African and European plates, subject to frequent earthquakes, extends the length of the peninsula. There are few large catchment basins and only the Po basin is suitable site for nuclear power plants.

The peninsula comprises much of Italy and includes the independent republic of San Marino as well as the Vatican City. In addition to the continental part there are two big islands, Sicily and Sardinia. The total area is 301 260 square kilometres.

Italy is located in the temperate zone, the mainland climate varies from the north to the south; summer temperatures are relatively uniform in most cities and range on average between 23°C and 28°C, while winter temperatures range between 12°C and 17°C. The annual average rainfall, generally, does not exceed 1000 mm.

In 1994, the population of Italy was 57 million with the density of 194 people per square kilometre. Table 1 gives the statistical data until 1993. The capital and largest city is Rome which had a population of 2 693 383 in 1991. The country is composed of 20 regions, which are subdivided into 95 provinces.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 50.2 | 53.8 | 56.4 | 57.0 | 57.1 | 57.2 | 0.1 |
| Population density (inhabitants/km²) | 166.6 | 178.7 | 187.3 | 189.3 | 189.7 | 189.8 | |
| Predicted population growth rate (%) 1994 to 2000 | | | | | | | |
| Area (1000 km²) | | 301.3 | | | | | |
| Urban population in 1994 as percent of total | | 67.0 | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 107,485 | 452,646 | 1,095,122 | 991,358 | 1,017,781 | 6.0 |
| GDP (millions of constant 1990 US$) | 607,102 | 878,864 | 1,095,122 | 1,113,778 | 1,138,281 | 1.9 |
| GDP per capita (current US$/capita) | 1,997 | 8,021 | 19,205 | 17,348 | 17,801 | 5.9 |
| GDP by sector : | | | | | | |
| Agriculture 3% | | | | | | |
| Industry 32% | | | | | | |
| Services 65% | | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.3. Energy Situation

Italy is poor in natural resources (Table 2), and depends heavily on imported energy supply. In 1994, almost 80% of Italy's energy was imported. About 56% of primary energy supply was accounted for imported coal, while 10% was provided by domestically produced natural gas. Natural gas is Italy's largest domestic source of energy with proven natural gas reserves of 282 $10^9$ cubic metres in 1993 (Table 3).

Italy's total primary energy consumption was 151.2 Mtoe in 1994, of which coal accounted for 6.1 Mtoe, oil 61.9 Mtoe, natural gas 32.3 Mtoe, and electricity 50.9 Mtoe. Historical data are given in Table 4.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro (2) | Total |
| Total amount in place | 0.84 | 1.85 | 10.26 | 0.00 | 32.78 | 45.76 |

(1) *This total represents essentially recoverable reserves.*
(2) *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.*
Source: IAEA Energy and Economic Data Base

TABLE 4. ENERGY STATISTICS

Exajoule

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Energy consumption | | | | | | | | |
| - Total(1) | 1.94 | 4.53 | 6.00 | 6.89 | 7.05 | 6.95 | 5.80 | 1.05 |
| - Solids(2) | 0.33 | 0.41 | 0.54 | 0.63 | 0.54 | 0.55 | 2.59 | 0.07 |
| - Liquids | 0.91 | 3.19 | 3.85 | 3.71 | 3.73 | 3.66 | 7.49 | -0.37 |
| - Gases | 0.25 | 0.44 | 1.06 | 1.85 | 1.93 | 1.88 | 7.60 | 4.18 |
| - Primary electricity(3) | 0.46 | 0.49 | 0.54 | 0.70 | 0.84 | 0.86 | 0.78 | 3.32 |
| Energy production | | | | | | | | |
| - Total | 0.83 | 1.04 | 1.10 | 1.27 | 1.45 | 1.52 | 1.45 | 2.35 |
| - Solids | 0.03 | 0.06 | 0.06 | 0.05 | 0.06 | 0.06 | 3.52 | -0.38 |
| - Liquids | 0.09 | 0.07 | 0.08 | 0.20 | 0.19 | 0.21 | -0.60 | 7.30 |
| - Gases | 0.25 | 0.46 | 0.48 | 0.65 | 0.73 | 0.77 | 3.43 | 3.40 |
| - Primary electricity(3)) | 0.46 | 0.45 | 0.48 | 0.37 | 0.46 | 0.49 | 0.19 | 0.15 |
| Net import (import - export) | | | | | | | | |
| - Total | 1.26 | 4.08 | 5.15 | 5.56 | 5.34 | 5.27 | 7.28 | 0.16 |
| - Solids | 0.30 | 0.38 | 0.49 | 0.60 | 0.43 | 0.47 | 2.52 | -0.29 |
| - Liquids | 0.97 | 3.71 | 4.11 | 3.78 | 3.67 | 3.67 | 7.51 | -0.81 |
| - Gases | | | 0.55 | 1.18 | 1.24 | 1.13 | | 5.29 |

(1) *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
(2) *Solid fuels include coal, lignite and commercial wood.*
(3) *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

## 1.4. Energy Policy

Although the five years of nuclear moratorium officially expired in December 1993, the Government remains steadfast in excluding nuclear energy as set forth in the last Energy Plan. This plan, approved by the Government in August 1988, focused on a set of actions capable of yielding substantial results in terms of energy conservation, environmental protection, development of domestic energy sources, diversification of imported energy sources and their origins, and safeguarding the competitiveness of the production system. In January 1991, the Government issued laws 9/91 and 10/91 to implement the energy plan. The laws were designed to liberalise energy production, with incentives to get energy from assimilated and renewable sources and to encourage energy conservation initiatives.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

In Italy the structure of the electricity sector - in terms of production, transmission and distribution - is combined with the structure of ENEL (Ente Nazionale per l'Energia Elettrica), Italian Electricity Generating Board. Hence, attention is focused on this huge company which operated as a monopoly for a long time.

In 1962, the electric sector was nationalised by Law 1643 of 6 December 1962. ENEL was established to be wholly responsible for electricity production and transmission, and partially responsible for distribution of electric energy. Recently, in August 1992, by Law 359, ENEL became a private company (ENEL S.p.A.).

For optimising various activities, the country's electric system has been divided into eight divisions, according to territorial and demographic distinctions. The eight seats are in Turin, Milan, Venice, Florence, Rome, Naples, Palermo and Cagliari. Each division is responsible for distribution and selling of electricity, construction of a distribution system, and administrative activities. A division is divided into several districts. In the aggregate there are 24 districts which are further subdivided into zones. There are about 200 zones.

### 2.2. Decision Making Process

The decision making process involves several actors at different levels:

- the Government is responsible for long term planning (e.g. Energy plan),
- CIPE co-ordinates the several Ministries involved and authorizes plant construction,
- ENEL implements governmental strategy

### 2.3. Main Indicators

Italy's total net installed capacity of electricity generating plants in 1993 amounted to 66 486 MW. Electricity generation from 202 thermal plants was 43 346 MW, from 651 hydro electric plants 19 669 MW, and from 39 geothermal units 471 MW (Table 5). Total electricity production in 1993 was 222.8 TW·h, of which thermal sources accounted for 174.6 TW·h, hydro 44.4 TW·h, and geothermal 3.6 TW·h. High voltage transmission lines, connecting power plants with the distribution system, are mainly based on 380 kV lines (9 084 km) and 220 kV lines (11 644 km). Italy abandoned the nuclear power production following referenda in 1987.

In 1993, the total consumption of electricity was 262.2 TW·h with per capita consumption of 4,588 kWh. In 1994, electricity's share in final domestic energy consumption was 34%. In 1993, ENEL provided almost 80 per cent of the Italian electricity production. The remainder was produced by industrial producers (16%), "local undertakings" (4%), and other minor private producers (0.3%). Energy related ratios are given in Table 6.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 56.24 | 116.83 | 183.46 | 216.90 | 222.80 | | 6.09 | |
| - Thermal | 8.03 | 70.22 | 133.35 | 178.60 | 174.6 | | 15.08 | |
| - Hydro | 46.11 | 40.70 | 45.23 | 35.08 | 44.48 | 47.73 | -0.10 | 0.38 |
| - Nuclear | | 3.18 | 2.21 | | | | | |
| - Geothermal | 2.10 | 2.73 | 2.67 | 3.22 | 3.67 | 3.42 | 1.20 | 1.77 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 17.69 | 30.41 | 46.82 | 56.50 | 63.50 | | 4.99 | |
| - Thermal | 4.79 | 16.15 | 29.15 | 37.30 | 43.30 | | 9.45 | |
| - Hydro | 12.61 | 13.34 | 15.83 | 18.77 | 19.67 | 19.75 | 1.14 | 1.59 |
| - Nuclear | | 0.55 | 1.42 | | | | | |
| - Geothermal | 0.29 | 0.37 | 0.43 | 0.50 | 0.47 | 0.47 | 2.02 | 0.67 |
| - Wind | | | | | | 0.01 | | |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1992 | 1993 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 39 | 87 | 107 | 121 | 125 | 117 |
| Electricity per capita (kW·h/capita) | 1,118 | 2,159 | 3,211 | 4,123 | 4,374 | 4,390 |
| Electricity production/Energy production (%) | 66 | 104 | 153 | 153 | 147 | 141 |
| Nuclear/Total electricity (%) | | 3 | 1 | | | |
| Ratio of external dependency (%)[(1)] | 65 | 87 | 85 | 81 | 79 | 74 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 36 | 44 | 45 | 44 | 42 | 40 |
| - Thermal | 19 | 50 | 52 | 55 | 48 | 46 |
| - Hydro | 42 | 35 | 33 | 21 | 27 | 26 |
| - Nuclear | | 66 | 18 | | | |

[(1)] *Total net import / Total energy consumption*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

Italy was among the first countries in the world to use nuclear technology for civil power generation purposes only. The Italian history of nuclear technology development can be split into three major periods:

i) pioneering period from 1946 to 1965 during which the private industry played a fundamental role;
ii) planning period from 1966 to 1987 during which the Government planned nuclear development;
iii) post referenda period from 1988 onward which is characterised by the efforts to abandon nuclear energy production.

***Pioneering Period***

In November 1946, CISE (Centro Informazioni, Studi ed Esperienze) was founded, with the participation of the elite post-war Italian industries (Edison, Montecatini, FIAT) and some of the most prominent Italian nuclear scientists. Early on, the purpose of CISE was to lay down the foundations of civil nuclear engineering and, later on, to design a natural Uranium fuelled, heavy water moderated test nuclear reactor.

In June 1952, the Government established CNRN (Comitato Nazionale per le Ricerche Nucleari), an agency in charge of developing and promoting nuclear technology; in August 1960 the agency was reorganised and renamed CNEN (Comitato Nazionale per l'Energia Nucleare).

In October 1958, the construction of the country's first nuclear power plant, Latina, began. This 200 MW(e) gas-graphite reactor (Magnox, from the Magnesium alloy used in the fuel cans) was connected to the electric grid in May 1963. It was ordered by SIMEA, an ENI[1] (Ente Nazionale Idrocarburi) subsidiary, and contracted to be built with the Nuclear Power Plant Company (NPPC) of the UK. The United Kingdom's Atomic Energy Authority was to offer support for the safety aspects.

In November 1959, construction work for the Garigliano nuclear power plant began. A Boiling Water Reactor prototype was ordered by SENN (Societa Elettro Nucleare Nazionale) from the International General Electric. In January 1964, Garigliano 150 MW(e) reactor started operation.

The Trino Vercellese nuclear power plant, a Westinghouse PWR with two separate turbine systems, was ordered by SELNI (Societa Elettro Nucleare Italiana), a subsidiary of the Edison group. Construction for the 260 MW(e) Trino Vercellese began in August 1961. It entered commercial operation in October 1964.

A general rule, Law 1860, to regulate peaceful use of atomic energy was issued for the first time in December 1962. This law assigned CNEN the role of the nuclear Regulatory Body and foresaw the issuance of a subsequent law for radioactive protection of population and workers.

In February 1964, the Italian Government issued a complete set of Regulations (D.P.R. 230) to cover into details the different aspects of nuclear safety and radiation protection. CNEN was confirmed as the official Regulatory Body. However, this responsibility created an inherent conflict of interests between its role as a public promoter of nuclear technology and as a Regulator. The safety criteria during the period was adopted from the countries exporting nuclear technology (mainly the UK and the USA).

In 1962, after a long political struggle, the electric sector was nationalised and ENEL was established as the sole Utility. In 1964, the ownership of Latina nuclear power plant was transferred to ENEL, and, in 1966, also the Garigliano and Trino units were transferred to ENEL, hence closing the first period of Italian nuclear history.

### *Planning Period*

In December 1966, ENEL announced a huge nuclear program forecasting 12 000 MW of nuclear power by 1980. A year later, in 1967, CIPE[2] (Comitato Interministeriale per la Programmazione Economica) - a Committee in charge of co-ordinating the activities of Ministries involved in the country's economic planning and of defining the nuclear program of ENEL - reorganised the nuclear sector. Among the most important actors were (all of state-owned companies):

i) ENEL, which maintained its position as the sole utility;
ii) ENI, which was placed in charge of nuclear fuel;
iii) ANSALDO, which was placed in charge of collaborating with foreign supplier(s) and later became the Italian nuclear components supplier.

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[1] Italian Hydrocarbons Board
[2] Interministerial Committee for Economic Planning

In 1967, an agreement was signed by CNEN and ENEL for developing an Italian version of the Canadian CANDU. This reactor type, called CIRENE, was designed to use heavy water as moderator and boiling water as coolant. In 1972, ANSALDO got the order for 40 MW(e) prototype to be built close to Latina nuclear power plant. CISE actively participated in the design and construction of CIRENE reactor, which, however, never became operational due to technical problems and the lack of economic resources. Its construction was finalised only in 1988.

In 1969, ENEL decided to build a BWR (G.E. BWR 4, Mark 2) on the site of Caorso; one year later ANSALDO, in a joint venture with G.E., officially received the order. The Caorso site construction began in 1970. After several delays in implementing improvements in the suppression pool and bolstering thermal fuel performance, this 860 MW(e) unit finally started commercial operation in 1981.

In 1974, following the Yom Kippur War and the consequent oil crisis, the Ministry of Industry, Commerce and Crafts (hereafter referred to as Ministry of Industry) approved a National Energy Plan that foresaw the construction of 20 nuclear power plants in order to reduce the contribution of oil on the Italian energy balance. The main effort during that period was to achieve a certain level of technological independence from the American licenser(s). Political indecision led the industry to spread technical and economic resources over five different reactor types; namely, the BWR of General Electric, the PWR of Westinghouse and Babcock types, the CANDU of AECL, and the indigenous CIRENE.

To attain the goals of the new energy plan, the Italian government in 1973, joined the EURODIF consortium. AGIP Nucleare, a subsidiary of ENI, and CNEN were in charge of providing the country with enriched Uranium for fuel fabrication. Meanwhile, in 1972, ANSALDO - in a joint venture with G.E. - completed the Fabbricazioni Nucleari (Bosco Marengo) to manufacture the fuel elements for the future BWR's. The plant can produce 100 tons of fuel annually. It entered in operation in 1976 and has produced more than 500 tons of fuel for the Italian nuclear power stations and Leibstadt nuclear power station in Switzerland.

Later, in December 1973, three major European utilities signed an agreement to build a Superphenix, 1200 MW(e) fast breeder reactor in France. A second smaller station was planned in Federal Republic of Germany. The three original partners were Electricité de France (EdF), ENEL and Rheinisch Westfalisches Elektrizitätswerk (RWE). Subsequently RWE was substituted by Schnell-Bruter Kernkraftwerkgesellschaft (SBK), a joint enterprise of RWE, Belgian and Dutch utilities and, to a lesser extent, the British Central Electricity Generating Board (CEGB). Under the terms of this agreement the NERSA company was created in 1974 to undertake the construction of the Creys-Malville station. EdF's share of NERSA was 51%, ENEL had 33% and SBK 16%. Preliminary work on the Creys-Malville site started in December 1974. The fist concrete was laid in December 1976. The reactor began operation in January 1986. Earlier, in 1983, construction had began for PEC (Prova Elementi di Combustible) for testing fast breeder fuel elements. This was intended to strengthen Italy's participation in the Superphenix venture.

In 1976, Montalto di Castro was selected as the site for two new BWR's (G.E. BWR 4, Mark 3). The site permit was issued in 1979, exactly one month before the Three Mile Island incident. This along with the active opposition of the environmental movements, delayed the implementation of the energy plan. Moreover, ENEL faced increasing difficulties with its nuclear power stations and conventional power plants with the construction of transmission system. During the 1980's, the nuclear option became one of the major political issues, almost completely halting all nuclear activities, despite the commitments of several energy plans.

The new National Energy Plan of 1982 reflected mixed attitudes. It called for two nuclear units at Montalto di Castro and six other units on three different sites (Piemonte, Lombardia and

Puglia). The plan also identified the development of the so-called PUN[3] (Progetto Unificato Nazionale), a Westinghouse pressurized water reactor as the final reactor type for the country. The most important characteristic of PUN design was to standardise nuclear plant design and construction. ENEA[4] (Ente Nazionale per la ricerca e lo sviluppo dell'energia nucleare e delle Energie Alternative), formerly CNEN, was split into two major branches: ENEA responsible for research and promotion of nuclear technology; and, ENEA/DISP[5], an independently acting nuclear Regulatory Body.

In 1986, few months before the Chernobyl nuclear disaster, CIPE reaffirmed its commitment for the two BWR units at Montalto di Castro and for the six PUN type pressurized water reactors. However, the impact of the Chernobyl disaster on public opinion was enormous and a general debate on the implications of the use of nuclear energy inflamed the contest in the political arena. In November 1987, three referenda were passed essentially stopping any activity in the nuclear sector.

***Disengagement Period***

In December 1987, CIPE halted construction of the Montalto di Castro and Piemonte plants. These were the only two sites where construction work was effectively in progress. A nuclear moratorium period of five years was became effective.

In June 1988, the Government, by Decree Nos. 230 and 324, ended all nuclear construction. The Caorso reactor, which was shut down in October 1986 for the annual refuelling remained in cold shut down for a complete safety review and assessment. In 1989, an OSART (Operational Safety Assessment Review Team, under the aegis of IAEA) inspection of the Caorso plant was conducted; but, despite of positive results of both reviews, CIPE decided, in July 1990, to close down the plant. At the same time Trino nuclear power plant was closed. From technical, economic, environmental and safety standpoints, Caorso and Trino NPP's could start commercial operation again. The remaining units of Garigliano and Latina had already been closed down in August 1978 and November 1986, respectively.

At the same time ENEA decided to close down a number of facilities relevant to the fuel cycle: IFEC (Impianto di Fabbricazione Elementi di Combustibile), EUREX (Enriched Uranium Extraction), ITREC (Impianto di Trattamento e Rifabbricazione Elementi di Combustibile) and the plutonium plant at its Casaccia Centre. In effect, Italy is currently inactive in the nuclear energy sector.

### 3.2. Current Policy Issues

At the present time electric demand is being met with increased uses of gas fired units and imported energy. The future of the nuclear sector remains uncertain pending development and acceptance of the new generation of enhanced safety reactors.

Other main nuclear policy issues relate to the decommissioning and waste disposal facilities. The ultimate strategic goal, for the former, is unrestricted site release. A middle-term policy of some ten years provides for a temporary safe storage (passive protective custody) depending on the reactor type, general condition of the plant and the site. As for the latter issue, final selection of a site for waste disposal facilities has not been made.

By Decree No. 333 of 11 July 1992, the Government decided to privatise some state-owned industrial and commercial companies. The new companies issued shares for a total value equal to the net fixed assets given in the last balance sheet. The shares have been allocated to the Treasury and

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[3] Standard Nuclear Plant Project

[4] Italian Commission for research and Development of Nuclear and Alternative Energy Resources, set up under Act No. 84 of 5 March 1982 to reorganise CNEN.

[5] Directorate for Nuclear Safety and Health Protection

the revenue obtained by their sale will be used to reduce the national debt and to balance the Government's books. Thus, in August 1992, ENEL became a private company (ENEL S.p.A.) with its shares in the hands of the Treasury.

### 3.3. Status and Trends of Nuclear Power

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| CAORSO | BWR | 860 | ENEL | Shut Down | AMN/GETS |
| ENRICO FERMI (TRINO) | PWR | 260 | ENEL | Shut Down | WEST |
| GARIGLIANO | BWR | 150 | ENEL | Shut Down | GE |
| LATINA | GCR | 153 | ENEL | Shut Down | TNPG |

| Station | Construction Date | Criticality Date | Grid Grid | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| CAORSO | 01-Jan-70 | 31-Dec.-77 | 23-May-78 | 01-Dec.-81 | 01-Jul.-90 |
| ENRICO FERMI (TRINO) | 01-Jul.-61 | 21-Jun.-64 | 22-Oct-64 | 01-Jan-65 | 01-Jul.-90 |
| GARIGLIANO | 01-Nov.-59 | 05-Jun.-63 | 01-Jan-64 | 01-Jun.-64 | 01-Mar-82 |
| LATINA | 01-Nov.-58 | 27-Dec.-62 | 12-May-63 | 01-Jan-64 | 01-Dec.-87 |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organizational Chart

Not provided for this report.

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

Due to the historical development of nuclear technology in Italy, it was not possible to develop separate organizations for the roles of architect engineer and nuclear steam systems supplier. For PUN, it was foreseen that ENEL would have covered the role of architect engineering, and ANSALDO would have been the nuclear supplier. For the other reactors both activities were performed mainly by foreign companies. For example, for Caorso nuclear power plant the supplier was a joint venture of ANSALDO and G.E. (AMN/GETS), while the architect engineering services were provided by Gibbs & Hill of the U.S.

At the present, ANSALDO is the only big company still active in the nuclear field. It participates, in a joint venture with AECL, in construction of five CANDU reactors in Cernovoda, Romania.

### 4.2. Operation of Nuclear Power Plants

Since 1962, ENEL has been the only utility owning and operating nuclear power reactors. ENEL has also acted as a maintenance company with several other private or state-owned companies (ANSALDO, Carlo Gavazzi, Fochi, Belleli, FIAT, etc.). For instance, half of the outage services at Caorso NPP are performed by the plant personnel and other half by external contractors. For training nuclear operators, ENEL established, in the 1980's, a training centre in Piacenza equipped with a full scale BWR simulator.

### 4.3. Fuel Cycle and Waste Management Service Supply

*Uranium enrichment and fuel fabrication:*

In Italy, there are no facilities for enriching Uranium. Several installations have the capability to manufacture fuel elements. However, at the present time, all of them are closed.

*Fuel transportation:*

Radioactive material can be transported only by authorised carriers. The authority responsible for issuing freight licences is the Ministry of Industry, after ANPA (Agenzia Nazionale per la Protezione dell'Ambiente, see section 5.1) has given its technical assessment. The rules regulating transport of radioactive material come from IAEA's Safety Series No. 6, and are in accordance with international regulations enacted by ICAO, ADR, RID and IMO.

*Spent fuel disposal and storage:*

Some irradiated fuel removed from ENEL power plants has been reprocessed in the United Kingdom. The remainder is stored at ENEL and at the COMPES storage facility. No significant steps have been taken so far to identify a permanent repository site. Pursuant to an agreement with the Ministry of Industry, ENEL plans to prepare an interim storage facility where residual spent fuel can be kept safely for several decades pending a governmental decision on final disposal.

*Waste management and disposal:*

The organization responsible for high level waste is ANPA, while the operator responsible for low and medium level waste is NUCLECO (a ENI and ENEA joint company, established in 1981). The sources of radioactive waste in Italy include the power plants formerly operated by ENEL, the fuel cycle plants operated by Fabbricazioni Nucleari S.p.A., ENEA research laboratories and experimental facilities, and non-energy applications (e.g., biomedical and other uses).

The criteria applicable to the classification, treatment and disposal of radioactive waste are set forth in ENEA/DISP's Technical Guide No. 26, issued in May 1988. These rules allow above ground disposal of treated low-level waste (Categories I and 11) and prescribe deep disposal for high-level waste (Category III).

At the present time, high-level and most low-level waste is stored at production sites (ENEL power plants and ENEA facilities). The quantities of energy related waste currently stored in Italy are the follows:

- cubic meters solid and 400 cubic meters liquid low level waste (Categories I and II). Solid low-level waste is to be super-compacted and cemented (about 1 000 cubic metres have already been treated). Liquid low-level waste is to be cemented in containers suitable for above ground storage.
- cubic meters solid high-level waste (Category III). This figure includes alpha-emitting waste, 120 cubic meters liquid waste.

Vitrification and cementation treatments are under consideration for liquid high-level waste, and cementation for solid high-level waste in category III containers for deep storage.

### 4.4. Research and Development Activities

Nuclear research is conducted by several agencies, institutions and universities. Every three years two governmental bodies - Consiglio Nazionale della Scienza e della Tecnologia and CIPE - issue the "Triennial Research Plan" in order to co-ordinate the whole research sector. The leading agency for applied nuclear research is ENEA with its Energy Research Centre (CRE) at Casaccia, near Rome. To a lesser extent, research activities are also performed by ENEL and CISE. Theoretical research in the nuclear field is performed mainly under the aegis of CNR[6] (Consiglio Nazionale delle Ricerche) and INFN[7] (Instituto Nazionale di Fisica Nucleare) in its four main laboratories - Laboratori Nazionali di Frascati, Laboratori Nazionali di Legnano, Laboratori Nazionali del Sud and the new Laboratori Nazionali del Gran Sasso.

In nuclear engineering, the universities with degree programs are the Università di Roma (power plant engineering), the Università di Pisa (safety assessments), and the Politecnico di Milano (plant engineering and probabilistic safety studies).

Some research activities, experiments and studies, mainly in connection with the above universities and agencies, are still performed at the facilities equipped with research reactors as shown in Table 8.

TABLE 8. RESEARCH REACTOR FACILITIES

| SITE | POWER | OPERATOR | STATUS |
|---|---|---|---|
| Bologna | 100 We | ENEA/RB3 | not operating |
| Palermo | 20 We | University of Palermo | in operation |
| Roma | 1 MW | ENEA/TRIGA | in operation |
| Roma | 5 kW | ENEA/TAPIRO | not operating |
| Pavia | 250 kW | University of Pavia | in operation |

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Italy participates in several international co-operative projects developed under the aegis of the European Community, NEA/OECD and the International Atomic Energy Agency. In this setting two important research centres must be pointed out: the Joint Research Centre of Ispra[8] and the International Centre for Theoretical Physics in Trieste, a branch of IAEA. ANPA is participating in the PHARE and TACIS programmes of assistance to Central Europe and CIS countries.

In the area of nuclear safety and environmental protection, bilateral agreements have been signed with NRC (USA), NII (UK), CSN (Spain), N.N.S.A.(China), and D.S.I.N (France).

Some noteworthy activities in progress are: nuclear fuel research conducted with the Halden reactor; participation in the international EPRI-DOE program on new generation reactors; and, in nuclear fusion field, participation in the Joint European Torus project.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

In Italy, the general framework of nuclear activities is given by Basic Act No. 1860 of 31 December 1962, on the peaceful uses of nuclear energy (G.U. No. 27, 30 Gennaio 1963). Licensing and operation of nuclear installations are governed by recent Legislative Decree No. 230 of March 1995 (G.U. No. 136, 13 Giugno 1995) on the safety of nuclear plants and the protection of workers and the population against the risks of ionizing radiation. This Decree replaces and updates the

[6] Italian National Research Council
[7] Italian National Institute for Nuclear Physics
[8] Reactor Safety, Fusion Technology (with the European Tritium Handling Laboratory) and Advanced Materials am only some of the activities performed in the Centre.
Another European research centre, in which Italy has a quota of 28%, is CERN (Consiglio Europeo per la Ricerca Nucleare) in Switzerland.

previous Decree No. 230/1964, incorporating several Directives of EURATOM (n. 80/836, 84/467, 84/466. 89/618, 90/641, 92/3) and introducing a specific licensing procedure for decommissioning nuclear plants (Art. 55, 56, 57). Both of these general Acts are complemented by several Decrees regulating specific aspects.

In accordance with Act No. 1860 and with Decree No. 230, the administrative authority responsible for licensing is the Minister for Industry, Commerce and Crafts. It grants the nuclear power plant construction permit and the operating license.

The National Agency for the Environmental Protection (ANPA), established by Act No. 61 of 21 January 1994, is entrusted with safety reviews, regulatory inspections and other technical tasks. Before the establishment of ANPA, these activities were performed by ENEA/DISP, a Directorate embodied in ENEA.

In the main steps of the licensing procedure, ANPA makes use of consultative advice from the Advisory Committee (Commissione Tecnica) made up of experts appointed by Ministries involved.

In addition to the provisions of Presidential Decree No. 230, ANPA publishes Technical Guides, which outline the safety criteria and license application formats. These guides are prepared for nuclear operators and are informational in nature. Their purpose is to provide a better understanding of the controls exercised by ANPA in matters of safety and health protection.

**5.2. Main National Laws and Regulations**

According to Article six of the Law 1860, any organization that intends to operate a nuclear installation has to be licensed by the Ministry of Industry, as advised by the Regulatory Body.

The Act No. 393 of 23 August 1975, outlines a construction licensing procedure, which is broken into two main stages: a study of the site in relation to the basic design principles of the power plant in question; and, a study of the preliminary project of the planned power plant. Act No. 393 on the NPP site selection instituted the co-operation of national authorities with regional and local authorities to take due account of the administrative decentralisation implemented in legislation.

In accordance with the established procedure, CIPE authorises the areas where nuclear power plants can be constructed. In order to facilitate this phase, the Regulatory Body drew up a "National Sites Map", which indicates the areas where the nuclear power plants can be built. The CIPE's decision is taken after a consultation with ENEA and in agreement with the Inter-regional Advisory Commission made up of the presidents of the regional governments. In the first phase, each region concerned has to indicate, within 150 days following the CIPE deliberations, at least two areas in its territory where nuclear power plants could be constructed.

Once the areas have been selected, the utility is given permission by the Ministry of Industry to proceed with all investigations that are needed to determine whether the areas selected are technically suitable and to decide which area it would propose for the installation. Within 12 months, the utility has to submit a detailed report on the proposed site to the Minister of Industry, to the regions concerned and to the Regulatory Body. The report contains a detailed analysis of nuclear safety and health protection issues in accordance with the procedures laid down in D.P.R. No. 230, as relates to the siting of the location. Under the terms of Act No. 393, ANPA has to consult all concerned, e.g., Ministries of Interior, Employment, Public Works, Health. The Ministries are required to reply within sixty days of being consulted. The outcome of the investigation is referred to the Advisory Committee by the Regulatory Body and ultimately forwarded to the Ministry of Industry.

This technical phase is followed by a decision making phase culminating in a final choice of the site by the region in agreement with the municipality concerned. The region's decision must be communicated to the Ministry of Industry within two months.

Once the site bas been approved, the Ministry of Industry authorises the utility to begin preliminary site preparation under the control of the Regulatory Body. From this point on the licensing procedure continues along the lines set out in D.P.R. 230. This consists of the issuance of the construction permit and the operating license.

Before the final authorisation is granted, nuclear power plants and facilities for the disposal of radioactive waste must undergo an environmental impact assessment, in accordance with Decree 377 of 1988.

*Filing of application:*

The utility submits the general design (site and plant) and the preliminary Safety Report to the Ministry of Industry and to the Regulatory Body. The documents supplied must also include a Preliminary Study on the treatment and disposal of radioactive waste.

The Regulatory Body draws up a technical report for nuclear safety and health protection evaluation of the installation. It also makes a critical appraisal of the preliminary safety report and the preliminary study on the treatment and disposal of radioactive waste determining whether these comply with the conditions laid down during site selection.

The Regulatory Body's technical report is forwarded to the Ministry of Industry which then sends it to the Ministries of the Interior, Employment, Public Works, and Public Health for their comments. The comments should be forwarded to the Regulatory Body within sixty days. Having considered the assessment of the Advisory Committee, the Regulatory Body gives the Ministry of Industry its final evaluation. The construction license is granted by Decree from the Minister.

The Regulatory Body, on the advice of the Advisory Committee, establishes a list of the parts of the installation that involve nuclear safety and health protection. A detailed plan for each part of the installation included in the list has to be approved by the Regulatory Body, on the assessment of the Advisory Committee, prior to the construction. The study on treatment and disposal of radioactive waste must be handed to the Commission of the European Communities in accordance with section 37 of the EURATOM Treaty.

Two series of tests - non nuclear and nuclear - must be carried out and successfully performed before an operator can apply for a license to commission the installation.

The results of non-nuclear tests are submitted to ANPA for approval The test can be carried out only with its permission and under its supervision. Depending on the reports produced by the operator and the results of the checks made during these tests, the Regulatory Body issues a certificate stating that from the safety viewpoint the installation is ready to be loaded with the nuclear fuel.

Nuclear tests may not be carried out until the operator has submitted the Final Safety Report (with Operating Rules, Operating Manual, Structure of Operating Organization, Proposal of Technical Specifications) and obtained the Regulatory Body's approval on the general test program, after the Advisory Committee has given its assessment. The approval is subject to the Ministry of the Interior's receipt of the emergency scheme for safety measures in case of an accident. Before beginning nuclear tests, the Regulatory Body also has to approve the maximum discharge levels for the radioactive effluents. The Operator must give the Regulatory Body a report on each nuclear test in order to get certified.

The operating license is granted in successive stages, depending on the results of the nuclear tests within the limits, conditions and technical specifications with which the operator must comply. A specific license is required for the reactor operators, reactor senior operators and plant supervisors. The operating license is granted by Decree of the Ministry of Industry and includes the technical requirements specified by the Regulatory Body. As a rule, the operating license is granted indefinitely. However, a general review of the installation's safety condition is usually undertaken after ten years. The period within which a safety review is carried out also depends on the operational life and on the status of the specific plant. Any modification to the initial design must be approved by the Ministry of Industry, which takes its decision after consulting the Regulatory Body.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related agreement INFCIRC/193 | Entry into force: | 21 February 1977 |
| • Improved procedures for designation of safeguards inspectors | Rejected but agreed to special procedures | |
| • Supplementary agreement on provision of technical assistance by the IAEA | | |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 2 May 1975 |
| • EURATOM | Member | |
| • Agreement on privileges and immunities | Entry into force: | 20 June 1985 |
| • Convention on physical protection of nuclear material | Signature: | 13 June 1980 |
| • Convention on early notification of a nuclear accident | Entry into force: | 11 March 1990 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 25 November 1990 |
| • Convention on civil liability for nuclear damage and joint protocol | Paris Convention:<br>Entry into force: | 17 September 1975<br>27 April 1992 |
| • Convention on nuclear safety | Signature: | 27 September 1994 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |

| | | |
|---|---|---|
| • Acceptance of NUSS Codes | Summary: National regulations are in conformity with revised codes. Codes are sound international safety standards which should be made obligatory in all states operating NPPs. Letter: | 27 December 1989 |
| • Establishment of CERN with 12 other European Countries | Paris | July 1953 |
| • Halden Boiling Water Reactor project Italian representative: ENEA | | June 1958 |
| • Joint European Torus Undertaking Italian representatives: ENEA and | Brussels CNR | May 1978 |

## REFERENCES


[1] Il regime giuridico dell'impiego pacifico dell'energia nucleare, Vol. I, II and III, ENEA, Roma, (1986) (Volumes II and III present the whole set of international agreements in which Italy participates).

[2] Il Nucleare in Italia, special edition of Professione Ingegnere, Anno 5, N.19/20, Luglio-Dicembre, (1992).

[3] Energia, ambiente, innovazione dal CNRN all'ENEA, a cura di G. Paoloni, Laterza; Bari, (1992).

[4] La questione energetica: dieci anni perduti 1963-1973, F. Ippolito, F. Simen, Feltrinelli; Milano, (1974).

[5] Il ruolo dell'organizzazione industriale nello sviluppo nucleare, P. Berra, A. Ninni, S. Vaccà, Economia delle fonti di energia, XXXIII, N. 42, (1990).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Ministry for Industry, Commerce<br>and Handicrafts (MICA)<br>Via Vittorio Veneto, 33<br>I-00100 Rome<br>Italy | Tel.:: +39 6 47051<br>Fax: +39 6 4817849<br>Telex: 616315 MICA |
| Italian Agency for New Technology,<br>Energy and the Environment (ENEA)<br>Lungotevere Thaon di Revel, 76<br>I-00198 Rome<br>Italy | Tel.: +39 6 36271<br>Fax: +39 6 36272591<br>Telex: 610183 ENEA |

**Regulatory Body**

| | |
|---|---|
| Italian Agency for Environmental<br>Protection (ANPA)<br>Via Vitaliano Brancati, 48<br>I-00144 Rome<br>Italy | Tel.: +39 6 50071<br>Fax: +39 6 5013429<br>+39 6 50072916 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Italian Forum for Nuclear Energy (FIEN)<br>Via Flavia, 104<br>00187 Rome<br>Italy | Tel.: +39 6 486415<br>Fax: +39 6 4744397 |

National Association for Nuclear
Engineering (ANDIN)
Located at same address as Italian Forum for Nuclear Energy, see above.

*NUCLEAR INDUSTRY*

**Supply of Nuclear Power Plants**

| | |
|---|---|
| ANSALDO S.p.A. Nuclear Division<br>Via Corso Perrone 25<br>16161 Genova. | Tel. +39 10 6551 |

**Operation of Nuclear Power Plants**

| | |
|---|---|
| ENEL S.p.A.<br>Via GB. Martini 3<br>00198 Roma | Tel.: +39 6 85091 |

**Fuel Fabrication**

| | |
|---|---|
| FN S.p.A. Nuove Tecnologie e Servizi Avanzati<br>S.S. 35 bis dei Giovi Km 15<br>15062 Bosco Marengo - Alessandria | Tel.: +39 131 2971<br>Fax.: +39 131 297250 |

**Transport**

| | | |
|---|---|---|
| Air carrier: | Alitalia<br>Via della Magliana 806<br>Roma | <br>Tel.: +39 6 65629133 |
| Land Carriers: | Borghi Nucleare<br>V. le Liegi 33<br>Roma | <br>Tel.: +39 6 8546104<br>Fax +39 6 8543798 |
| | MIT Nucleare<br>Via dell'Artigianato 12<br>Carugate (Mi) | <br>Tel.: +39 2 921591<br>Fax +39 2 92150244 |
| Rail Carrier: | Ferrovie dello Stato<br>Piazza della Croce Rossa 1<br>Roma | <br><br>Tel.: +39 6 47305700 |
| Marine Carrier: | Lloyd Triestino S.p.A.<br>Piazza Unità d'Italia 1<br>Trieste | <br><br>Tel.: +39 40 3180111 |

Several other carriers are licensed for radioactive and fissile materials, their addresses are available from ANPA or from the Ministry of Industry.

| | | |
|---|---|---|
| **Spent fuel** | COMPES<br>Via Cuneo 21<br>Torino | <br>Tel.: +39 11 26001<br>Fax: +39 11 850642 |
| **Waste Management** | NUCLECO<br>Via Anguillarese 301<br>Roma | |
| **Research and Development** | ENEA<br>Lungotevere Thaon di Revel, 76<br>I-00198 Rome<br>Italy | <br>Tel.: +39 6 36271<br>Fax: +39 6 36272591<br>Telex: 610183 ENEA |
| | ENEA/CRE<br>Via Anguillarese 301<br>S.M. di Galeria (RM) | <br>Tel.: +39 6 30481<br>Fax +39 6 30494203 |
| | CNR<br>le A. Moro 7<br>Roma | <br>Tel.: +39 6 49931<br>Fax +39 6 4461954 |
| | INFN<br>Piazza dei Caprettari 70<br>Roma | <br><br>Fax +39 6 68307924 |

# JAPAN

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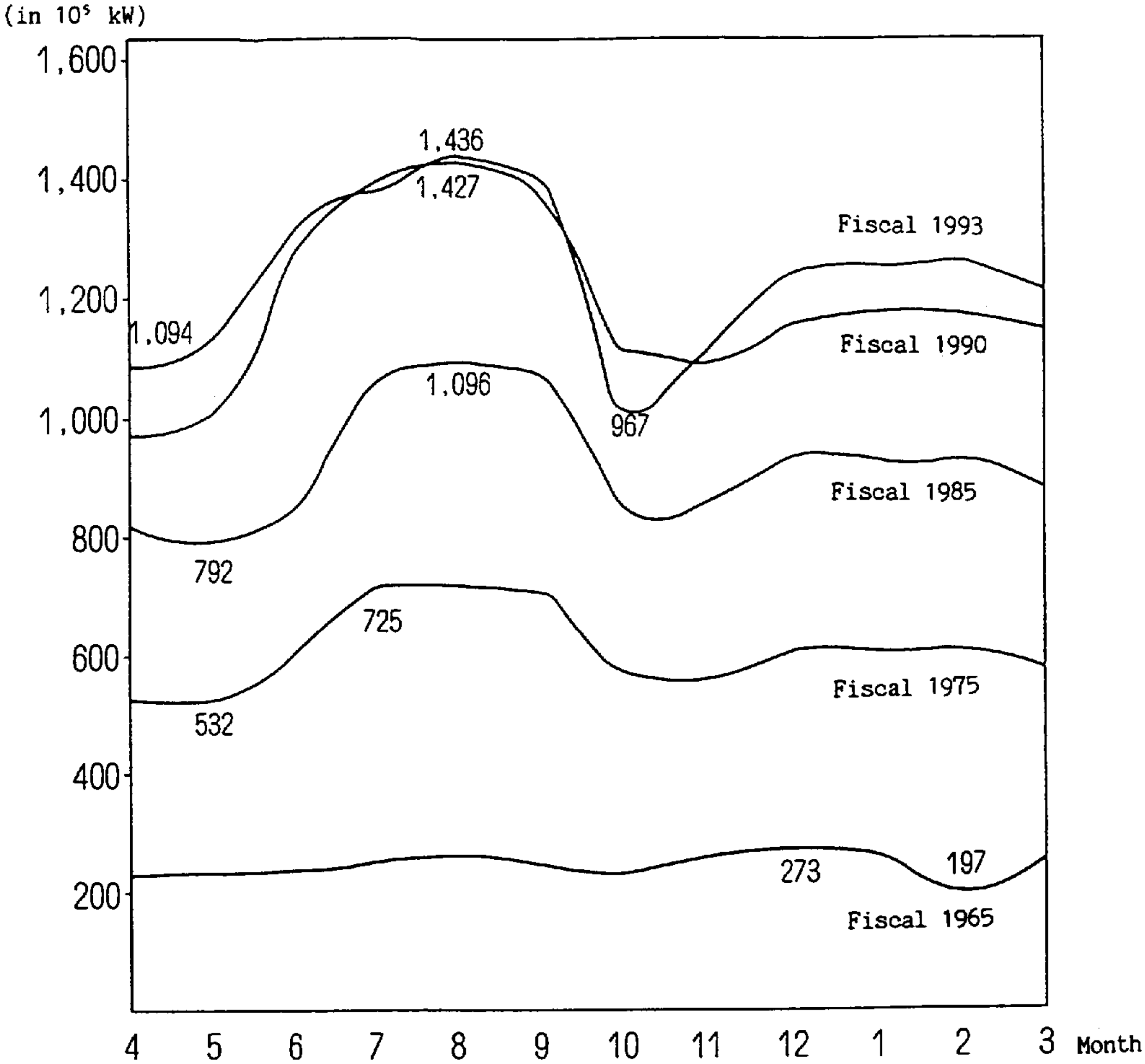
## 1. GENERAL INFORMATION

### 1.1. General Overview

Situated in the far east of Asia, Japan is subject to a monsoon climate in the Temperate Zones. Japan has four distinct seasons which affect changes in the demand for energy or electric power. The annual fluctuation of Japan's electric power demand has two peak periods, the highest being the summer peak based on air-conditioning, and the winter peak based on heating. Figure 1 shows Japan's annual power demand fluctuations. Table 1 shows Japan's total population, its density and rate of increase.




Source: Nuclear Power Charts 1994 Edition, Federation of Electric Power Companies

*FIG. 1. Trend of Annual Power Demand (Composite Sum of 9 Power Companies)*

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 94.1 | 104.3 | 116.8 | 123.5 | 124.5 | 124.8 | 0.5 |
| Population density (inhabitants/km²) | 249.1 | 276.2 | 309.2 | 327.0 | 329.6 | 330.4 | |
| Predicted population growth rate (%) 1993 to 2000 | | 0.2 | | | | | |
| Area (1000 km²) | | 377.8 | | | | | |
| Urban population in 1993 as percent of total | | 77.0 | | | | | |

Source: IAEA Energy and Economic Data Base

### 1.2. Economic Indicators

Table 2.1 shows Japan's total GDP and its GDP per capita and Table 2.2 GDP by sector figures and the growth rate.

TABLE 2.1. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 203,736 | 1,059,257 | 2,932,088 | 4,215,530 | 4,590,941 | 11.0 |
| GDP (millions of constant 1990 US$) | 1,261,338 | 1,959,820 | 2,932,088 | 3,088,581 | 3,107,112 | 3.3 |
| GDP per capita (current US$/capita) | 1,953 | 9,068 | 23,734 | 33,850 | 36,782 | 10.5 |
| GDP by sector : Agriculture 3%, Industry 42%, Services 56% | | | | | | |

Source: IAEA Energy and Economic Data Base

TABLE 2.2. GDP BY SECTOR

| Item | 1992 | | 1993 | |
|---|---|---|---|---|
| | Real Value (in trillion yen) | Growth over Previous year (%) | Real Value (in trillion yen) | Growth over Previous year (%) |
| Agriculture, Forestry and Fishery | 9.806 | 2.2 | 9.361 | -4.5 |
| Mining | 1.075 | -1.9 | 1.030 | -4.2 |
| Manufacturing | 130.809 | -2.0 | 127.510 | -2.5 |
| Construction | 36.691 | 0.5 | 37.138 | 1.2 |
| Electricity, Gas & Water Supplies | 13.983 | 2.5 | 14.391 | 2.9 |
| Wholesale and Retail | 58.971 | 3.0 | 59.060 | 0.2 |
| Finance and Insurance | 24.566 | -0.7 | 22.705 | -7.6 |
| Real Estate | 41.494 | 2.0 | 42.561 | 2.6 |
| Transportation and Communication | 26.217 | -0.2 | 26.830 | 2.3 |
| Others | 77.011 | 5.2 | 79.180 | 2.8 |
| Total | 420.622 | 1.1 | 419.765 | -0.2 |
| GDP per Capita | 372.7 (Ten thousand Yen) | 2.3 | 373.9 (Ten thousand Yen) | 0.3 |

Source: Annual Report on National Accounts 1995: Economic Planning Agency

### 1.3. Energy Situation

Short of energy sources, Japan's energy dependence on imports exceeds 80%. Her primary energy dependence on petroleum is now approximately 60%, almost all of which is imported. More than 90% of coal and natural gas requirements have to be met with imports. Compared with the world's major advanced countries, this is an extremely unstable energy supply structure. Table 3 shows the estimated energy reserves in Japan.

Highly advanced in international trade and industry, Japan ranks very high in the world as pertains to national energy consumption and per capita energy consumption. Figures 2.1 and 2.2 presents the primary energy supply and energy consumption. Table 4.1 shows Japan's basic energy situation and Table 4.2 the trend of energy consumption by sector.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 20.45 | 0.30 | 1.47 | | 69.18 | 91.40 |

[1] *This total represents essentially recoverable reserves.*
[2] *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1992) by a factor of 10.*
Source: IAEA Energy and Economic Data Base

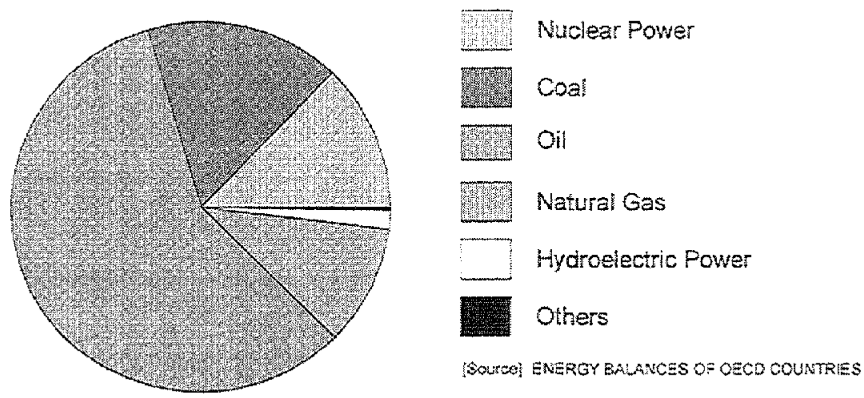



*FIG. 2.1.* ***Proportions of Primary Energy Supplies (1992)***

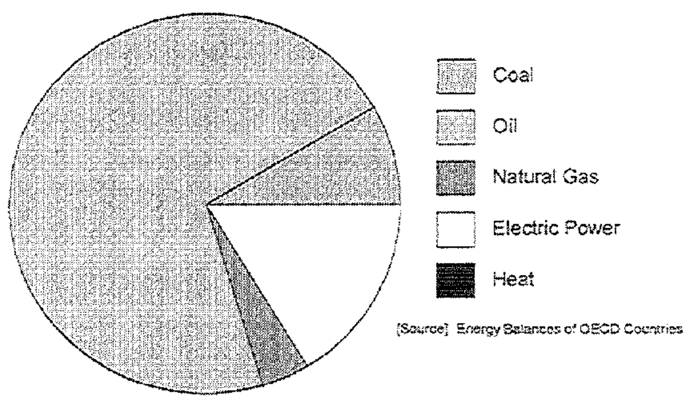



***FIG. 2.2. Proportions of Total Final Energy Consumption (1992)***

TABLE 4.1. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[(1)] | 3.39 | 11.30 | 14.63 | 18.07 | 19.02 | 19.60 | 7.58 | 2.11 |
| - Solids[(2)] | 1.65 | 2.62 | 2.52 | 3.39 | 3.42 | 3.50 | 2.15 | 2.38 |
| - Liquids | 1.15 | 7.71 | 9.45 | 9.94 | 9.97 | 10.49 | 11.10 | 0.75 |
| - Gases | 0.03 | 0.16 | 0.97 | 2.00 | 2.22 | 2.37 | 18.53 | 6.57 |
| - Primary electricity[(3)] | 0.56 | 0.82 | 1.69 | 2.74 | 3.41 | 3.24 | 5.66 | 4.74 |
| Energy production | | | | | | | | |
| - Total | 2.13 | 2.14 | 2.27 | 3.06 | 3.71 | 3.53 | 0.33 | 3.20 |
| - Solids | 1.51 | 1.17 | 0.47 | 0.22 | 0.18 | 0.17 | -5.65 | -7.02 |
| - Liquids | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.10 | 2.06 |
| - Gases | 0.03 | 0.11 | 0.09 | 0.08 | 0.09 | 0.09 | 4.93 | 0.65 |
| - Primary electricity[(3)]) | 0.56 | 0.82 | 1.69 | 2.74 | 3.41 | 3.24 | 5.66 | 4.74 |
| Net import (import - export) | | | | | | | | |
| - Total | 1.58 | 9.74 | 13.06 | 15.36 | 15.93 | 16.88 | 11.15 | 1.85 |
| - Solids | 0.24 | 1.48 | 1.98 | 3.13 | 3.21 | 3.32 | 11.09 | 3.74 |
| - Liquids | 1.34 | 8.22 | 10.19 | 10.28 | 10.59 | 11.27 | 10.69 | 0.72 |
| - Gases | | 0.04 | 0.89 | 1.94 | 2.13 | 2.29 | | 7.01 |

[(1)] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[(2)] *Solid fuels include coal, lignite and commercial wood.*
[(3)] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

TABLE 4.2. TREND OF END-USE ENERGY CONSUMPTION (fiscal year)

(in 100 million kl of crude oil equivalent)

| (fiscal year) | 1973 | 1986 | 1992 | 1993 |
|---|---|---|---|---|
| End-Use Energy Consumption | 2.85 | 2.94 | 3.60 | 3.62 |
| Industry | 1.87 | 1.56 | 1.81 | 1.81 |
| Commerce and Residence | 0.52 | 0.72 | 0.93 | 0.94 |
| Transportation | 0.47 | 0.66 | 0.86 | 0.87 |

Source: Natural Resources and Energy '95/'96 Edition, Agency of Natural Resources and Energy (MITI)

## 1.4. Energy Policy

While the national medium and long term energy demand continues to increase, the dependency of Japan's energy supply on imported resources remains high at approximately 84%. For this reason, the fundamental basis of Japan's energy policy is to secure a stable energy supply, a fundamental requirement of both economic and civil activities.

The Agency of Industrial Science and Technology of the Ministry of International Trade and Industry initiated the 'Sunshine Project' in 1974 for the development of new energy technology, and the 'Moonlight Project' in 1978 for the implementation of energy conservation. These projects advanced through co-operation between industry, government and academia with the long-term perspective of developing energy related technology. Steady achievements are accomplished in each project including the establishment of a new technological basis, and the application of technological achievements and their propagation to related industrial areas. Responding to today's social demand for reduction of environmental loads, the Agency has also established a research and development framework for global environmental technology.

In 1993, these three efforts, the development of new energy resources, energy conservation and global environmental technology, which were pursued under the 'Sunshine Project', the 'Moonlight Project' and through global environmental technology research and development, were unified into the 'New Sunshine Project', thereby embarking an innovative technology development effort designed to simultaneously resolve the problem of energy supply for continued economic growth and the environmental problems.

As nuclear power is the most promising energy resource to replace oil, the siting of nuclear power plants is advanced under the 'Three Laws for Electric Power' (Electric Power Development Promotion Tax Law, Special Account Law for Electric Power Development Promotion and Law for the Adjustment of Areas Adjacent to Power Generating Facilities) in order to secure a stable energy supply.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Japan is divided into nine zones by nine electric power companies. These are private enterprises who specialise only in electric utility operations and are the sole power suppliers in each zone, thus monopolising the local power market. Apart from these, there is also the Oaken Electric Power Company, a smaller electric utility company, operating in Oaken Prefecture comprised of many small islands. These power companies run their own facilities from power generation to transmission and distribution as an integrated business operation.

The Electric Power Development Company which has its own thermal and hydro electric power stations, and the Japan Atomic Power Company which has its own nuclear power stations are other private enterprises that produce electric power and act as wholesalers to the nine electric power companies. However, in relation to Japan's total installed capacity, their installed capacity is relatively small.

Table 5.1 shows the historical electricity production and the installed capacity and Tables 5.2 and 5.3 show the installed capacity of, and the actual energy generated by, the installers or owners of power plants.

TABLE 5.1. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total(1) | 115.95 | 361.23 | 577.52 | 857.27 | 906.71 | 964.33 | 8.36 | 3.73 |
| - Thermal | 57.47 | 276.32 | 401.75 | 573.27 | 553.14 | 628.29 | 10.21 | 3.25 |
| - Hydro | 58.48 | 80.09 | 92.09 | 95.84 | 105.47 | 75.66 | 2.30 | -1.39 |
| - Nuclear | | 4.58 | 82.59 | 186.42 | 246.30 | 258.30 | | 8.49 |
| - Geothermal | | 0.24 | 1.09 | 1.74 | 1.78 | 2.06 | | 4.66 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 23.77 | 68.71 | 143.70 | 194.73 | 212.91 | 220.74 | 9.41 | 3.11 |
| - Thermal | 11.09 | 47.35 | 98.07 | 125.71 | 134.61 | 139.55 | 11.51 | 2.55 |
| - Hydro | 12.68 | 19.99 | 29.78 | 37.83 | 39.97 | 41.93 | 4.36 | 2.48 |
| - Nuclear | | 1.34 | 15.69 | 30.92 | 38.03 | 38.88 | | 6.70 |
| - Geothermal | | 0.03 | 0.16 | 0.27 | 0.30 | 0.38 | | 6.26 |
| - Wind | | | | | 0.01 | 0.01 | | |

*(1) Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 5.2. POWER GENERATION CAPACITY OF EACH PLANT OWNER (for electric utility) (as of April 1994)

| Owner Name | Nuclear Power | | Hydroelectric Power | | Thermal Power | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Power Generation | Proportion | Power Generation | Proportion | Power Generation | Proportion | Power Generation | Proportion |
| Hokkaido Electric Power Co. | 115.8 | 21.4 | 119.6 | 22.1 | 306.0 | 56.5 | 541.4 | 100 |
| Tohoku Electric Power Co. | 52.4 | 4.8 | 243.8 | 22.5 | 786.8 | 72.7 | 1,082.8 | 100 |
| Tokyo Electric Power Co. | 1,349.6 | 27.3 | 674.2 | 13.6 | 2,925.4 | 59.1 | 4,949.2 | 100 |
| Chubu Electric Power Co. | 361.7 | 14.3 | 365.5 | 14.4 | 1,807.5 | 71.3 | 2,534.6 | 100 |
| Hokuriku Electric Power Co. | 54.0 | 10.8 | 180.6 | 36.1 | 266.2 | 53.2 | 500.8 | 100 |
| Kansai Electric Power Co. | 976.8 | 27.9 | 668.6 | 19.1 | 1,858.1 | 53.0 | 3,503.5 | 100 |
| Chugoku Electric Power Co. | 128.0 | 12.9 | 227.0 | 22.8 | 640.6 | 64.3 | 995.6 | 100 |
| Shikoku Electric Power Co. | 113.2 | 20.9 | 112.0 | 20.7 | 317.1 | 58.5 | 542.3 | 100 |
| Kyushu Electric Power Co. | 289.88 | 19.9 | 232.3 | 16.0 | 932.1 | 64.1 | 1,454.2 | 100 |
| Japan Atomic Power Co. | 278.3 | 100 | | | | | 278.3 | 100 |
| Electric Power Development Co. | | | 763.3 | 62.1 | 465.5 | 37.9 | 1,228.8 | 100 |
| Others | | | 7.9 | 0.8 | 1,040.7 | 99.3 | 1,048.5 | 100 |
| Total | 3,719.6 | 19.9 | 3,594.6 | 19.3 | 11,345.8 | 60.8 | 18,660.0 | 100 |

Source: Summary of Thermal Power Facilities (as of April, 1994) the Federation of Electric Power Companies

TABLE 5.3. ENERGY GENERATION OF EACH PLANT OWNER (for electric utility) (in fiscal 1993)

| Owner Name | Nuclear Power | | Hydroelectric Power | | Thermal Power | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Energy Generation | Proportion | Energy Generation | Proportion | Energy Generation | Proportion | Energy Generation | Proportion |
| Hokkaido Electric Power Co. | 82 | 32.9 | 36 | 14.4 | 131 | 52.7 | 249 | 100 |
| Tohoku Electric Power Co. | 35 | 7.3 | 98 | 20.7 | 342 | 72.0 | 475 | 100 |
| Tokyo Electric Power Co. | 902 | 38.8 | 145 | 6.2 | 1,275 | 54.9 | 2,322 | 100 |
| Chubu Electric Power Co. | 228 | 22.4 | 96 | 9.5 | 693 | 68.2 | 1,017 | 100 |
| Hokuriku Electric Power Co. | 39 | 21.3 | 68 | 37.0 | 76 | 41.7 | 183 | 100 |
| Kansai Electric Power Co. | 610 | 47.8 | 158 | 12.4 | 508 | 39.8 | 1,277 | 100 |
| Chugoku Electric Power Co. | 86 | 22.4 | 42 | 10.9 | 257 | 66.8 | 385 | 100 |
| Shikoku Electric Power Co. | 75 | 32.3 | 25 | 11.0 | 131 | 56.7 | 231 | 100 |
| Kyushu Electric Power Co. | 242 | 42.4 | 53 | 9.3 | 274 | 48.2 | 569 | 100 |
| Japan Atomic Power Co. | 185 | 100 | | | | | 185 | 100 |
| Electric Power Development Co. | | | 143 | 32.1 | 302 | 67.9 | 444 | 100 |
| Others | | | 115 | 18.5 | 505 | 81.5 | 1,620 | 100 |
| Total | 2,482 | 31.2 | 979 | 12.3 | 4,496 | 56.5 | 7,957 | 100 |

Source: Nuclear Power Generation Data, MITI (April 1995)

### 2.2. Policy and Decision Making Process

The Electric Power Industry Advisory Council (Supply and Demand Working Committee), comprised of non-governmental professionals and experts including those from electric power companies, provide advice and recommendations to the Minister of International Trade and Industry, on a regular basis, regarding the basic national policies on regional network operations for the stable supply of power, promotion of demand-oriented energy saving measures, promotion of load levelling, further development of electric power, etc. Based on this advice, the Ministry of International Trade and Industry together with related Ministries and Agencies confer regularly with individual power companies to review the up-to-date demand and supply performances and to evaluate the power supply program for the future.

### 2.3. Main Indicators

Table 6 shows the trends in various energy and electricity ratios. Table 7 and Figure 3 show the trends of installed generation capacity and energy generated in Japan

TABLE 6. ENERGY AND ELECTRICITY RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 36 | 108 | 125 | 146 | 153 | 157 |
| Electricity per capita (kW·h/capita) | 1,232 | 3,347 | 4,708 | 6,543 | 6,869 | 7,273 |
| Electricity production/Energy production (%) | 52 | 157 | 233 | 255 | 222 | 248 |
| Nuclear/Total electricity (%) | | 1 | 15 | 23 | 29 | 28 |
| Ratio of external dependency (%)(1) | 47 | 86 | 89 | 85 | 84 | 86 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 56 | 60 | 46 | 50 | 49 | 50 |
| - Thermal | 59 | 67 | 47 | 52 | 47 | 51 |
| - Hydro | 53 | 46 | 35 | 29 | 30 | 21 |
| - Nuclear | | 39 | 60 | 69 | 74 | 76 |

*(1) Net import / Total energy consumption*
Source: IAEA Energy and Economic Data Base

TABLE 7. ELECTRIC POWER PLANT CAPACITY OUTLOOK (for Electric Utilities)

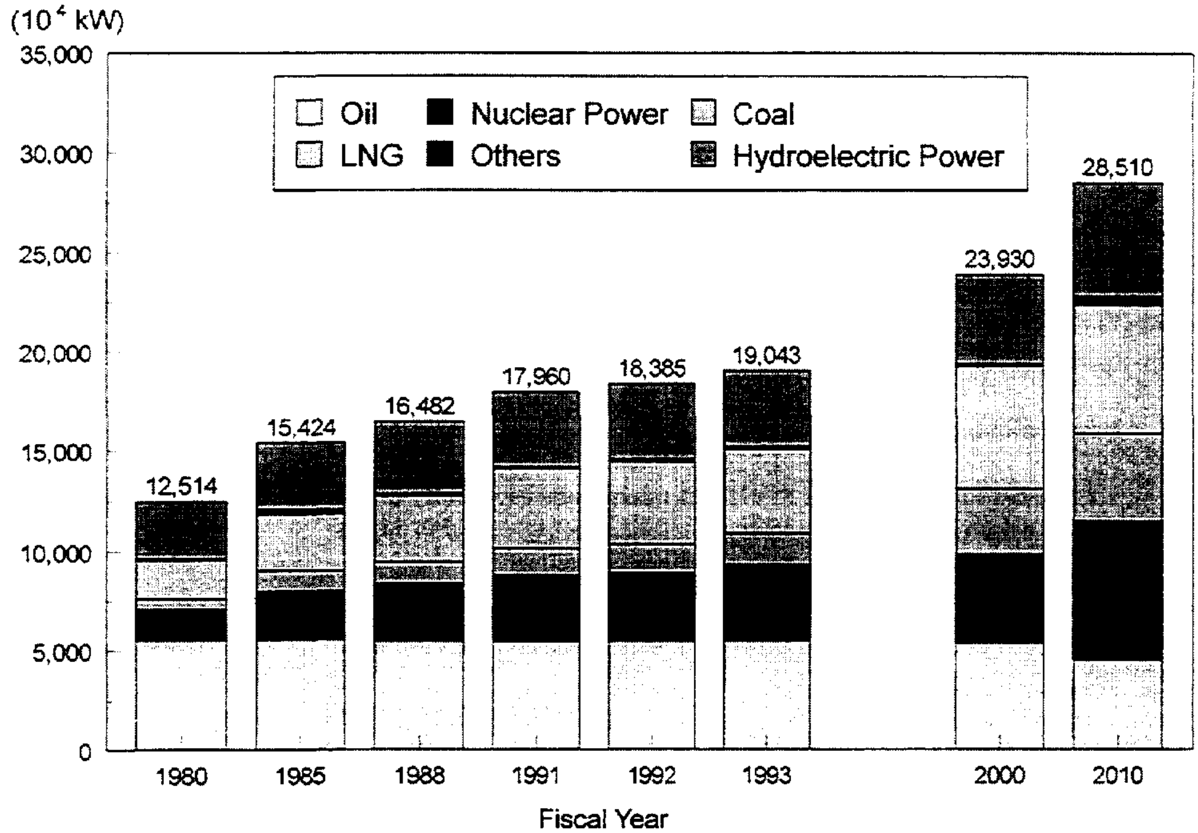
($10^4$ kW)

| Source of supply | 1980 | 1985 | 1988 | 1991 | 1992 | 1993 | 2000 | 2010 |
|---|---|---|---|---|---|---|---|---|
| Oil | 5,948 | 5,526 | 5,463 | 5,428 | 5,442 | 5,450 | 5,340 | 4,500 |
| Nuclear Power | 1,551 | 2,452 | 2,870 | 3,324 | 3,442 | 3,838 | 4,510 | 7,000 |
| Coal | 526 | 1,034 | 1,112 | 1,362 | 1,467 | 1,597 | 3,260 | 4,400 |
| LNG | 1,971 | 2,855 | 3,306 | 3,949 | 4,095 | 4,173 | 6,160 | 6,450 |
| Others | 73 | 238 | 118 | 124 | 124 | 126 | 110 | 460 |
| Hydroelectric Power | 2,867 | 3,319 | 3,613 | 3,773 | 3,815 | 3,859 | 4,550 | 5,700 |
| Total | 12,936 | 15,425 | 16,482 | 17,960 | 18,384 | 19,043 | 23,930 | 28,510 |

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

Enactment of the Atomic Energy Law (1955) introduced the promotion of atomic energy development and utilisation toward peaceful objectives in compliance with the three basic principles of Democratic Management, Voluntary and Open Information. Inauguration of the Atomic Energy Commission (1956) established an advisory board for the Prime Minister on matters regarding promotion of atomic energy development and utilisation.




Source: Interim Report, Demand/Supply Subcommittee, Electric Utility Industry Council (June 1994)

*FIG. 3. Electric Power Plant Capacity Outlook (for Electric Utilities)*

Long-term planning for atomic power development began in 1956. Today, it is the basic program for the nation on nuclear power development and utilisation. The plan is revised and updated every five years. The Ministry of International Trade and Industry was reorganised in 1966 to accommodate its increasing workload. This change provided additional rules and regulations for the introduction of the commercial light water reactors in Japan after 1966.

In 1974, three basic laws for the promotion of electric power development were made into law; namely, the "Law for Area Consolidation around Power Station", the "Electric Power Promotion Tax Law", and the "Electric Power Promotion Means Special Accounting Law". These laws also advanced the siting of nuclear power stations.

In 1978, the Nuclear Safety Commission was formed as a separate entity from the Atomic Energy Commission. Safety assurance measures were enhanced in 1980 to reflect the lessons learned from the TMI-2 Accident (1979) and, later, the Chernobyl No. 4 Accident in 1987.

The overall appraisal of the Vision of Nuclear Power in 1985 provided long range prospects of energy availability and electric power requirements through 2030. In 1986, program for enhancement of safety, called "Safety 21" further reinforced safety assurance measures.

In 1990, Japan revised its supply targets to include alternative energy sources due to its growing demand for oil and its contribution to the greenhouse effect on the Earth.

### 3.2. Current Policy Issues

The latest revision of the basic long range plan for nuclear power development and utilisation in 1994 includes four basic principles: Confirmation of the peaceful use of atomic energy, safety assurance, deployment of recycling nuclear fuel, and enhancement of basic research and development of atomic energy science and technology.

- Safety assurance policies: safety assurance of old and ageing nuclear power equipment and facilities; enhancement of preventive maintenance based on practical lessons gained from incidents and failures which have occurred both within and outside the country in the light of views and knowledge of the latest technical and scientific development; reduction of human error; enhancement of severe-accident countermeasures and safety research; enhancement of radioactive disaster prevention.

- Policies for deployment of recycling nuclear fuel: utilisation of MOX fuel, reprocessing of spent nuclear fuel, storage and management of spent nuclear fuel, and domestic processing of MOX fuel.

- Radioactive waste management, reprocessing and disposal of high-level radioactive waste is recognised as a very important task.

- Funding for the construction of light water nuclear power plants and commercial fuel recycling plants will be provided by electric power company bonds and low-interest loans from banks, including the Japan Development Bank.

### 3.3. Status and Trends of Nuclear Power

Table 8 provides a list of the nuclear power plants in operation, under construction and firmly planned together with those out of service in Japan. Table 9 lists future nuclear power plants to be either built at new sites or at existing sites in Japan.

At the end of 1996, Japan's total installed capacity of nuclear power plants was 42,369 MW. The target for the year 2000 is 45,100 MW and 70,000 MW of total installed capacity by the year 2010. As a long range prospect, Japan anticipates 100,000 MW by 2030.

TABLE 9. EXPANSION OF NPPS IN FUTURE

| Power Plant Name | Owner Name | Capacity MW | Construction Start (FY) | Commissioning (FY) | Note |
|---|---|---|---|---|---|
| Oma | Electric Power Development | 606 | 10-4 | 16-3 | ATR |
| Hamaoka 5 | Chubu | 1358 | 10-11 | 16-5 | BWR |
| Higashi-Dori 1 | Tohoku | 1100 | 11-2 | 17-7 | BWR |
| Namie-Kodaka | Tohoku | 825 | 12 | 17* | BWR |
| Ashihama 1 | Chubu | 1350 | 13-4 | 17 | - |
| Ashihama 2 | Chubu | 1350 | 13-4 | 17 | - |
| Shika 2 | Hokuriku | 1358 | 11 | 17 | BWR |

* Fiscal Year or Later
Source: Nuclear Power Generation Data, MITI (April 1995)
(Construction Plans Adopted by Electric Power Development Coordination Council in Fiscal 1995/96)
7 Nuclear Power Sites (7947 MW)

TABLE 8. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| FUKUSHIMA-DAIICHI-1 | BWR | 439 | TEPCO | Operational | GE | 25-Jun-67 | 10-Oct-70 | 17-Nov-70 | 26-Mar-71 | |
| FUKUSHIMA-DAIICHI-2 | BWR | 760 | TEPCO | Operational | GE | 09-Jun-69 | 10-May-73 | 24-Dec-73 | 18-Jul-74 | |
| FUKUSHIMA-DAIICHI-3 | BWR | 760 | TEPCO | Operational | TOSHIBA | 28-Dec-70 | 06-Sep-74 | 26-Oct-74 | 27-Mar-76 | |
| FUKUSHIMA-DAIICHI-4 | BWR | 760 | TEPCO | Operational | HITACHI | 12-Feb-73 | 28-Jan-78 | 24-Feb-78 | 12-Oct-78 | |
| FUKUSHIMA-DAIICHI-5 | BWR | 760 | TEPCO | Operational | TOSHIBA | 22-May-72 | 26-Aug-77 | 22-Sep-77 | 18-Apr-78 | |
| FUKUSHIMA-DAIICHI-6 | BWR | 1067 | TEPCO | Operational | GE | 26-Oct-73 | 09-Mar-79 | 04-May-79 | 24-Oct-79 | |
| FUKUSHIMA-DAINI-1 | BWR | 1067 | TEPCO | Operational | TOSHIBA | 16-Mar-76 | 17-Jun-81 | 31-Jul-81 | 20-Apr-82 | |
| FUKUSHIMA-DAINI-2 | BWR | 1067 | TEPCO | Operational | HITACHI | 25-May-79 | 26-Apr-83 | 23-Jun-83 | 03-Feb-84 | |
| FUKUSHIMA-DAINI-3 | BWR | 1067 | TEPCO | Operational | TOSHIBA | 23-Mar-81 | 18-Oct-84 | 14-Dec-84 | 21-Jun-85 | |
| FUKUSHIMA-DAINI-4 | BWR | 1067 | TEPCO | Operational | HITACHI | 28-May-81 | 24-Oct-86 | 17-Dec-86 | 25-Aug-87 | |
| GENKAI-1 | PWR | 529 | KYUSHU | Operational | M | 15-Sep-71 | 28-Jan-75 | 14-Feb-75 | 15-Oct-75 | |
| GENKAI-2 | PWR | 529 | KYUSHU | Operational | M | 01-Feb-77 | 21-May-80 | 03-Jun-80 | 30-Mar-81 | |
| GENKAI-3 | PWR | 1127 | KYUSHU | Operational | M | 01-Jun-88 | 28-May-93 | 15-Jun-93 | 18-Mar-94 | |
| GENKAI-4 | PWR | 1127 | KYUSHU | Operational | M | 15-Jul-92 | 23-Oct-96 | 12-Nov-96 | 01-Jul-97 | |
| HAMAOKA-1 | BWR | 515 | CHUBU | Operational | TOSHIBA | 10-Jun-71 | 20-Jun-74 | 13-Aug-74 | 17-Mar-76 | |
| HAMAOKA-2 | BWR | 806 | CHUBU | Operational | TOSHIBA | 14-Jun-74 | 28-Mar-78 | 04-May-78 | 29-Nov-78 | |
| HAMAOKA-3 | BWR | 1056 | CHUBU | Operational | TOSHIBA | 18-Apr-83 | 21-Nov-86 | 20-Jan-87 | 28-Aug-87 | |
| HAMAOKA-4 | BWR | 1092 | CHUBU | Operational | TOSHIBA | 13-Oct-89 | 02-Dec-92 | 27-Jan-93 | 03-Sep-93 | |
| IKATA-1 | PWR | 538 | SHIKOKU | Operational | M | 15-Jul-73 | 29-Jan-77 | 17-Feb-77 | 30-Sep-77 | |
| IKATA-2 | PWR | 538 | SHIKOKU | Operational | M | 21-Feb-78 | 31-Jul-81 | 19-Aug-81 | 19-Mar-82 | |
| IKATA-3 | PWR | 846 | SHIKOKU | Operational | M | 01-Nov-86 | 23-Feb-94 | 29-Mar-94 | 15-Dec-94 | |
| KASHIWAZAKI KARIWA-1 | BWR | 1067 | TEPCO | Operational | TOSHIBA | 05-Jun-80 | 12-Dec-84 | 13-Feb-85 | 18-Sep-85 | |
| KASHIWAZAKI KARIWA-2 | BWR | 1067 | TEPCO | Operational | TOSHIBA | 18-Nov-85 | 30-Nov-89 | 08-Feb-90 | 28-Sep-90 | |
| KASHIWAZAKI KARIWA-3 | BWR | 1067 | TEPCO | Operational | TOSHIBA | 07-Mar-89 | 19-Oct-92 | 08-Dec-92 | 11-Aug-93 | |
| KASHIWAZAKI KARIWA-4 | BWR | 1067 | TEPCO | Operational | HITACHI | 05-Mar-90 | 01-Nov-93 | 21-Dec-93 | 11-Aug-94 | |
| KASHIWAZAKI KARIWA-5 | BWR | 1067 | TEPCO | Operational | HITACHI | 20-Jun-85 | 20-Jul-89 | 12-Sep-89 | 10-Apr-90 | |
| KASHIWAZAKI KARIWA-6 | BWR | 1315 | TEPCO | Operational | TOSHI/GE | 03-Nov-92 | 18-Dec-95 | 29-Jan-96 | 07-Dec-96 | |
| MIHAMA-1 | PWR | 320 | KEPCO | Operational | WEST | 01-Feb-67 | 29-Jul-70 | 08-Aug-70 | 28-Nov-70 | |
| MIHAMA-2 | PWR | 470 | KEPCO | Operational | WEST/M | 29-May-68 | 10-Apr-72 | 21-Apr-72 | 25-Jul-72 | |
| MIHAMA-3 | PWR | 780 | KEPCO | Operational | M | 07-Aug-72 | 28-Jan-76 | 19-Feb-76 | 01-Dec-76 | |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 8. CONTINUED, STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| MONJU | FBR | 246 | PNC | Operational | M | 25-Oct-85 | 01-Jan-94 | 01-Feb-94 | | |
| OHI-1 | PWR | 1120 | KEPCO | Operational | WEST | 26-Oct-72 | 02-Dec-77 | 23-Dec-77 | 27-Mar-79 | |
| OHI-2 | PWR | 1120 | KEPCO | Operational | WEST | 08-Dec-72 | 14-Sep-78 | 11-Oct-78 | 05-Dec-79 | |
| OHI-3 | PWR | 1127 | KEPCO | Operational | M | 03-Oct-87 | 17-May-91 | 07-Jun-91 | 18-Dec-91 | |
| OHI-4 | PWR | 1127 | KEPCO | Operational | M | 13-Jun-88 | 28-May-92 | 19-Jun-92 | 02-Feb-93 | |
| ONAGAWA-1 | BWR | 498 | TOHOKU | Operational | TOSHIBA | 09-Jul-80 | 18-Oct-83 | 18-Nov-83 | 01-Jun-84 | |
| ONAGAWA-2 | BWR | 796 | TOHOKU | Operational | TOSHIBA | 03-Aug-89 | 01-Nov-94 | 23-Dec-94 | 28-Jul-95 | |
| SENDAI-1 | PWR | 846 | KYUSHU | Operational | M | 15-Dec-79 | 25-Aug-83 | 16-Sep-83 | 04-Jul-84 | |
| SENDAI-2 | PWR | 846 | KYUSHU | Operational | M | 12-Oct-81 | 18-Mar-85 | 05-Apr-85 | 28-Nov-85 | |
| SHIKA-1 | BWR | 513 | HOKURIKU | Operational | HITACHI | 01-Dec-88 | 20-Nov-92 | 12-Jan-93 | 30-Jul-93 | |
| SHIMANE-1 | BWR | 439 | CHUGOKU | Operational | HITACHI | 18-May-70 | 01-Jun-73 | 02-Dec-73 | 29-Mar-74 | |
| SHIMANE-2 | BWR | 791 | CHUGOKU | Operational | HITACHI | 11-Jan-85 | 25-May-88 | 11-Jul-88 | 10-Feb-89 | |
| TAKAHAMA-1 | PWR | 780 | KEPCO | Operational | WEST | 25-Apr-70 | 14-Mar-74 | 27-Mar-74 | 14-Nov-74 | |
| TAKAHAMA-2 | PWR | 780 | KEPCO | Operational | M | 09-Mar-71 | 20-Dec-74 | 17-Jan-75 | 14-Nov-75 | |
| TAKAHAMA-3 | PWR | 830 | KEPCO | Operational | M | 12-Dec-80 | 17-Apr-84 | 09-May-84 | 17-Jan-85 | |
| TAKAHAMA-4 | PWR | 830 | KEPCO | Operational | M | 19-Mar-81 | 11-Oct-84 | 01-Nov-84 | 05-Jun-85 | |
| TOKAI-1 | GCR | 159 | JAPCO | Operational | GEC | 01-Mar-61 | 04-May-65 | 10-Nov-65 | 25-Jul-66 | |
| TOKAI-2 | BWR | 1080 | JAPCO | Operational | GE | 03-Dec-73 | 18-Jan-78 | 13-Mar-78 | 28-Nov-78 | |
| TOMARI-1 | PWR | 550 | HEPCO | Operational | M | 17-Apr-85 | 16-Nov-88 | 06-Dec-88 | 22-Jun-89 | |
| TOMARI-2 | PWR | 550 | HEPCO | Operational | M | 12-Jun-85 | 25-Jul-90 | 27-Aug-90 | 12-Apr-91 | |
| TSURUGA-1 | BWR | 341 | JAPCO | Operational | GE | 24-Nov-66 | 03-Oct-69 | 16-Nov-69 | 14-Mar-70 | |
| TSURUGA-2 | PWR | 1115 | JAPCO | Operational | M | 06-Nov-82 | 28-May-86 | 19-Jun-86 | 17-Feb-87 | |
| KASHIWAZAKI KARIWA-7 | BWR | 1315 | TEPCO | Under Construction | HITA/GE | 01-Jul-93 | 01-Dec-96 | 17-Dec-96 | 01-Jul-97 | |
| ONAGAWA 3 | BWR | 796 | TOHUKU | Under Construction | TOSHIBA | 01-Nov-96 | | | 01-Mar-02 | |
| MAKI | BWR | 796 | TOHOKU | Planned | | 01-Jan-98 | | | 01-Jan-04 | |
| JPDR-II | BWR | 13 | JAERI | Shut Down | GE | 01-Dec-60 | 22-Aug-63 | 26-Oct-63 | 26-Oct-63 | 06-Dec-82 |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organizational Chart

Figure 4 shows Japan's organization chart in nuclear power, comprising government regulatory authorities, electric power companies and contracting engineers/suppliers.

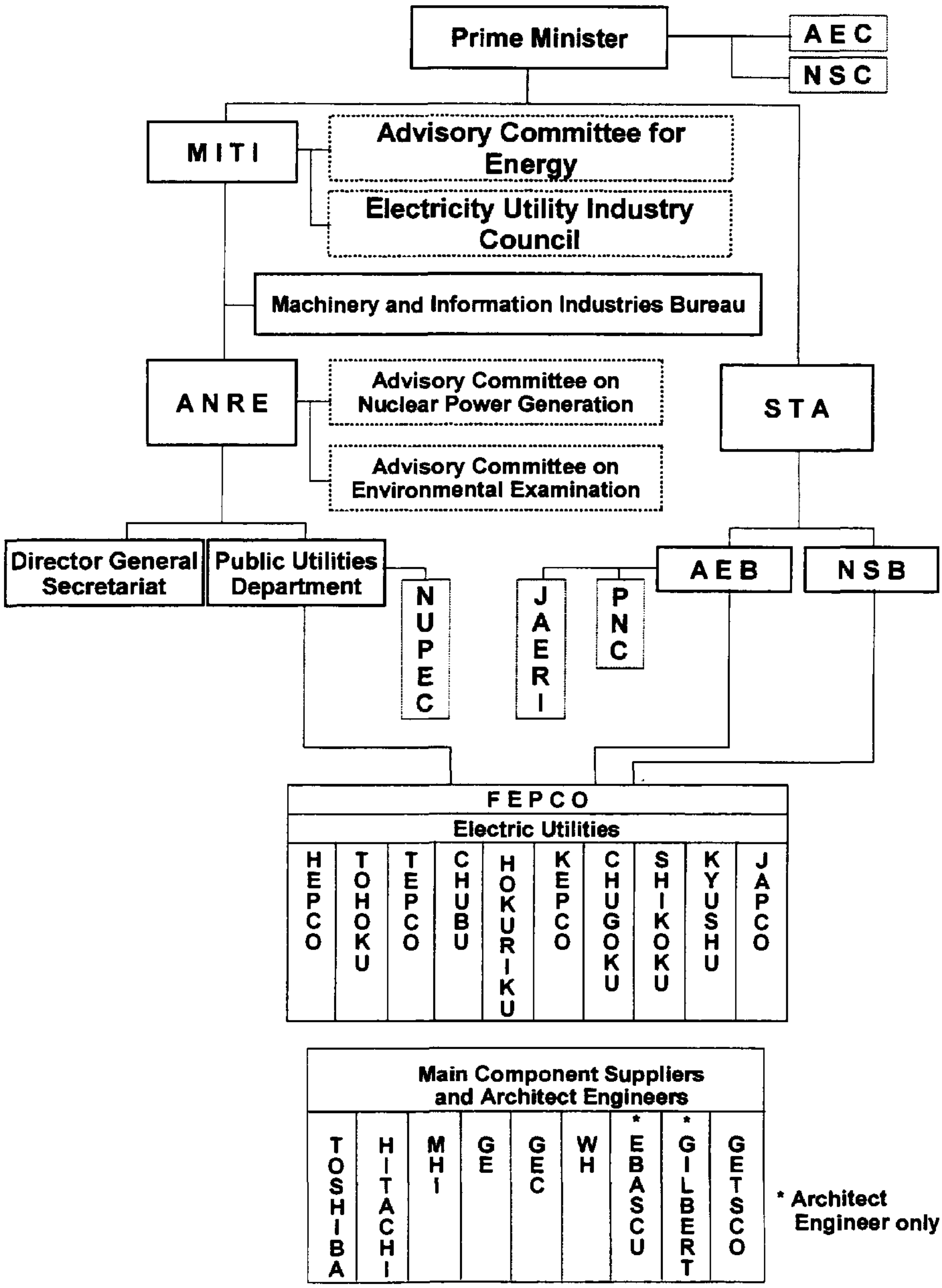



*FIG. 4. Japan's Organization Chart*

**'Organizational Chart', List of the abbreviations**

| | |
|---|---|
| AEC: | Atomic Energy Commission |
| NSC: | Nuclear Safety Commission |
| MITI: | Ministry of International Trade and Industry |
| ANRE: | Agency of Natural Resources and Energy |
| STA: | Science and Technology Agency |
| AEB: | Atomic Energy Bureau |
| NSB: | Nuclear Safety Bureau |
| NUPEC: | Nuclear Power Engineering Corporation |
| JAERI: | Japan Atomic Energy Research Institute |
| PNC: | Power Reactor and Nuclear Fuel Development Corporation |
| FEPCO: | Federation of Electric Power Companies |
| HEPCO: | Hokkaido Electric Power Co. |
| TOHOKU: | Tohoku Electric Power Co. |
| TEPCO: | Tokyo Electric Power Co. |
| CHUBU: | Chubu Electric Power Co. |
| HOKURIKU: | Hokuriku Electric Power Co. |
| KEPCO: | Kansai Electric Power Co. |
| CHUGOKU: | Chugoku Electric Power Co. |
| SHIKOKU: | Shikoku Electric Power Co. |
| KYUSHU: | Kyushu Electric Power Co. |
| JAPCO: | The Japan Atomic Power Co. |
| TOSHIBA: | Toshiba Corporation |
| HITACHI: | Hitachi Ltd. |
| MHI: | Mitsubishi Heavy Industries Ltd. |
| GE: | General Electric Co. |
| GEC: | The General Electric Co. Ltd. |
| WH: | Westinghouse Electric Corporation |
| EBASCO: | Ebasco Services Incorporated |
| GILBERT: | Gilbert/Commonwealth International |
| GETSCO: | General Electric Technical Services Co. |

## 4. NUCLEAR POWER INDUSTRY

The development of light water reactors in Japan began with PWRs from Westinghouse and BWRs from G.E. As nuclear power technologies are incorporated by the domestic industry, successive expansion projects of nuclear power plants are of Japanese design and construction. Today, Toshiba, Hitachi and Mitsubishi Heavy Industries have emerged as Japan's representative suppliers of nuclear steam supply systems (NSSS). Construction of nuclear power plants is made possible by an industrial system with one or more of the above-mentioned three companies acting as prime contractors, forming a joint venture with contract engineers or construction companies as subcontractors.

### 4.1. Supply of Nuclear Power Plants

In Japan, five companies have supplied nuclear steam supply systems which are currently in operation: for BWRs these were Toshiba, Hitachi, G.E., and G.E. and Toshiba jointly, while for PWRs these were Mitsubishi, Westinghouse, and Westinghouse and Mitsubishi jointly.

Many companies are capable of supplying equipment and services to Japan's nuclear power industry. These range from the suppliers of the major equipment and machinery to those supplying ordinary equipment or offering engineering services. They also include firms related to the nuclear fuel cycle or nuclear fuel recycling.

### 4.2. Operation of Nuclear Power Plants

Figure 4 includes the nine electric power companies which operate commercial light water reactors, and one company which is a producer and wholesaler of nuclear power in Japan.

Regarding nuclear power plant operator training in Japan, both the BWR and PWR groups have their own training centres. These were financed, built and utilised jointly by the member companies of each group, comprised of electric power companies and contract engineering firms. In addition, each electric power company has its own training facility. Engineering qualification tests for operator certification are conducted at the training centres jointly operated by the member companies.

The representative suppliers of Japan's maintenance services are Toshiba, Hitachi and Mitsubishi. The electric power companies contract with these maintenance service companies. Efforts are made to enable the contractors to assume responsibility for repair and maintenance services for their nuclear power plants.

### 4.3. Fuel Cycle and Waste Management Service Supply

The fuel cycle activities in Japan comprise enrichment, reconversion, fuel fabrication, zircaloy cladding reprocessing and radioactive waste activities. Figure 5 shows the affiliated enterprises.

### 4.4. Research and Development Activities

The Atomic Energy Commission (AEC), amongst other responsibilities, advises on R&D. The long-term programme for the development and use of nuclear energy is revised by the AEC every five years; the latest revision was July 1992. The chairman is also the director general of the Science and Technology Agency (STA), which it has been said, decreases the likelihood of the AEC adopting policies unacceptable to the government. Government responsibilities for R&D are shared between the STA and the Ministry of International Trade and Industry (MITI). The STA is responsible for the planning and administration of R&D. It has two bureaux each with several divisions. The Atomic Energy Bureau is concerned with reactor and fuel cycle developments, including FBR and ATR, enrichment and reprocessing. The STA supervises the work of the Power Reactor and Nuclear Fuel Development Corporation (PNC), established in 1967, and also of the Japan Atomic Energy Research Institute (JAERI), established in 1956. PNC is the main channel for the development of advanced reactors and the establishment of the fuel cycle. In both there is close collaboration with the private sector including shared funding on some projects. Since 1985, the Nuclear Ship Research and Development Agency has been integrated in JAERI. The Agency of Natural Resources and Energy carries out activities, which include studies of improvements in reactor design and approval of design modifications proposed by utilities, and decommissioning.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Table 10 shows the main international co-operation projects that Japan participates in.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the licensing Procedures

Figure 6 shows the process of approval or permission of nuclear power plant in Japan.

### 5.2. Main National Laws and Regulations

Figure 7 show the main laws controlling nuclear power plants in Japan. It is Japan's fundamental policy to dismantle and remove decommissioned nuclear power generation facilities which have completed their service life, while assuring complete safety in that process. Based on this fundamental policy, the standard procedure (standard work schedule) is one of 'enclosure management plus disassembly/removal'. It is appropriate to choose an enclosure management period of five to ten years and a disassembly/removal period of three to four years.

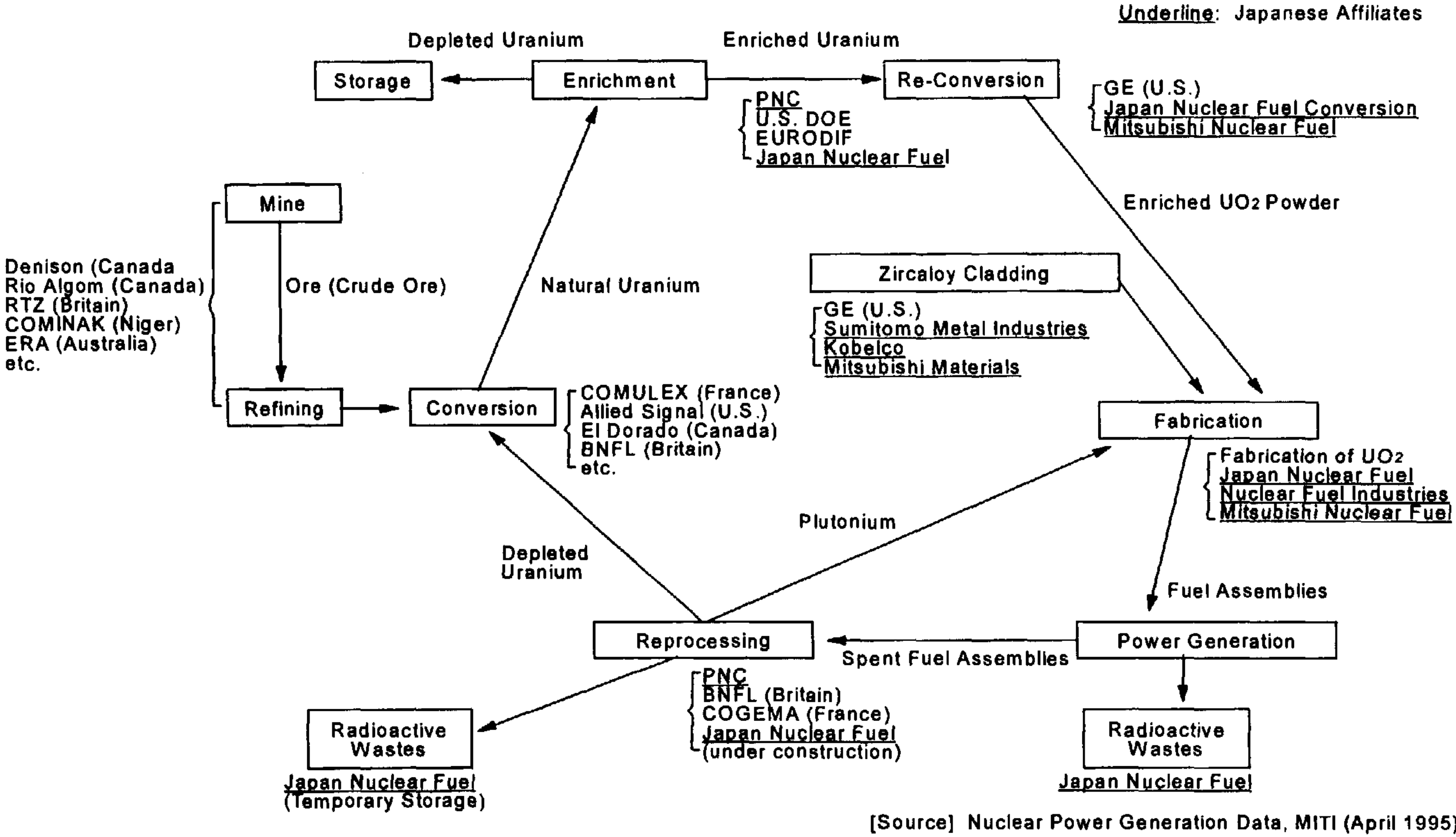



***FIG. 5. Nuclear Fuel Cycle Diagram***

TABLE 10. THE MAIN INTERNATIONAL CO-OPERATION PROJECTS

| Multilateral Cooperation | |
|---|---|
| **Former USSR and East Europe** | **Asia** |
| (1) IAEA-OSART Missions (dispatched 21 times in total)<br>(2) IAEA-ASSET Missions (dispatched 35 times in total)<br>(3) Dispatching of specialists at the request of IAEA (3 persons in FY 1993)<br>(4) Acceptance of trainees at the request of IAEA (7 persons in FY 1993)<br>(5) IAEA special contribution ($ 861,285 in FY 1993)<br>(6) Nuclear safety assistance by G7 countries<br>(7) Commission on Nuclear Safety Assistance Coordination by G24 countries | (1) IAEA-OSART Missions (dispatched 13 times in total)<br>(2) IAEA-ASSET Missions (dispatched 6 times in total)<br>(3) Dispatching of specialists at the request of IAEA (3 persons in FY 1993)<br>(4) Acceptance of trainees at the request of IAEA (13 persons in FY 1993) |
| **Bilateral Cooperation** | |
| **Former USSR and East Europe** | **Asia** |
| (1) International study and training on nuclear power plant operation control (one thousand trainees, 81 persons in FY 1993)<br>(2) International study and training on nuclear safety (22 persons in FY 1993)<br>(3) Preparation and arrangement of Nuclear Plant Operation Technical Center for Russia (¥ 20.4 billions)<br>(4) Technology transfer of in-service malfunction detecting system for Russia (¥ 960 millions) | (1) International study and training on nuclear power plant operation control (one thousand trainees, 14 persons in FY 1993)<br>(2) International study and training on nuclear safety (11 persons in FY 1993) |

The estimated cost of reactor decommissioning in Japan (referring to precedents in other countries), is approximately 30 billion yen (1984 prices) for a 1 100 MW class nuclear power plant, when its safe storage period is 5 years. The Agency of Natural Resources and Energy is implementing verification tests of reactor decommissioning technology such as reactor vessel and reactor internals dissection technology, which are important in assuring better safety and reliability.

For the installation of a commercial nuclear power plant, it is necessary to go through licensing procedures based on more than 30 laws. Many of the laws also apply to general industrial facilities.

Main nuclear-related laws and regulations are respectively systematized according to organizations, research and development, regulations and compensation based on the Atomic Energy Laws and regulations are respectively systematized according to organizations, research and development and regulations and compensation based on the Atomic Energy Law, shown in Fig. 7. Among them, laws concerning the safety regulations reactors are the laws for Regulations of Nuclear Source Materials, Nuclear Fuel materials and Reactors (hereafter called LRNR) and the Electricity Utilities Industry Law (hereafter called EUIL).

The purpose of LRNR is to enforce regulations based on the potential danger of nuclear reactors and nuclear substances, whereas EUIL aims to make a good supply of electricity, assuring the safety of hydroelectric power plants, thermoelectric power plants and power transmission lines as well as nuclear power plants with a view to a stable supply of electricity. Thus, the two laws stand on different viewpoints.

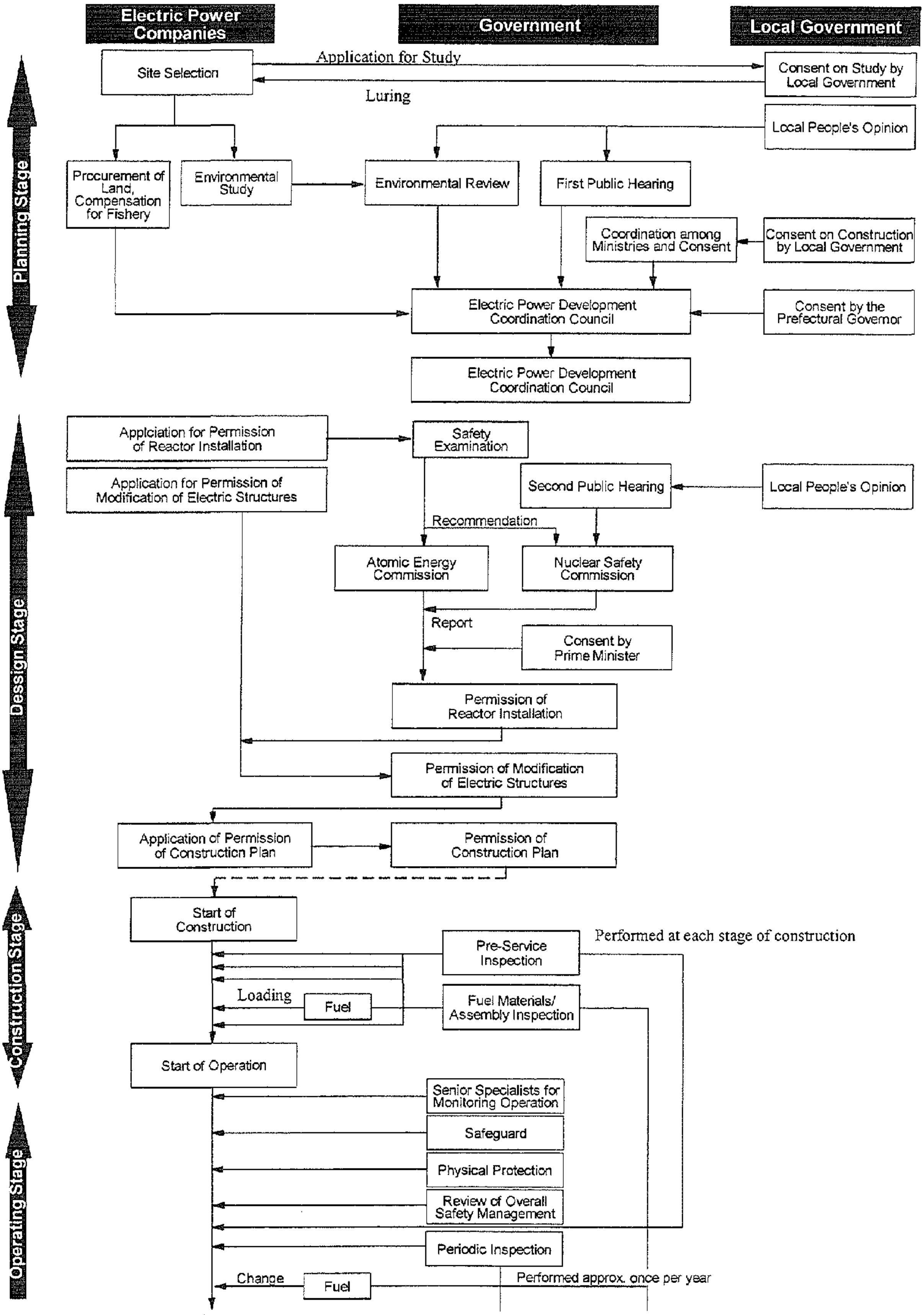



*FIG. 6. Process of Approval or Permission of Nuclear Power Plant in Japan*

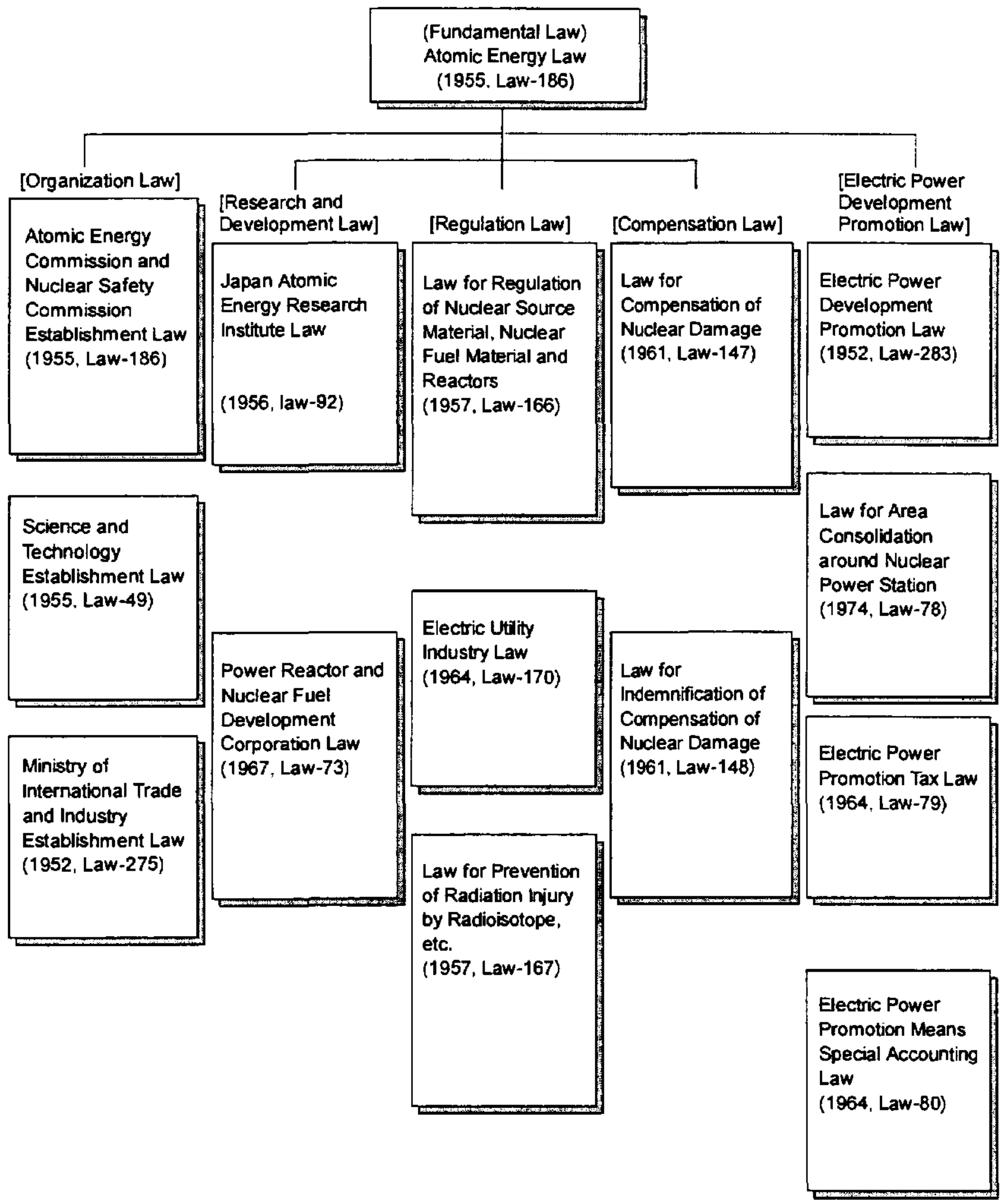



***FIG. 7. Scheme Diagram of major Nuclear Laws in Japan***

*MAIN NUCLEAR-RELATED LAWS AND REGULATIONS ARE AS FOLLOWS:*

1. Atomic Energy Law (1955.12.19 - Publications)

The research, development and use of nuclear energy shall be limited only for the peaceful purposes aiming at safety assurance. The Act prescribes a principal of three parts:

1) Under a democratic management
2) Voluntarily
3) Opens information

Nuclear-related laws and regulations are enacted based on the spirit of the Act.

2. Law for Regulations of Nuclear Source Materials, Nuclear Fuel Materials and Reactors (1957.6.10 - Publications)

The Law, usually abbreviated as LRNR, prescribes regulations necessary for the installation and operation of reactors, refining, processing, work for disposal of nuclear wastes. Following are the main regulations concerning the installation and operation of reactors:

- Permission for reactor installation (basic design)
- Permission for a construction plan (detailed design)
- Pre-use inspection
- Notification of an operation plan
- Measures taken for safety
- Approval of safety regulations
- Appointment of Chief Reactor Engineer
- Periodical inspection, etc.

LRNR excludes permission for a construction plan, pre-use inspection and periodical inspection, which the Electricity Utilities Industry Law applies to.

3. Electricity Utilities Industry Law (1964.7.11 - Publications)

The Law intends to protect benefits, assure safety and facilitate sound development of electricity utilities for users of electricity.

- Main regulations for nuclear power plans are:
- Permission for a construction plan (detailed design)
- Preuse inspection
- Periodical inspection
- Appointment of Chief Electric Engineer and Boiler and Turbine Engineer

Decree for conformity with technical standard (It has subordinate rules specifying technical standards).

4. Law for Prevention of Radiation Injury by Radioisotopes, etc. (1957.6.10 - Publications)

The Law intends to prevent radiation injury by regulating the use and disposal of radioisotopes and the use of radiation producers. In a nuclear power plant, the Law applies when neutron sources are used or radioisotopes are employed for calibration of equipment.

5. Law for Compensation for Nuclear Damage (1961.6.8 - Publication)

Nuclear energy enterprises (electric power companies) owe no-fault liability for compensation to the injured when nuclear damage is caused by the operation of nuclear reactors and the like. In such cases, liability focus on the concerned nuclear energy enterprises.

Nuclear energy enterprises are compelled to deposit a constant amount of money (30 billion yen at maximum) for the measures taken for the film fulfillment of the compensation for damage.

- To make an insurance contract for compensation for damage with private insurers.
- To execute an indemnity contract with the Government

When damage is more than the deposit amount for compensation, the Government assists if necessary.

6. Electric Power Developing Promotion (Three Laws for Electric Power) (1974.6.6 - Publications)

- Electric Power Development Promotion Tax Law
- Electric Power Development Promotion Means Special Accounting Law
- Laws for Area Consolidation around Power Generation Stations

Those Laws intend to promote the electric power development by returning benefits to the whole country obtained from a stable supply of electricity through the siting of a power plant, to the local area.

The Tax law for Promotion of the Electric Power Development is for collecting the tax of the promotion for the Electric Power Development (according to electric power sold), the Special Accounts Law for Promotion Measures of the Electric Power Development is for clarifying the Government accounts of the undertakings performed by the tax revenue, and the Laws for area Consolidation around Power Generation Stations is setting up smoothly Generating Facility by the promotion of completing public institution.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related safeguards agreement INFCIRC/255 | Entry into force: | 2 December 1977 |
| • Improved procedures for designation of safeguards inspectors | Wishes to continue with the present system | |
| • Multilateral safeguards agreement Japan/France INFCIRC/171 | (The application of which has not yet been suspended) Entry into force: | 22 September 1972 |
| • RCA | Entry into force: | 11 September 1992 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 8 June 1976 |
| • Agreement on privileges and immunities | Entry into force: | 18 April 1963 |
| • Convention on physical protection of nuclear material | Entry into force: | 27 November 1988 |
| • Convention on early notification of a nuclear accident | Entry into force: | 10 July 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 10 July 1987 |
| • Conventions on civil liability for nuclear damage and joint protocol | Non-Party | |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |

| | | |
|---|---|---|
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | Japanese measures, legislation and regulations basically consistent with Codes. Letter of: | 19 April 1989 |
| • Nuclear Suppliers Group | Member | |

*BILATERAL AGREEMENTS**

| | | |
|---|---|---|
| Agreement for :<br>(i) provision of information;<br>(ii) provision of nuclear materials, facilities and equipment;<br>(iii) transfer of patent rights;<br>(iv) use of facilities and equipment;<br>(v) provision of technical aid and services.<br>(The above content is an example only. Other forms of cooperation are not to be neglected.) | Canada<br>Effective Date:<br>Agreement Revised:<br>(valid for 10 years, terminated thereafter by notice 6 months prior to the said termination) | <br>27 July 1960<br>2 September 1980 |
| Agreement for:<br>(i) provision and exchange of information;<br>(ii) provision of nuclear materials, facilities and equipment;<br>(iii) provision of services.<br>(iv) other means | United Kingdom<br>Effective Date:<br>(valid for 30 years) | <br>15 October 1968 |
| Agreement for:<br>(i) exchange of experts;<br>(ii) exchange of information;<br>(iii) provision of nuclear materials, facilities and secrecy technologies;<br>(iv) provision of services;<br>(v) cooperation in mining and the exploitation and use of mines;<br>(vi) other means. | France<br>(valid for 45 years starting on the effective date of the current Japan-France Agreement. Terminated thereafter by notice 6 months prior to the said termination date.) | |
| Agreement for:<br>(i) exchange of experts<br>(ii) provision and exchange of information<br>(iii) provision of nuclear materials, facilities and secrecy technologies<br>(iv) provision of services<br>(v) other means | Australia<br>Effective date:<br>(Valid for 30 years, terminated thereafter by notice 6 months prior to the said termination date.) | <br>17 August 1982 |

* Source: Nuclear Power Pocket Book 1994, Japan Atomic Industrial Forum, Inc.

| Agreement for: | China | |
|---|---|---|
| (i) exchange of experts | Effective date: | 10 July 1986 |
| (ii) provision and exchange of information | (Valid for 15 years, automatically | |
| (iii) provision of nuclear materials, facilities and secrecy technologies | extended thereafter for 5 years unless notice is provided 6 months | |
| (iv) provision of services | prior to the termination date) | |
| (v) other means | | |

| Agreement for: | USA | |
|---|---|---|
| (i) exchange of experts | Effective date: | 17 July 1988 |
| (ii) provision and exchange of information | (Valid for 30 years, terminated | |
| (iii) provision of nuclear materials and facilities | thereafter by notice 6 months prior | |
| (iv) provision of services | to the said termination date.) | |
| (v) other means | | |

Table 11 shows Japan's the co-operation with major international organizations.

TABLE 11. CO-OPERATION WITH INTERNATIONAL ORGANIZATIONS

| Organization | Outline of cooperation |
|---|---|
| IAEA | Promotion of peaceful uses of atomic energy (safety related cooperation, technical aid to developing countries and R&D), and provision of safeguards to ensure that nuclear activities are not transferred for military purposes.<br>Japan participates positively in INSAG (International Nuclear Safety Advisory group), NUSSAG (Nuclear Safety Standard Advisory Group), ASSET (Assessment of Safety Significant Event Team), OSART and special safety evaluation studies of former USSR reactors. |
| OECD/NEA | The purpose is to provide useful information to member countries through technological study and mutual cooperation regarding problems common in nuclear energy use in the advanced countries.<br>Japan participates positively in CNRA (Committee for Nuclear Regulatory Activities) and CSNI (Committee for Safety of Nuclear Installation). |
| Assistance by G7 for nuclear safety | Participation for the improved safety of former USSR reactors was proposed at the Munich Summit in 1992.<br>Japan has played a positive role along the theme of the declaration.<br>Currently, the major problem is the closing of the Chernobyl Power Plant. |
| Nuclear Safety Assistance Coordination by G24 | G24 mandate was extended to the former USSR area to adjust multi-national or bilateral support activities in the former USSR and central and eastern Europe. The G24 Nuclear Safety Support Adjustment Committee was established to carry out the related activities. |

## REFERENCES


[1] The New Long-Range Plan for Development and Utilisation of Nuclear Energy (Revised June 1994)

[2] "Ideals and Realities of New Long Term Program" (Atoms in Japan edited by JAIF, June 1994)

[3] Interim report by the Nuclear Power Subcommittee of General Energy Investigation Committee (June, 1994)

[4] Energy Balances of OECD Countries 1991-1992, (1994)

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*GOVERNMENT ORGANIZATIONS*

| | |
|---|---|
| Atomic Energy Commission (AEC)<br>c/o Science and Technology Agency(STA)<br>2-2-1 Kasumigaseki, Chiyoda-ku<br>Tokyo, Japan | Tel.: +81-3 3581 5271<br>Fax: +81-3 3581 5198<br>Telex:0222 6720 STA SGDJ<br>Cable:SCIENTECHAGENCY JAPAN |
| Science and Technology Agency (STA)<br>2-2-1 Kasumigaseki, Chiyoda-ku<br>Tokyo, Japan | Tel.: +81-3 3581 5271<br>Fax: +81-3 3581 5198<br>Telex: 0222 6720 STA SGDJ |
| Ministry of International Trade and Industry (MITI)<br>1-3-1 Kasumigaseki, Chiyoda-ku<br>Tokyo, Japan | Tel.: +81-3 3501 1511<br>Fax: +81-3 3501 0541 |

*CORPORATIONS RELATED TO NUCLEAR POWER*

(1) Japan Atomic Energy Research Institute (JAERI)

| | |
|---|---|
| Address of HQ | 2-2, Uchisaiwaicho 2-Chome, Chiyoda-ku, Tokyo |
| Contact Section | Office of Planning |
| Telephone | 03-3592-2100 |
| Fax | 03-3592-2119 |
| Main Activities | Development and research of advanced utilizing nuclear power |

(2) Power reactor and Nuclear Fuel Development Co., (PNC)

| | |
|---|---|
| Address of HQ | 9-13, Akasaka 1-Chome, Minato-ku, Tokyo |
| Contact Section | Reactor Development Project |
| Telephone | 03-3586-3311 |
| Fax | 03-5562-9437 |
| Main Activities | Development and research of FBR and ATR, and advanced development of nuclear fuel cycle |

Nuclear Power Engineering Corporation (NUPEC)

| | |
|---|---|
| Address of HQ | 17-1, Toranomon 3-Chome, Minato-ku, Tokyo |
| Contact Section | Safety Information Research Center |
| Telephone | 03-5470-5500 |
| Fax | 03-5470-5524 |
| Main Activities | Safety and reliability testing of nuclear power plant equipment, safety analysis, information assessment and research of human factors |

(4) Japan Atomic Industrial Forum Inc. (JAIF)

| | |
|---|---|
| Address of HQ | 1-13, Shinbashi 1-Chome, Minato-ku, Tokyo |
| Contact Section | Department of Planning and Information Services |
| Telephone | 03-3508-2411 |
| Fax | 03-3508-2094 |
| Main Activities | Information exchange between the government, industry and several atomic societies by holding several nuclear energy conferences |

Source 1) Organization and Staff of Electric Utilities and Corporation Related, Japan Electric Association
2) Nuclear Power Yearbook 1993, Japan Atomic Industrial Forum Inc.

*SUPPLIERS OF NPPS*

(1) Toshiba Corporation (TOSHIBA)
Address of HQ 1-1, Shibaura 1-Chome, Minato-ku, Tokyo
Contact Section Marketing and Business Planning Department, Energy Systems Group
Address 1-6, Uchisaiwai-cho 1-Chome, Chiyoda, Tokyo
Telephone 03-3597-2066
Fax 03-3597-2067
Main Activities Design, manufacture, setting of BWR facilities and their relative equipment

(2) Hitachi Ltd. (HITACHI)
Address of HQ 4-6, Kanda-surugadai, Chiyoda-ku, Tokyo
Contact Section Nuclear Power Systems Division, Nuclear Power Plant Department
Telephone 03-3558-1111
Fax 03-3258-2348
Main Activities Design, manufacture, setting of BWR facilities and their relative equipment

(3) Mitsubishi Heavy Industries Ltd. (MHI)
Address of HQ 5-1, Marunouchi 2-Chome, Chiyodaku, Tokyo
Contact Section First Nuclear Energy Systems Department Second Nuclear Energy Systems Department
Telephone 03-3212-3111
Fax 03-3214-9857, 9858
Main Activities Design, manufacture, setting of PWR facilities and their relative equipment

Source: 1) Organization and Staff of Electric Utilities and Corporation Related, Japan Electric Association
2) Nuclear Power Yearbook 1993, Japan Atomic Industrial Forum Inc.

*OWNERS/OPERATORS*

The Federal of Electric Power Companies (FEPCO)
Address 9-4 Otemachi 1-Chome, Chiyoda-ku, Tokyo
Contact Section Nuclear Power Department,
Telephone 03-3279-2187
Fax 03-3241-1780
Main Activities Decision making of important policy about electricity utilization

(1) Hokkaido Electric Power co., Inc. (HEPCO)
Address of HQ Higashi 1-Chome, Ohdori, Chuoku, Sapporo
Telephone 011-251-111

(2) Tohoku Electric Power Co., Inc. (TOHOKU)
Address of HQ 7-1, Ichibancho 3-Chome, Aoba-ku, Sendai
Telephone 022-225-2111

(3) Tokyo Electric Power Co., Inc. (TEPCO)
Address of HQ 1-3, Uchisaiwai-cho, 1-Chome, Chiyoda-ku, Tokyo
Telephone 03-3501-8111

(4) Chubu Electric Power Co., Inc. (CHUBU)
Address of HQ Ichibanchi Toshin-Cho, Higashi-ku, Nagoya
Telephone 052-951-8211

(5) Hokuriku Electric Power Co., Inc. (HOKURIKU)
Address of HQ 15-1, Ushijima, Toyama
Telephone 0764-41-2511

(6) Kansai Electric Power Co., Inc. (KEPCO)
Address of HQ 3-22, Nakanoshima 3-chome, Kita-ku, Osaka
Telephone 06-441-8821

(7) Chugoku Electric Power Co., Inc. (CHUGOKU)
Address of HQ 4-33, Komachi, Naka-ku, Hiroshima
Telephone 082-241-0211

(8) Shikoku Electric Power Co., Inc. (SHIKOKU)
Address of HQ 2-5, Marunouchi, Takamatsu
Telephone 0878-21-5061

(9) Kyushu Electric Power Co., Inc. (KYUSHU)
Address of HQ 2-1-82, Watanabe-Dori, Chuo-ku, Fukuoka
Telephone 092-761-3031

(10) Japan Atomic Power Co., Inc. (JAPCO)
Address of HQ 6-1, 1-Chome, Ohtemachi, Chiyoda-ku, Tokyo
Telephone 0303201-6631

Source: 1) Organization and Staff of Electric Utilities and Corporation Related, Japan Electric Association
2) Nuclear Power Yearbook 1993, Japan Atomic Industrial Forum Inc.

*FUEL CYCLE*

Enrichment

(1) Power Reactor and Nuclear Fuel Development Corporation
Head office address: 1-9-13 Akasaka, Minato-Ku, Tokyo
Phone: 03-3586-3311
Scope of business: Development of fast breeder reactors and advanced converters, pioneering developments on nuclear fuel cycle, etc.

(2) Japan Nuclear Fuel, Inc.
Head office address: 2-2-2 Uchisaiwai-cho, Chiyoda-Ku, Tokyo
Phone: 03-3581-8831
Scope of business: Uranium enrichment, reprocessing of spent fuel generated by nuclear power plants, temporary storage of low level radioactive wastes, etc.

Reconversion

(3) Japan Nuclear Fuel Reconversion, Inc.
Head office address: 5-10-5 Shinbashi, Minato-ku, Tokyo
Phone: 03-3437-6694
Scope of business: Conversion of UF6 to U02 and fabrication, regeneration of U02 from cold scrap, etc.

(4) Mitsubishi Nuclear Fuel, Inc.
Head office address: 1-6-1 Otemachi, Chiyoda-Ku, Tokyo
Phone: 03-3214-0051
Scope of business: Complete production of PWR fuel assemblies from conversion of UF6, fabrication and assembly, as well as related services.

Fabrication

(5) Japan Nuclear Fuels, Inc.
Head office address: 2-3-1 Uchikawa, Yokosuka City, Kanagawa Prefecture
Phone: 03-3572-8316
Scope of business: Manufacture of boiling water reactor nuclear fuels, etc.

(6) Nuclear Fuel Industries, Inc.
Head office address: 3-23-5 Mishi-Shinbashi, Minato-ku, Tokyo
Phone: 03-3433-3111
Scope of business: Light water reactor fuels (PWR, BWR), fuels for advanced reactors (ATR, FBR), and nuclear fuel related inspection equipment/repair equipment, etc.

(7) Mitsubishi Nuclear Fuels, Inc.
Refer to Item (4)

Zircaloy Cladding

(8) Sumitomo Metal Industries, Inc.
Head office address: 1-1-3 Otemachi, Chiyoda-Ku, Tokyo
Phone: 03-3282-6111
Scope of business: Manufacture of various nuclear fuel cladding, manufacture of various special tubes for nuclear power applications, etc.

(9) Kobelco, Inc.
Head office address: 1-3-18 Wakihama-Cho, Chuo-Ku, Kobe City, Hyogo Prefecture
Phone: 03-3586-3311
Scope of business: Cladding tubes, pressure vessels, generators, materials related to nuclear power facilities such as heat exchangers, research, development and engineering services related to radioactive waste storage/processing facilities.

(10) Mitsubishi Materials, Inc.
Head office address: 1-5-1 Otemachi, Chiyoda-Ku, Tokyo
Phone: 03-5252-5200
Scope of business: Development of technology related to light water reactor fuels, development of nuclear fuel cycle technology including conversion of UF6, reprocessing, etc., and design and construction of related facilities.

Reprocessing

(11) PNC
Head office address: Refer to Item (1) above

(12) Japan Nuclear Fuel, Inc. (under construction)
Head office address: Refer to Item (2) above

Radioactive Wastes

(13) Japan Nuclear Fuel, Inc. (under construction)
Head office address: Refer to Item (2) above

Source: Nuclear Power Yearbook 1993, Japan Atomic Industrial Forum Inc

# KAZAKHSTAN

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# 1. GENERAL INFORMATION

## 1.1. General Overview

Kazakhstan is a new independent Euro-Asian republic, created in 1991 with the dissolution of the former USSR. Total length of its borders is more than 15,000 kilometres and it has an area of 2.7 million square kilometres. To the west of the country is the Eastern Europe. To the east and to the south-east are the Altai and Tyan Shyan mountains. Kazakhstan borders with China in the south-east, with Ural and Siberia regions of Russia in the north, and with Central Asian countries, Uzbekistan, Kyrgyzstan, and Turkmenistan, in the south. It has a coastline of 2 320 kilometres on the Caspian sea. The climate is strongly continental, but with wide variations throughout the territory. Average temperatures in January range from -18°C in the north to -3°C in the south; July averages are 19°C in the north and 30°C in the south. Levels of precipitation are equally varied with average annual rainfall in mountainous regions reaching 1,600 mm, and central desert areas less than 100 mm.

Kazakhstan's population is 17 million from more than 100 nationalities, but mainly Kazak and Russian. In 1991, population growth rate was 1.01%. Its population density is estimated at 6.2 people per square kilometre (Table 1). Average annual income in Kazakhstan is about 1,670 U.S. dollars per person.

TABLE 1. POPULATION INFORMATION

| | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|
| Population (millions) | 17.0 | 17.0 | |
| Population density (inhabitants/km²) | | | |
| Predicted population growth rate (%) 1993 to 2000 | 0.6 | | |
| Area (1000 km²) | | | |
| Urban population in 1993 as percent of total | 59.0 | | |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

Historical Gross Domestic Product (GDP) data are given in Table 2.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|
| GDP (millions of current US$) | | 38,936 | | | |
| GDP (millions of constant 1990 US$) | 21,196 | 38,936 | 26,630 | 26,790 | 1.7 |
| GDP by sector (1991): | | | | | |
| Agriculture 29% | | | | | |
| Industry 41% | | | | | |
| Services 30% | | | | | |

Source: IAEA Energy and Economic Data Base

### 1.3. Energy Situation

Power plants fuelled with coal and black oil are the basis of Kazakhstan's electrical energy. Coal is the country's largest industry, with planned further development if corresponding investments are secured. Coal reserves are estimated at 64 billion tons. Annual hard coal production is about 111.8 million metric tons, brown coal production is estimated at 4.6 million metric tons.

Kazakhstan also has a well developed oil and gas industry. More than 1 600 oil and gas fields have been located in Tengiz and Karachaganak containing more than 2.9 billion tons of conditional fuel. Natural gas production was estimated at 5 416 million cubic metres in 1993. Kazakhstan has begun building a major oil pipeline, 1 200 kilometres from the west to the east. Construction of three new oil refineries is planned. Every year about 25 million tons of liquid hydrocarbons and seven billion cubic meters of natural gas are extracted.

About 20% of the world's uranium reserves are in Kazakhstan. In 1993, production of uranium amounted to 2 110 metric tons. There are several uranium processing and enrichment plants. Fast breeder reactor BN-350 operates in western Kazakhstan. The scientific and industrial basis in the nuclear field provides necessary conditions for development of atomic energy in the Republic. The basic energy balance is given in Table 3.

TABLE 3 ENERGY STATISTICS

Exajoule

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Energy consumption (EJ) | | | |
| - Total [1] | 4.0 | 3.7 | 3.2 |
| - Solids [2] | 2.3 | 2.1 | 2.0 |
| - Liquids | 0.9 | 0.9 | 0.7 |
| - Gases | 0.6 | 0.5 | 0.3 |
| - Primary electricity[3] | 0.2 | 0.2 | 0.2 |
| Energy production (EJ) | | | |
| - Total | 4.7 | 4.2 | 3.9 |
| - Solids | 3.3 | 2.9 | 2.7 |
| - Liquids | 1.1 | 1.0 | 0.9 |
| - Gases | 0.3 | 0.2 | 0.1 |
| - Primary electricity | 0.1 | 0.1 | 0.1 |
| Net import (import-export) (EJ) | | | |
| - Total | -0.7 | -0.6 | -0.8 |
| - Solids | -0.9 | -0.8 | -0.7 |
| - Liquids | -0.1 | | -0.3 |
| - Gases | 0.4 | 0.2 | 0.2 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

The energy policy of Kazakhstan aims to achieve energy independence through electric power production with maximum use of its cheap, low-grade coal.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Kazakhstan's electrical energy was a key link to the eastern part of common energy systems of the former USSR. It had a strong branch division and management which was carried out by corresponding Ministries of the USSR.

The structure of the energy sector of the Republic is shown in Figure 1. The total length of electric lines of all voltages is 440,000 kilometres. The first section of the international Siberia - Kazakhstan - Ural transmission line (1,900 kilometres) has been placed in operation. This line is expanded to the south to connect north and south Kazakhstan and the power grids in Central and Middle Asian countries.

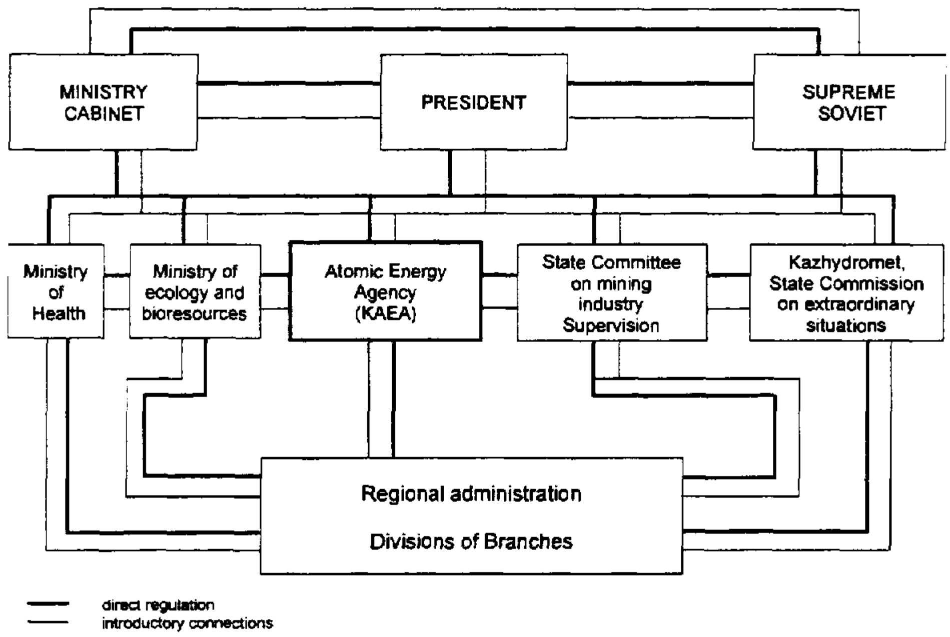


*FIG. 1. Structure and management of the Energy Sector*

### 2.2. Policy and Decision Making Process

### 2.3. Main Indicators

The historical electricity production and installed capacity are given in Table 4, the 1994 electric power balance in Table 5 and the energy related ratios in Table 6:

The net installed capacity of electric power plants in Kazakhstan is about 15,910 MW, or about 1.1 kW per capita. Share of thermal and hydro electricity generation, in 1993, of the total electricity generated was 12,410 MW and 3,500 MW, respectively.

Total electricity generated in 1993 was 77.44 TW·h of which coal's share was 55.3 TW·h, oil 6.7 TW·h, gas 7.7 TW·h, and hydro 7.6 TW·h.

TABLE 4. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Electricity production (TW·h) | | | |
| - Total[(1)] | 82.7 | 77.89 | 66.78 |
| - Thermal | 75.4 | 69.90 | 57.22 |
| - Hydro | 6.9 | 7.63 | 9.18 |
| - Nuclear | 0.5 | 0.36 | 0.38 |
| Capacity of electrical plants (GW(e)) | | | |
| - Total | 18.7 | 18.50 | 18.90 |
| - Thermal | 15.2 | 16.23 | 16.73 |
| - Hydro | 3.5 | 2.20 | 2.10 |
| - Nuclear | 0.1 | 0.07 | 0.07 |

[(1)] *Electricity losses are not deducted.*

Source: IAEA Energy and Economic Data Base

TABLE 5. 1994 ELECTRIC POWER BALANCE

| | | 1994 |
|---|---|---|
| 1. | **Electric energy** | |
| | Resources | 86.42 billion kWh |
| | Consumption | 79.09 billion kWh |
| | Total production: | 66.05 billion kWh |
| | Coal | 79% |
| | Gas - Black Oil | 12-13% |
| | Hydro | 6-7% |
| | Nuclear Power | 0.6% |
| | Import | 20.37 |
| | Export | 7.34 |
| | Balance deficit | 13.03 |
| 2. | **Thermal energy** (output of Kazakhstan-energo) | 59595 thousands of Gkal |
| | **Fuel consumption** for production of electric energy | 386 g/kWh |
| 3. | of thermal energy | 182.1 kg/Gkal |

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

The nuclear scientific industrial complex in Kazakhstan was established as a unified part of atomic industry and science in the former Soviet Union.

Kazakhstan's uranium industry consists of uranium prospecting firms, a number of natural mines using mining and underground leaching techniques, two $U_3O_8$ production plants at Aktau and Stepnogorsk, and a metallurgical plant producing metaloceramic fuel pellets for RBMK and VVER reactor fuel assemblies. The power plant at Aktau (MAEK) is used to produce heat and electricity, and desalinate water. It has both natural gas and nuclear units. The latest unit is a BN-350 fast neutron reactor with sodium coolant.

On the territory of the former Semipalatinsk Nuclear Test Site, three research reactors are engaged in testing and development of nuclear space engines and safe nuclear power plants. In 1992, the National Nuclear Centre was created (based on Semipalatinsk reactors) along with the Institute of Nuclear Physics in Almaty.

TABLE 6. ENERGY RELATED RATIOS

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 240 | 210 | 189 |
| Electricity per capita (kW·h/capita) | 5,740 | 5,285 | 4,597 |
| Electricity production/Energy production (%) | 17 | 18 | 17 |
| Nuclear/Total electricity (%) | 1 | | 1 |
| Ratio of external dependency (%)[1] | -17 | -22 | -24 |
| Load factor of electricity plants | | | |
| - Total (%) | 50 | 48 | 40 |
| - Thermal | 57 | 49 | 39 |
| - Hydro | 22 | 40 | 50 |
| - Nuclear | 76 | 59 | 62 |

Source: IAEA Energy and Economic Data Base

### 3.2. Current Policy Issues

The current policy in the field of atomic energy emphasises:

i) maintenance of existing facilities in accordance with international safety standards;
ii) support of scientific, technical, design and construction connections with Russian Federation and other CIS countries and establishing contacts with international organisations;
iii) creation of state system of accountancy and control of nuclear materials in accordance with Non-Proliferation Treaty obligations and Agreement on Safeguards that is expected to be ratified by Presidential Decree in the near future;
iv) elaboration of legislation on atomic energy use;
v) finalising of an Atomic Energy Development Concept for the Republic of Kazakhstan;
vi) improvement of regulations for congruence with other CIS regulations;
vii) liquidation of results of nuclear explosions;
viii) creation of a radioactive waste storage and disposal system.

### 3.3. Status and Trends of Nuclear Power

*Nuclear reactor*

| | |
|---|---|
| Type: | BN-350, sodium-cooled fast breeder reactor |
| Location: | Aktau (former Shevchenko) at the coast of the Caspian Sea, in western part of Kazakhstan |
| Operator: | Mangyshlak Power Generation Company (MAEK) |
| Units: | One |
| Total capacity: | 520 MW (thermal) |
| Start of operation: | 1972 |
| Fuel: | Uranium enriched to 17%, 21%, and 26% |
| Status: | Operational |

The BN-350 reactor is used for electricity generation and for water desalination - up to 100,000 tons per day. Total net nuclear production in 1994 was 378.07 million kW·h. Nuclear share in overall electricity production was 0.6%. Kazakhstan would like to replace the reactor with a new reactor.

| | |
|---|---|
| Type: | WWR-K, water cooled, moderated and reflected tank-type reactor |
| Location: | Alatau, near Almaty |
| Operator: | Owned by the National Nuclear Centre (NNC) and operated by its Institute of Atomic Energy (IAE) |
| Total capacity: | 10 MW |
| First criticality: | 1967 |
| Fuel: | U-A1 fuel with a U-235 enrichment of 36% |
| Status: | Temporarily halted in 1988 for improvements in seismic load levels |

| | |
|---|---|
| Type: | IGR, impulse homogeneous uranium-graphite thermal neutron reactor with graphite reflector |
| Location: | Baical Test Facility, Kurchatov (former Semipalatinsk-21) |
| Operator: | Owned by the National Nuclear Centre and operated by its Institute of Atomic Energy (IAE) |
| Start operation: | 1961 |
| Fuel: | enriched to over 90% U |
| Heat release: | Maximum 5,2 Gjoules (1 GJ in a pulse) |
| Neutron flux: | Maximum thermal $0.7*10^{17}cm^{-2}s^{-1}$ I |

| | |
|---|---|
| Type: | EWG-1M, thermal light water heterogeneous vessel reactor with light water moderator and coolant, beryllium reflector |
| Location: | Kurchatov (former Semipalatinsk-21) |
| Operator: | Owned by NNC and operated by IAE |
| Total capacity: | 60 MW (thermal) |
| First criticality: | 1972 |
| Fuel: | U-Zr fuel with U-235 enrichment of 90% |
| Neutron flux: | $1.7\text{-}3.4*10^{14}cm^{-2}s^{-1}$ |

| | |
|---|---|
| Type: | RA thermal neutron high temperature gas heterogeneous reactor with air coolant, zirconium hydride moderator, beryllium reflector |
| Location: | Kurchatov |
| Operator: | Owned by NNC and operated by IAE |
| Total capacity: | up to 0.4 MW |
| First criticality | 1986 |
| Fuel: | Ampoule bodies with 90%U-235 enrichment |
| Neutron flux: | Up to $5*10^{12}cm^{-2}s^{-1}$ |

### 3.4. Organizational Chart

The structure of the Atomic Energy Agency of Kazakhstan is given in Figure 2.

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

A joint resolution on nuclear safety and technical support for nuclear energy facilities in Kazakhstan was signed between KAEA and Russian Federation's Ministry of Atomic Energy.

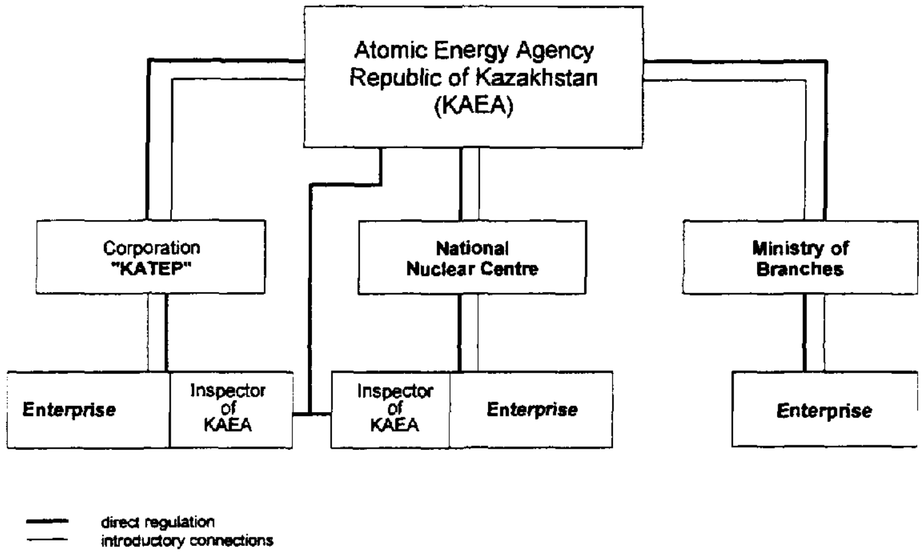


*FIG. 2. Structure of Atomic Energy Agency*

The BN-350 reactor was designed and constructed by organisations of the former Soviet Union, under the supervision of the Ministry of Atomic Energy (MINATOM). The chief scientific supervisor is the Institute of Physics and Power engineering (IPPE- Obninsk). The chief designer is the Experimental Design Bureau on Machinery Building (OKBM-N, Novgorod), and main constructor is the All Russian Scientific Research and Design Institute for Power Technologies (VNIIPIET - Moscow). The plant is operated by the Mangyshlak Power Generation Company (MAEK). At the present, the regulatory body supervising the plant safety is the Atomic Energy Agency of Kazakhstan (KAEA). Figure 3 shows the structure of the atomic industrial complex.

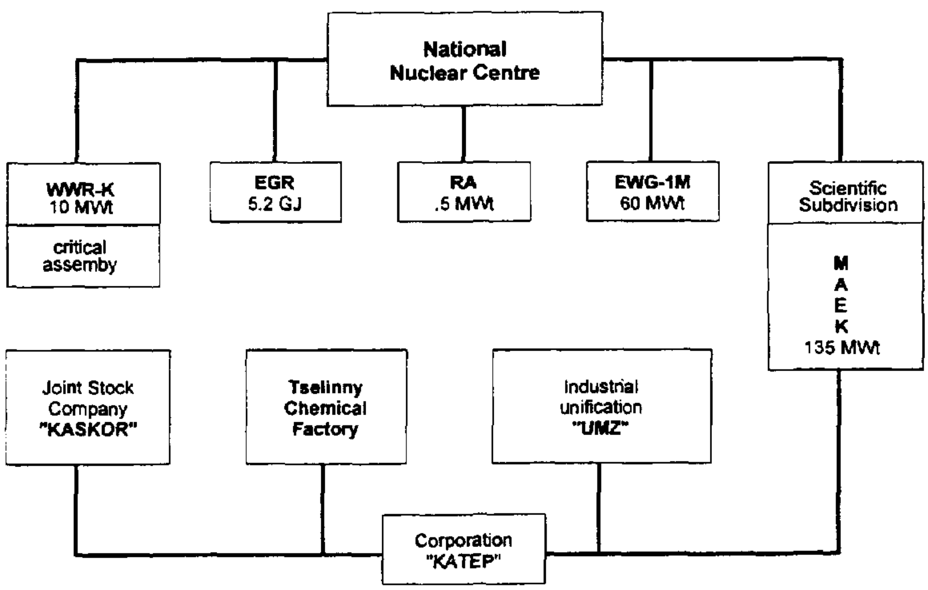


*FIG. 3. Structure of Atomic Scientific-industrial Complex of Kazakhstan*

## 4.2. Operation of Nuclear Power Plants

The BN-350 reactor is owned by the National Joint-Stock Company KATEP and operated by Mangyshlak Power Generation Company. About 500 people are working at the power plant, organised to two sections: the Operations Section with shift teams and technical division; and, the Maintenance Section divided into seven divisions. MAEK nuclear power plant has six shifts, each shift containing 24 people (radioprotection not included). Sixteen of these shift workers are for surveillance and early maintenance. The required qualifications for each person are specified. Periodic (every one to three years) examinations to confirm the competence of the personnel, including the plant management, are administered by KAEA. Examinations for reactor operators are given by a plant committee.

Special training for each new staff member includes class room instruction, on the job training, and examinations at appropriate intervals. Nuclear plant procedures are prepared in written form for all normal operations and for foreseeable accidents. These procedures are revised every three years. There is no simulator at BN-350.

### 4.3. Fuel Cycle and Waste Management Service Supply

Kazakhstan has more than 50 uranium deposits in six provinces: Kokshetau province on the north and Pribalkhashsky on the south have endogenetic type uranium deposits; Iliskay, Chu-Sarusu, Sur-Darya, and Prikaspiy have endogenic type deposits. Deposits in Chu-Sarusu and Sur-Durya provinces are located in sand penetrating sediments and are useful for in-situ leaching process.

Waste from uranium mining and milling constitutes more than 90% of all radioactive waste in Kazakhstan. Therefore, implementation of the Republic's Concept on the radioactive waste management is the main task.

The Ulba Metallurgical Plant (UMZ) started production of $UO_2$ fuel pellets in 1976. Physical and chemical technologies are used at all stages of production, from treatment of $UF_6$ material, to conversion into $UO_2$, production of $UO_2$ pellets, and sintering of the pellets. Quality control is maintained during all process stages. The design capacity of the plant is 2,000 tons of pellets per year. Fuel assemblies from UMZ are used at nuclear power plants in Russia, the Ukraine, and other countries. The $U^{235}$ content is 1.6 - 4.4%. UMZ also produces rare earth metal products and superconducting materials.

### 4.4. Research and Development Activities

Kazakhstan has four research reactors at the National Nuclear Centre where the following research is carried out:

i) radiation material science; study of the interaction between construction materials and coolants; investigation of fission produced emission from fuel rods, its precipitation and filtration under different conditions;
ii) safety of nuclear power plants; fuel assemblies and rod tests at transition and break-down modes of operation; simulation of reactor core fragment melting and interaction of melted material with coolant;
iii) development and implementation of nuclear physics methods and technologies; production of isotopes for different applications, for example, thallium-201 chloride for early diagnostics of heart decease.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

In 1995-96, in addition to the regular program of technical co-operation with IAEA, Kazakhstan has activities in two national projects: radiation and waste management services upgrading (KAZ/9/003), and safety upgrading of WWR-K research reactor (KAZ/9/004).

Also, there are efforts under the Co-ordinated Plan of Technical Support of the Republic Kazakhstan to establish a national system for nuclear materials accountancy, control and physical protection as detailed by the International Atomic Energy Agency.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

Until licensing of nuclear activities in Kazakhstan will be formulated into a law, a system of special licensing falls under the Temporary Regulation. Recently, KAEA introduced three documents outlining the procedures required for temporary licenses for nuclear power plants, research reactors, critical and undercritical assemblies producing nuclear materials.

### 5.2. Main National Laws and Regulations

Until Nuclear Activity Laws will come into force, interaction between state institutions is based on the guidelines given in the "Itinerary Provision on Nuclear Energy Use". It defines the field of activities and responsibilities of the participants. The legislation on nuclear activities prognosticates four basic laws:

- Law on radiation protection of the population
- Law on radioactive waste management
- Law on use of nuclear energy
- Law on export-import control of nuclear materials

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related agreement INFCIRC/504 | Entry into force: | 11 August 1995 |
| • Supplementary agreement on provision of technical assistance by the IAEA | | Not applicable |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 14 February 1994 |
| • Agreement on privileges and immunities | Non-Member | |
| • Convention on physical protection of nuclear material | Non-Party | |
| • Convention on early notification of a nuclear accident | Non-Party | |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Non-Party | |
| • Vienna convention on civil liability for nuclear damage and joint protocol | Non-Party | |
| • Convention on nuclear safety | Non Party | |
| • ZANGGER Committee | Non-Member | |

| | |
|---|---|
| • Nuclear Export Guidelines | Not adopted |
| • Acceptance of NUSS Codes | Not accepted |

*BILATERAL AGREEMENTS*

- The Agreement between the Russian Federation and the Republic of Kazakhstan on the Peaceful use of Atomic Energy.
- The Agreement between the Russian Federation and the Republic of Kazakhstan on Transportation of fission materials.
- Agreement of KAEA and GAEN of the Russian Federation on co-operation in the field of nuclear safety.
- Agreement of KAEA and NRC of the USA on technical information exchange and co-operation in the field of nuclear safety.

## REFERENCES


[1] IMF Economic Reviews 1993.

[2] Energy Statistics of Non-OECD Countries 1992-93.

[3] World Bank World Tables 1995.

[4] IAEA Energy and Economic Data Base.

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Atomic Energy Agency | |
| of Kazakhstan (KAEA) | Tel: +7-3272-626040 |
| Republic sq. 13 | Fax: +7-3272-634885, +7-3272-633356 |
| Almaty 480013 Kazakhstan | Telex: 251232 PTB SU box 76 |

**The KAEA is a Department of the Ministry of Science and New Technologies**

| | |
|---|---|
| State Corporation for Atomic | |
| Energy and Industry (KATEP) | |
| Vogenbay Batyr | |
| Almaty 480012 | Tel.: +7-3272-626412 |
| Kazakhstan | Fax: +7-3272-676017 |

*OTHER NUCLEAR ORGANIZATIONS*

Institute of Nuclear Physics, Almaty

# KOREA, REPUBLIC OF

## KOREA, REPUBLIC OF

# 1. GENERAL INFORMATION

## 1.1. General Overview

The Republic of Korea (ROK) lies on the southern part of the Korean peninsula neighbouring China. The terrain is mostly rugged and mountainous with only 21% of the land being arable. The climate is temperate with hot and humid summers and relatively long, dry, cold winters. Located in the East Asian Monsoon belt, Korea's annual rainfall may reach about 150 cm along the southern coast. Spring and autumn are short and moderate. As of 1993, the Republic of Korea had a population of 44.1 million inhabitants with 0.9 percent growth rate. Korea has a land area of approximately 99,314 $km^2$ (Table 1).

Korea is an energy resource-poor country. Consequently, energy security is a prime concern of the Korean government. There are no significant oil or gas resources and only limited anthracite coal deposits in the ROK. Uranium deposits identified are low grade and no development of these have taken place. Thus, energy security is a prime concern of the ROK government.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 25.0 | 31.9 | 38.1 | 42.9 | 44.1 | 44.6 | 1.1 |
| Population density (inhabitants/$km^2$) | 252.5 | 322.4 | 385.0 | 432.9 | 445.7 | 450.0 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.9 |
| Area (1000 $km^2$) | 99.0 |
| Urban population in 1993 as percent of total | 78.0 |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

The Korean economy has over the last thirty years been through a remarkable period of growth. Over the period 1961 to 1990 Korea's Gross Domestic Product (GDP) growth rate has averaged nearly 8.8% per year and in 1990 GDP reached 179.6 trillion Won. Korea's large economic growth has slowed somewhat in recent times. Over the last few years the Korean economy has experienced rapid wages growth, high inflation, rising imports and falling exports, etc. and in 1993 Gross Domestic Product (GDP) was 265.5 trillion Won. Table 2 shows the historical GDP statistics in US$ and Table 3 the GDP by sector for 1993.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 8,913 | 62,626 | 253,672 | 330,831 | 379,623 | 13.7 |
| GDP (millions of constant 1990 US$) | 47,865 | 104,146 | 253,672 | 304,988 | 330,530 | 8.6 |
| GDP per capita (current US$/capita) | 279 | 1,643 | 5,917 | 7,497 | 8,519 | 12.5 |

| GDP by sector (1993): | |
|---|---|
| Agriculture | 7% |
| Industry | 43% |
| Services | 50% |

Source: IAEA Energy and Economic Data Base

TABLE 3. GROSS DOMESTIC PRODUCT (GDP) PER SECTOR IN 1993 AT 1990 CONSTANT PRICES (BILLION WON):

| | |
|---|---|
| Agriculture | 16,210.7 |
| Mining and Quarrying | 885.0 |
| Manufacturing | 62,997.3 |
| Construction | 24,901.7 |
| Electricity, Gas and Water | 5,069.9 |
| Wholesale & Retail Trade, Restaurants, Hotels | 27,486.8 |
| Finance & Insurance, Estate and Business Services | 37,505.1 |
| Transport, Storage and Communication | 15,961.8 |
| Others | 26,220.9 |
| Total | 217,239.1 |
| GDP per capita (1000 won) | 4,931.0 |

## 1.3. Energy Situation

Table 4 shows the Korean energy reserves and Tables 5 and 6 the primary and final energy consumption, respectively. Table 7 gives the overall energy balance. In Korea, as in many other countries that are not endowed with fossil fuel reserves, nuclear power is considered to be the most reliable energy source capable of meeting the soaring energy demand necessary for economic development (i.e. an economic growth rate of some 10% per year). Korea has, consequently, chosen nuclear power as its major energy source in the future. Under the government's Power Development Programme, nuclear power is to become the major energy source by 2006 with the construction of 23 nuclear power plants, supplying about fifty percent of the nation's total electrical power.

TABLE 4. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro (2) | Total |
| Total amount in place | 3.67 | | | | 8.50 | 12.17 |

(1) *This total represents essentially recoverable reserves.*

(2) *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.*

Source: IAEA Energy and Economic Data Base

TABLE 5. PRIMARY ENERGY CONSUMPTION

1000 toe

| | 1970 | 1975 | 1980 | 1985 | 1990 | 1993 |
|---|---|---|---|---|---|---|
| Coal | 5,829 | 8,075 | 13,199 | 22,022 | 24,385 | 25,882 |
| Petroleum | 9,293 | 15,637 | 26,830 | 27,142 | 50,175 | 78,495 |
| LNG | | | | | 3,023 | 5,723 |
| Hydro | 305 | 421 | 496 | 915 | 1,590 | 1,502 |
| Nuclear | | | 869 | 4,186 | 13,222 | 14,535 |
| Others | 4,251 | 3,420 | 2,517 | 2,031 | 797 | 742 |
| Total | 19,678 | 27,553 | 43,911 | 56,296 | 93,192 | 126,879 |
| Per capita (toe) | 0.6 | 0.8 | 1.2 | 1.4 | 2.2 | 2.9 |
| Domestic production | 10,333 | 11,397 | 12,491 | 38,717 | 68,672 | 21,166 |
| Imports | 9,345 | 16,156 | 31,420 | 17,579 | 24,520 | 105,713 |

The nuclear share in total electricity generation is over 36%. The electricity consumption per capita, some 3 MW·h per year, is rather low compared to the level of other industrialised countries. Therefore, electricity demand is expected to grow rapidly during the next decades. The nuclear power programme of the Republic of Korea aims towards meeting the increase in demand and alleviating the dependence on imported fossil fuels as well as the environmental burdens arising from fossil fuel burning.

TABLE 6. FINAL ENERGY CONSUMPTION

1000 toe

| | 1970 | 1975 | 1980 | 1985 | 1990 | 1993 |
|---|---|---|---|---|---|---|
| Coal | 5,593 | 7,566 | 12,426 | 17,940 | 19,855 | 19,058 |
| Petroleum | 7,373 | 11,004 | 19,824 | 22,580 | 45,252 | 69,876 |
| Town gas | | 4 | 15 | 84 | 1,012 | 3,027 |
| Electricity | 666 | 1,430 | 2,815 | 4,363 | 8,117 | 10,985 |
| Others | 4,250 | 3,420 | 2,517 | 2,031 | 871 | 1,102 |
| Total | 17,882 | 23,424 | 37,597 | 46,998 | 75,107 | 104,048 |
| Growth rate (%) | 12.3 | 3.1 | 1.7 | 4.8 | 14 | 10 |
| Per capita (toe) | 0.55 | 0.66 | 0.99 | 1.15 | 1.75 | 2.36 |

TABLE 7. ENERGY STATISTICS

Exajoule

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Energy consumption | | | | | | | | |
| - Total[(1)] | 0.15 | 0.83 | 1.76 | 3.76 | 4.90 | 5.36 | 13.20 | 8.28 |
| - Solids[(2)] | 0.11 | 0.44 | 0.64 | 1.12 | 1.10 | 1.19 | 9.07 | 4.48 |
| - Liquids | 0.03 | 0.38 | 1.06 | 1.96 | 2.97 | 3.28 | 19.79 | 8.38 |
| - Gases | | | | 0.13 | 0.24 | 0.31 | | |
| - Primary electricity[(3)] | 0.01 | 0.01 | 0.05 | 0.55 | 0.59 | 0.58 | 11.86 | 18.67 |
| Energy production | | | | | | | | |
| - Total | 0.12 | 0.46 | 0.52 | 0.91 | 0.81 | 0.76 | 7.57 | 2.82 |
| - Solids | 0.11 | 0.45 | 0.46 | 0.37 | 0.22 | 0.18 | 7.25 | -6.40 |
| - Liquids | | | | | | | | |
| - Gases | | | | | | | | |
| - Primary electricity[(3)]) | 0.01 | 0.01 | 0.05 | 0.55 | 0.59 | 0.58 | 11.86 | 18.67 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.03 | 0.38 | 1.33 | 2.93 | 4.68 | 5.14 | 21.33 | 10.15 |
| - Solids | | -0.01 | 0.20 | 0.67 | 0.99 | 1.11 | -28.23 | 13.16 |
| - Liquids | 0.03 | 0.39 | 1.13 | 2.14 | 3.45 | 3.71 | 20.07 | 8.86 |
| - Gases | | | | 0.12 | 0.24 | 0.32 | | |

[(1)] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*

[(2)] *Solid fuels include coal, lignite and commercial wood.*

[(3)] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*

Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

The key objectives of Korea's general energy policies can broadly be described under four main headings:

- Korea has a high level of dependency on energy imports and particularly oil. Thus, one of the main aims of Korea's energy policies has been to improve the country's energy security.
- A second concern has been the desire to ensure that the Korean energy sector is managed in such a way as to provide low cost energy supplies to encourage and sustain economic development and growth.
- Energy conservation is seen as a tool for improving energy security, and is now receiving increasing attention from the government. However, in a number of cases the increased government focus on conservation has yet to be reflected in the thinking within government controlled energy corporations.
- The fourth major aspect of Korea's energy policies is the development and implementation of comprehensive environmental and safety protection policies.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

The ministry chiefly responsible for developing electricity policy in Korea is the Ministry of Trade, Industry and Energy (MOTIE) in consultation and close co-operation with the Economic Planning Board (EPB), the Ministry of Finance (MOF)[1], the Korean Electric Power Corporation (KEPCO) among others. With energy being regarded as a key component of Korea's rapid economic development, the government has maintained a strong presence in the sector.

MOTIE, through direct or indirect government ownership of energy companies, utilities and several energy research institutes, has maintained a high degree of control in all aspects of energy policy development and implementation.

The electricity industry in Korea is dominated by KEPCO, the government-controlled, vertically integrated electric utility that owns and operates 85% of the installed electric capacity. KEPCO is also the statutory monopoly for the transmission and distribution of power.

In addition to KEPCO, there are some small and two other large electricity generating companies in Korea that own and operate 15% of the Korea's total installed capacity. Korea Water Resource Corporation (KWRC) and Kyungin Energy are obligated to sell all the power they produce to KEPCO. There are also a few industrial auto producers who sell their surplus power to KEPCO.

### 2.2. Policy and Decision Making Process

One of the objectives of Korea's energy policy is a reliable electricity supply at low cost. The government feels that keeping industrial electricity prices low is important for maintaining international competitiveness of Korean industry. Under the Electric Enterprises Act, rates are approved by MOTIE. Electricity price determination is based on the principle that prices should be based on costs, including a fair return on the utility's investment. At present, prices vary among customer classes, time of use, season and level of voltage.

Under the Electric Enterprises Act, KEPCO is obligated to apply to MOTIE for a rate change. MOTIE, under the Price Stabilisation Act and in consultation with EPB, asks the Price Stabilisation Committee (which includes some consumer representatives) to review KEPCO's application. After a final review by the Cabinet and the President of the Republic, the Minister of Trade, Industry and Energy approves the new rates.

Electricity rates in South Korea are "bundled", i.e., there is one charge covering generation, transmission and distribution costs. Consequently, the Korean government plays a major role in the setting of nearly all energy prices.

### 2.3. Main Indicators

In December 1995, the Korean Government announced a revised long term electric system expansion plan, covering the period from 1995 to 2010. According to the plan, peak electricity demand is expected to increase by 5.8% per year, taking into account demand control. Total electric capacity is expected to grow from 32 GW(e) in 1995 to 80 GW(e) in 2010.

Table 8 gives the historical electricity production and installed capacities. The latter are also shown in Figure 1. The energy and electricity related ratios are given in Table 9.

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[1] EPB and MOF merged into the Ministry of Finance and Economy (MOFE) at the end of 1994.

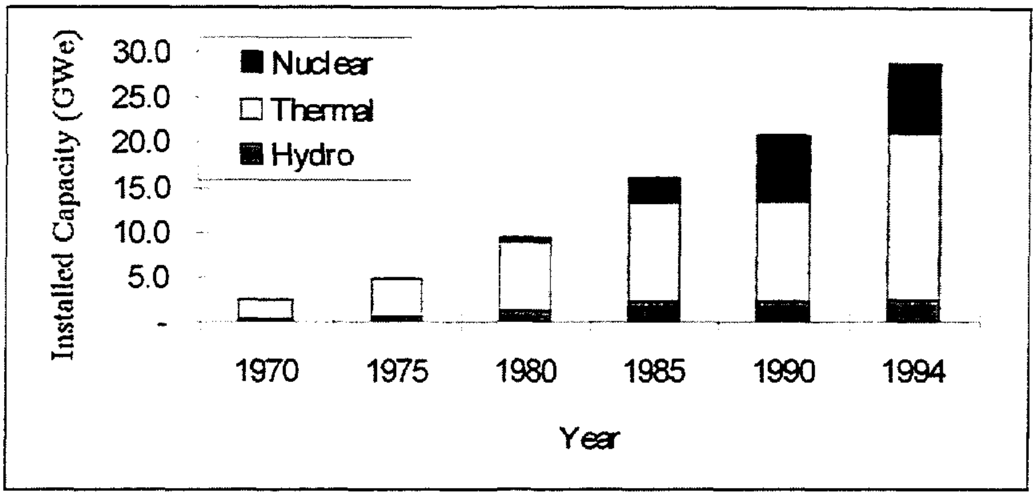



*FIG. 1. Installed Generation by Plant Type*

TABLE 8. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 1.76 | 9.60 | 40.08 | 118.74 | 163.45 | 185.99 | 16.92 | 11.59 |
| - Thermal | 1.18 | 8.38 | 34.62 | 62.15 | 102.02 | 125.98 | 18.42 | 9.67 |
| - Hydro | 0.58 | 1.22 | 1.98 | 6.36 | 6.01 | 4.10 | 6.34 | 5.32 |
| - Nuclear | | | 3.48 | 50.23 | 55.42 | 55.92 | | 21.95 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 0.44 | 2.76 | 10.38 | 23.08 | 30.52 | 31.67 | 17.13 | 8.30 |
| - Thermal | 0.30 | 2.44 | 8.63 | 13.52 | 20.80 | 21.00 | 18.37 | 6.56 |
| - Hydro | 0.14 | 0.33 | 1.16 | 2.34 | 2.50 | 2.49 | 11.02 | 5.64 |
| - Nuclear | | | 0.59 | 7.22 | 7.22 | 8.17 | | 20.69 |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 9. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 6 | 26 | 46 | 88 | 111 | 120 |
| Electricity per capita (kW·h/capita) | 70 | 288 | 997 | 2,644 | 3,551 | 4,008 |
| Electricity production/Energy production (%) | 14 | 19 | 71 | 120 | 186 | 226 |
| Nuclear/Total electricity (%) | | | 9 | 44 | 35 | 31 |
| Ratio of external dependency (%)[(1)] | 19 | 47 | 75 | 78 | 96 | 96 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 46 | 40 | 44 | 59 | 61 | 67 |
| - Thermal | 45 | 39 | 46 | 52 | 56 | 68 |
| - Hydro | 46 | 42 | 20 | 31 | 27 | 19 |
| - Nuclear | | | 68 | 79 | 88 | 78 |

[(1)] *Total net import / Total energy consumption*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

Nuclear activities in Korea were initiated in 1957 when Korea became a member of IAEA. In 1959, the Office of Atomic Energy was established as a government organization in conformity with the global trend toward developing peaceful uses of atomic energy. The Atomic Energy Law was promulgated in the previous year.

The Republic of Korea has one of the most dynamic nuclear power programmes in the world. It has carried out a very ambitious nuclear power programme since the 1970's in parallel with the nation's industrialisation policy, and has maintained a strong commitment to nuclear power development as an integral part of the national energy policy aimed at reducing external vulnerability and insuring against global fossil fuel shortage.

During the early years of nuclear power development, power plants were constructed mostly through "Turn-Key" contracts, providing little opportunity for domestic industries to participate in the construction. Since then, however, domestic participation in overall construction management, design, equipment supply, and civil construction has continuously increased through the adoption of the "Non Turn-Key" approach. Recently, a high degree of technological self-reliance is being achieved through the construction of Yonggwang Nuclear Units (YGN) 3 and 4 in various fields of the nuclear industry. At present, nuclear power plant technology and related fuel cycle technologies are maturing.

### 3.2. Current Policy Issues

In 1994, the Korean government established long-term nuclear policy directions through 2030 to demonstrate long-term national vision and basic policy directions regarding nuclear energy and its utilisation. The objectives secured in this policy are:

i) To enhance stable energy supply by establishing nuclear energy as a major energy source in national electric power generation;
ii) To establish self-supporting nuclear reactor technology and non-proliferating nuclear fuel cycle technology through systematic research and development of nuclear energy;
iii) To promote nuclear technology as an export industry through upgrading nuclear industrial technology on the basis of civil creativity and participation;
iv) To develop nuclear technology for a leading role in fostering national welfare and creative science and technology by expanding the uses of nuclear energy in agriculture, engineering, medical science, and industrial applications.

Recently, Korea is placing even more emphasis on nuclear safety. To carry out its nuclear programme successfully, Korea is determined to ensure nuclear safety throughout every stage of development.

Public acceptance (PA) is another important factor in the development of the nuclear industry. As the social environment changes, public concern for nuclear safety rises. The Korean government is strengthening its PA activities, including the dissemination of accurate information on nuclear programmes to the public. Publication of safety evaluation reports and the development of a public hearing system are also important for PA advancement.

Korea had originally planned to build an Away From Reactor (AFR) interim storage facility for spent fuel with 3,000 ton capacity and a low/intermediate level radwaste disposal facility with a capacity of 250,000 drums by 1997 and 1995, respectively. However, it has been delayed for 3-4 years mainly because of the lack of public acceptance brought on by strong opposition from residents near the planned radioactive waste disposal sites. In December 1994, the Korean government announced that the island of Kulup-do was selected as a final repository for low level radioactive waste disposal and for temporary storage of spent fuel. The country's first radwaste disposal site, the Kulup-do island is located far off Korea's western coast, and has an area of 1.7 $km^2$ and 10 residents.

In order to achieve self-reliance in nuclear technology and to establish self-sufficiency in the supply of nuclear energy by the early 2000's, Korea established a long-term nuclear research and development programme to be implemented over a ten-year period. This programme consists of 20 government-led and 14 industry-led research and development projects with a total funding of 2.5 billion US$. The implementation of this programme is in progress. To support the active nuclear power development programme and to stimulate the development of basic science and technology in the Korean nuclear society, Korea Atomic Energy Research Institute (KAERI) has constructed a 30 MWth research reactor of Korean design called HANARO (renamed from the former Korea Multi-purpose Research Reactor: Hi-Flux Neutron Application Reactor). KAERI started HANARO's main construction work in February 1989 and fuel was loaded in February 1995.

### 3.3. Status and Trends of Nuclear Power ( as of June 1996)

The nuclear power development programme of the Republic of Korea started in the early 1970s and the first nuclear units were turnkey imports. Progressively, through technology adaptation and transfer, and national R&D, a comprehensive programme was implemented leading to the establishment of a domestic nuclear industry. The first domestic reactor was a 950 MW(e) PWR built at Yonggwang-3, which entered commercial operation in 1995. The eleventh nuclear unit, Yonggwang-4 (a 950 MW(e) PWR) was also connected to the grid in 1995, three months ahead of schedule, bringing the total nuclear installed capacity to more than 9 GW(e). The Yonggwang units 3 and 4 are considered as the reference reactor for future construction. Two more of these domestic PWRs are being built at Yonggwang. The next domestic reactor is a 650 MW(e) pressurised heavy water reactor (PHWR), fabricated by Korea Heavy Industries & Construction Company. The reactor will be shipped to Wolsong for installation in unit 4.

Currently (yearend 1996), there are five units in an advanced stage of construction, two 950 MW(e) PWRs and three 650 MW(e) CANDUs, all of which are scheduled for commissioning before the end of the century. Construction work commenced on two more units (both 1000 MW(e) PWRs of the same type as units 3 and 4 of the Ulchin power plant) at the Yonggwang site at year-end and is expected to be completed in 2001 and 2002 respectively. The status of the nuclear power plants is given in Table 10 (operating, under construction and firmly planned). According to the Government's long-term electric system expansion plan nine more nuclear power plants with a capacity of 9 GW(e) are planned, to bring the total to 27 operable plants with an installed capacity of 26 GW(e) in 2010. The tentative plans for future expansion is given in Table 11.

Although nuclear power is generally well accepted by the population, finding new sites for the additional planned units might raise some issues in a country which is relatively small. The national utility, the Korean Electric Power Corporation (KEPCO), has demonstrated impressive efficiency in the operation and maintenance of its nuclear units. In 1993 and 1994, the average availability factor exceeded 87% (Table 12), and the excellent project management, in particular during construction, has made it possible to enhance the competitiveness of nuclear generated electricity, which is some 20% cheaper than the other sources of generation used in the country's electricity system.

TABLE 11. FUTURE EXPANSION OF NUCLEAR POWER PLANTS

| Name | Type | Capacity (MW) | Commercial Operation |
|---|---|---|---|
| Untitled | PWR | 1000 | 2003.6 |
| Untitled | PWR | 1000 | 2004.6 |
| Untitled | PWR | 1000 | 2005.6 |
| Untitled | PWR | 1000 | 2006.6 |
| Untitled | PHWR | 700 | 2006.6 |

TABLE 10. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| KORI 1 | PWR | 556 | KEPCO. | Operational | WEST | 01-Aug.-72 | 19-Jun.-77 | 26-Jun.-77 | 29-Apr.-78 | |
| KORI-2 | PWR | 605 | KEPCO. | Operational | WEST | 01-Mar-77 | 09-Apr.-83 | 22-Apr.-83 | 25-Jul.-83 | |
| KORI-3 | PWR | 895 | KEPCO. | Operational | WEST | 01-Oct-79 | 01-Jan-85 | 22-Jan-85 | 30-Sep-85 | |
| KORI-4 | PWR | 895 | KEPCO. | Operational | WEST | 01-Apr.-80 | 26-Oct-85 | 15-Nov.-85 | 29-Apr.-86 | |
| ULCHIN-1 | PWR | 920 | KEPCO. | Operational | FRAM | 26-Jan-83 | 25-Feb.-88 | 07-Apr.-88 | 10-Sep-88 | |
| ULCHIN-2 | PWR | 920 | KEPCO. | Operational | FRAM | 05-Jul.-83 | 25-Feb.-89 | 14-Apr.-89 | 30-Sep-89 | |
| WOLSONG-1 | PHWR | 629 | KEPCO. | Operational | AECL | 30-Oct-77 | 21-Nov.-82 | 31-Dec.-82 | 22-Apr.-83 | |
| YONGGWANG-1 | PWR | 900 | KEPCO. | Operational | WEST | 04-Jun.-81 | 31-Jan-86 | 05-Mar-86 | 25-Aug.-86 | |
| YONGGWANG-2 | PWR | 900 | KEPCO. | Operational | WEST | 01-Dec.-81 | 15-Oct-86 | 11-Nov.-86 | 10-Jun.-87 | |
| YONGGWANG-3 | PWR | 950 | KEPCO. | Operational | KHKAECE | 23-Dec.-89 | 13-Oct-94 | 30-Oct-94 | 31-Mar-95 | |
| YONGGWANG-4 | PWR | 950 | KEPCO. | Operational | KHKAECE | 26-May-90 | 07-Jul.-95 | 18-Jul.-95 | 01-Jan-96 | |
| ULCHIN-3 | PWR | 960 | KEPCO. | Under Construction | KHKAECE | 21-Jul.-93 | 01-Jan-98 | 01-Mar-98 | 01-Jun.-98 | |
| ULCHIN-4 | PWR | 960 | KEPCO. | Under Construction | KHKAECE | 01-Nov.-93 | 01-Nov.-98 | 01-Jan-99 | 01-Jun.-99 | |
| WOLSONG-2 | PHWR | 650 | KEPCO. | Under Construction | AECL/KHI | 25-Sep-92 | 01-Mar-97 | 01-Apr.-97 | 01-Jun.-97 | |
| WOLSONG-3 | PHWR | 650 | KEPCO. | Under Construction | AECL/KHI | 17-Mar-94 | 01-Mar-98 | 01-Apr.-98 | 01-Jun.-98 | |
| WOLSONG-4 | PHWR | 650 | KEPCO. | Under Construction | AECL/KHI | 22-Jul.-94 | 01-Mar-99 | 01-Apr.-99 | 01-Jun.-99 | |
| ULCHIN 5 | PWR | | KEPCO. | Planned | | 01-Apr.-99 | | | 01-Jun.-04 | |
| ULCHIN-6 | PWR | | KEPCO. | Planned | | 01-Apr.-99 | | | 01-Jun.-04 | |
| YONGGWANG-5 | PWR | 950 | KEPCO. | Planned | KHKAECE | 01-Sep-96 | | | 01-Jun.-01 | |
| YONGGWANG-6 | PWR | 950 | KEPCO. | Planned | KHKAECE | 01-Mar-97 | | | 01-Jun.-02 | |

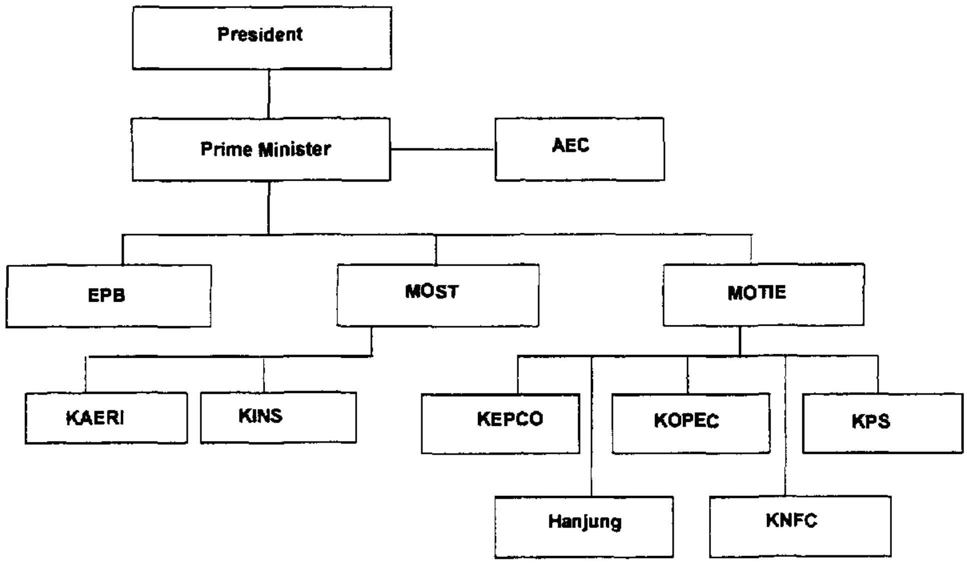
Power Reactor Information System, yearend 1996

TABLE 12. THE AVERAGE CAPACITY FACTOR OF NUCLEAR POWER PLANTS

| | 1980 | 1985 | 1990 | 1993 |
|---|---|---|---|---|
| Plant factor (%) | 67.4 | 78.7 | 79.3 | 87.2 |

### 3.4. Organizational Chart

The Nuclear Power Development Organization in Korea is shown in Figure 2:




AEC Atomic Energy Commission
EPB Economic Planning Board - See footnote page 334
MOST Ministry of Science and Technology
MOTIE Ministry of Trade, Industry and Energy
KAERI Korea Atomic Energy Research Institute
KINSKorea Institute of Nuclear Safety
KEPCO Korea Electric Power Corporation
KOPEC Korea Power Engineering Company
KPS Korea Power Plant Services Co.(Previously called KEPOS - Korea Electric Power Operation Services Co.)
KNFC Korea Nuclear Fuel Company
KINSKorea Nuclear Society
Hanjung Previously called HANJUNG (Korea Heavy Industry & Construction Co.)

*FIG. 2. Nuclear Power Development Organization in Korea*

## 4. NUCLEAR POWER INDUSTRY

In 1985, the Korean government made a milestone decision to implement the national self-reliance policy and divided the role among domestic nuclear organizations as follows:

| | |
|---|---|
| – Total Project Management | KEPCO |
| – Architectural Engineering | KOPEC |
| – Nuclear Steam Supply Systems /Fuel Design | KAERI |
| – Maintenance Services | KPS |
| – NSSS, Turbine and Generator Manufacturing | Hanjung |
| – Nuclear fuel Fabrication | KNFC |

This self-reliance strategy was applied during construction of Yonggwang 3 & 4 project. Domestic nuclear industries were the project's prime contractors with supporting technology transfer from foreign subcontractors. Since 1985, KAERI has been designated to be responsible for nuclear steam supply system design and engineering technology development through participation in the Yonggwang 3 & 4 nuclear power projects. As a result, Korea had achieved an overall self-reliance level of 95 % by the end of 1995.

### 4.1. Supply of Nuclear Power Plants

Hanjung is taking part in power plant construction in Korea by virtue of its capability to supply heavy industrial construction equipment and machinery built to precise standards.

KOPEC was established in 1975 to foster the nation's self-reliance in power technologies, particularly in nuclear power engineering for pressurised water reactors. As such, KOPEC carries out the prime architect engineer's responsibility for PWR's in Korea. KOPEC is collaborating with Canada to obtain also PHWR engineering experience.

KPS provides maintenance services for all the power stations including NPP's under operation or under start-up.

KNFC was established in November 1982 by the joint investment of KEPCO and KAERI to localise the nuclear fuel fabrication for pressurised water reactors.

### 4.2. Operation of Nuclear Power Plants

KEPCO is the sole entity in Korea responsible for long-term planning, development, generation, transmission, and distribution of electric power. KEPCO is also the largest stockholder of KOPEC, Hanjung, KEPOS and KNFC. It has implemented a comprehensive programme for improving the NPP's capacity factor leading to a steadily improvement of the Korean NPP's operation.

### 4.3. Fuel Cycle and Waste Management Service Supply

KAERI is a government-supported national nuclear research and development institute established to promote peaceful uses of nuclear energy in Korea. In September 1990, the Nuclear Environment Management Centre (NEMAC), an affiliated organization of KAERI, was established as the responsible organization for management of low-level radwaste and spent fuels in the nation. In order to carryout Korea's radioactive waste management programme more successfully, the government promulgated a law relating to the promotion of radioactive waste management programmes with support to neighbouring local support programmes, such as improvements in the standard of living, public works and education.

There are plans to build an Away From Reactor interim storage facility for spent fuel and a low/intermediate level radwaste disposal facility.

### 4.4. Research and Development Activities

The nuclear power R&D programme of the Republic of Korea, carried out by KEPCO and the Korean Atomic Energy Research Institute (KAERI) in co-operation with foreign companies, covers advanced reactor development and fuel cycle activities including fabrication of enriched uranium and mixed oxide fuel and management of spent fuel and radioactive waste. The development of an advanced reactor of domestic design is planned to be completed by the end of the century and the first unit of this type is schedule for commissioning before 2010.

## 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Korea is eager to share with other countries its experience in solving the difficult problems that arise in the various stages of planning and implementation of nuclear programmes for the peaceful uses of nuclear energy. The Republic of Korea has entered the international market as a nuclear technology supplier and in 1994 Korean companies signed agreements with China and Turkey. With respect to the latter, KAERI won a contract to provide comprehensive consultancy services to Turkey's first nuclear power plant project. Construction of Turkey's Akkuyu nuclear plant is scheduled to start in 1998. Because high-level technological consultation will be required during the construction of the Akkuyu Nuclear Power Plant, KAERI will supervise all administrative and technological activities related to the project, including evaluation of foreign suppliers of nuclear equipment. Under the contract, signed between KAERI and the Turkish Electricity Authority on December 30 1994, KAERI's consultancy work began in early 1995 and will continue for about one and a half years.

# 5. REGULATORY FRAMEWORK

## 5.1. Safety Authority and the licensing Procedures

There are three nuclear regulatory organizations in Korea :

- AEC a national level decision-making body;
- MOST a governmental regulatory authority with enforcement power;
- KINS a technical expert group established to support MOST.

Nuclear energy issues are principally the responsibility of the Atomic Energy Office within MOST and headed by an Assistant Vice Minister. KINS was established in February 1990 to support MOST with its technical expertise in the development of nuclear regulatory policy.

Regulation and licensing procedures for nuclear power plants in Korea (Figure 3) are divided into three stages:

- In the site selection stage, the conceptual design is examined to determine the appropriateness of the proposed site. The safety requirements of the site have been previously reviewed from standpoints of the design, the construction, and the operation of the plant.

- For the construction permit, the utility submits a Preliminary Safety Analysis Report (PSAR) and an overall quality assurance programme for the Project along with the reference design of the plant. Additionally, the utility is required to prepare an environmental impact statement.

- When the utility requests an operating license, MOST must confirm that the as-built plant conforms to the submitted design. In this stage, operational technical specification, and emergency plans and procedures against radiation hazards are submitted.

## 5.2. Main National Laws and Regulations

The Korean government promulgated the Atomic Energy Act as a fundamental legislation to regulate the nuclear activities in Korea. The regulatory organizations and functions are also described in the Act. MOST has ultimate responsibility for the protection of the public and environment, while the prime responsibility rests with the utilities.

In Korea, the legislative system of Atomic Energy law has several levels according to origination and applicability, i.e., the Atomic Energy Act, Enforcement Decree, Enforcement

Regulation, Notice of the Minister of MOST, and Technical Specification which is a part of the safety analysis reports. The regulatory authority for regulating nuclear industry activities is based on the Atomic Energy Act. In conformity with the atomic energy laws, the licensee submits to MOST various documents demonstrating the adequacy of the proposed design.

A Nuclear Damage Compensation Deliberation Committee within MOST co-ordinates extra-judicial settlement of claims for nuclear damage compensation and surveys and evaluates nuclear damage.

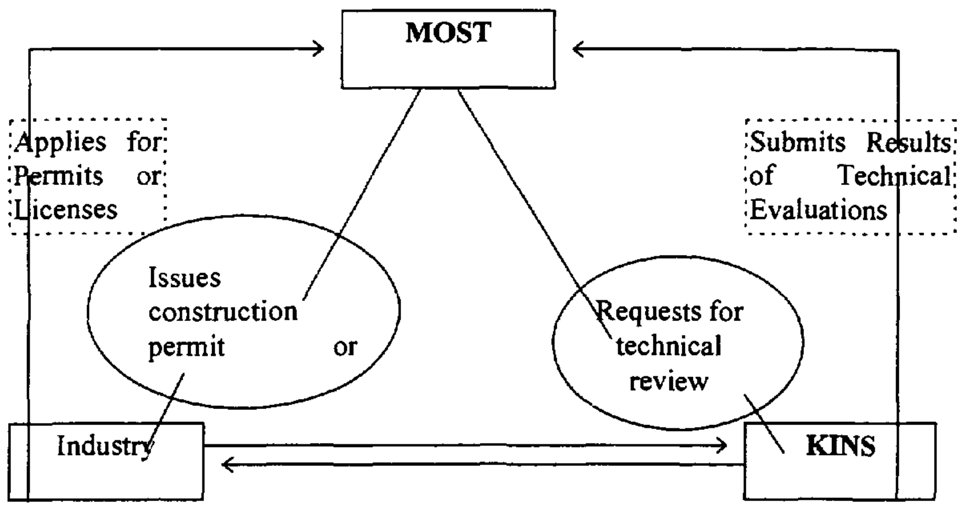



*FIG. 3. Licensing Procedure for Nuclear Facilities in Korea*

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related agreement INFCIRC/236 | Entry into force: | 14 November 1975 |
| • Improved procedures for designation of safeguards inspectors | Not yet accepted | |
| • Korea/USA, safeguards related INFCIRC/111 | Entry into force: | 5 January 1968 |
| • Korea/France, safeguards related INFCIRC/233 | Entry into force: | 22 September 1975 |
| • Korea/France, agreement on Technical Co-operation | In effect since | 1974. |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 21 January 1980 |
| • RCA | Entry into force: | 4 December 1992 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 23 April 1975 |
| • Agreement on privileges and immunities | Entry into force: | 17 January 1962 |
| • Convention on physical protection of nuclear material | Entry into force: | 8 February 1987 |
| • Convention on early notification of a nuclear accident | Entry into force: | 9 July 1990 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 9 July 1990 |
| • Conventions on civil liability for nuclear damage and joint protocol | Non-Party | |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines | Not adopted | |
| • Acceptance of NUSS Codes | No reply | |
| • Partial Test-Ban Treaty | Entry into force: | 24 July 1964 |

*BILATERAL AGREEMENTS*

- Agreement for Co-operation between the ROK and the USA concerning Civil Uses of Atomic Energy, in effect since 1956.
- Agreement between Korea and France for the Peaceful Uses of Nuclear Energy, signed in April 1981.
- Agreement between Korea and Canada for Co-operation in the Peaceful Uses of Atomic Energy, in effect since 1976.
- Agreement between Korea and Australia concerning Co-operation in Peaceful Uses of Nuclear Energy and the Transfer of Nuclear Materials, in effect since 1979
- Notes between Korea and Japan for co-operation in the field of peaceful uses of nuclear energy, exchanged in May 1990
- Protocol on co-operation in the field of peaceful uses of nuclear energy between the Ministry of Science and Technology of the ROK and the Ministry of Atomic Power and Industry of the USSR, in effect since December 1990.
- Agreement between the ROK and the UK for co-operation in the peaceful use of nuclear energy, signed in November 1991.

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[5] Korea Economic Yearbook, The Federation of Korean Industries, (1993).

[6] Korean Atomic Yearbook, Korea Atomic Industry Forum, (1994).

[7] Korean Nuclear Whitebook, MOTIE, KEPCO, (1994).

[8] Energy and Economic Data Base/IAEA.

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

**AEC**
Chungang-dong
Kwachon
Kyunggi-do — Tel.: +82-2-503-7646
Rep. of Korea — Fax: +82-2-503-7673

**MOST**
Government Complex II
Chungang-dong, Kwachon — Tel.: +82-2-503-7651
Kyunggi-do 427-760 — Fax: +82-2-503-7673
Rep. of Korea — Cable: MOSTROK SEOUL

**MOTIE**
1, Chungang-dong
Kwachon
Kyunggi-do — Tel.: +82-2-503-9600
Rep. of Korea — Fax: +82-2-503-9649

*OTHER NUCLEAR ORGANIZATIONS*

**KAERI**
150, Dukjin-dong
Yusong-ku
Taejon — Tel.: +82-42-868-2000
Rep. of Korea — Fax: +82-42-861-2702

**KINS**
150, Dukjin-dong
Yusong-ku
Taejon — Tel.: +82-42-868-2600
Rep. of Korea — Fax: +82-42-861-1700

**KEPCO**
167 Samsung-dong
Kangnam-ku
Seoul — Tel.: +82-2-550-3114
Rep of Korea — Fax: +82-2-550-4999

**Hanjung**
555 Guygok-dong
Changwon — Tel.: +82-2-551-69-6114
Rep. of Korea — Fax: +82-2-551-64-5551

**KOPEC**
87 Samsung-dong
Kangnam-ku
Seoul — Tel.: +82-2-510-5114
Rep. of Korea — Fax: +82-2-540-4184

**KNFC**
150, Dukjin-dong
Yusong-ku
Taejon
Rep. of Korea

Tel.: +82-42-868-1000
Fax: +82-42-861-2380\

**KPS**
87 Samsung-dong
Kangnam-ku
Seoul Tel.: +82-2-540-0077
Rep. of Korea

Fax: +82-2-547-4298

# LITHUANIA

## LITHUANIA

# 1. GENERAL INFORMATION

### 1.1. General Overview

The Republic of Lithuania is situated on the eastern coast of the Baltic sea, in central Europe. Lithuania is bordered by Latvia in the north, Byelorussia in the east, Poland in the south, Kaliningrad Region of the Russian Federation in the southwest and the Baltic sea in the west.

Lithuania is situated in a temperate climate zone. The average annual air temperature in Lithuania is 5.5°C, with 17.8°C in June and -6.5°C in January. The absolute maximum recorded temperature is 36°C and the absolute minimum -40°C. There are noticeable east-west weather variations. The western part, mostly influenced by the Baltic sea, is characterised by the smallest temperature variations. The eastern part, where the Ignalina nuclear power plant is situated, has longer and colder winters and warmer but shorter summers. Western and south western winds predominate.

The average annual amount of precipitation is 638 mm. About 70% of the precipitation takes place during the warm period of the year (April - October). The minimum relative humidity (53 - 63%) is in June and the maximum (exceeding 90%) in January.

The steady growth of the population (about 0.9% a year) in the period 1970 to 1990, primarily caused by influx of people from other Soviet republics, was abruptly stopped in 1991 and a period of slow decrease, caused mostly by the outflow, followed. The forecast of 0.4% growth in 1993 given in the National Energy Strategy did not materialise. The population was 3.7 million in 1993 (Table 1).

TABLE 1. POPULATION INFORMATION

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Population (millions) | 3.7 | 3.7 | 3.7 |
| Predicted population growth rate (%) 1994 to 2000 | -0.1 | | |
| Urban population in 1994 as percent of total | 71 | | |

Source: IAEA Energy and Economic Data Base

### 1.2. Economic Indicators

Lithuanian Gross Domestic Product (GDP) increased on average by 4.6% per year from 1980 to 1989. However, because of Lithuania's export oriented economy and the shortage of domestic mineral and energy resources, Lithuania suffered from a very steep decline in production during the transition to a market economy. A slow decrease of 5% in GDP in 1990 was followed by a much more serious recession during the period 1991 to 1993. The situation gradually stabilised in 1994 with preliminary data on GDP of the same level as in 1993. The historical GDP data are shown in Table 2.

### 1.3. Energy Situation

Lithuania's energy resources are not substantial and have not been thoroughly explored. The country has limited oil and gas reserves. There is no information about resources of uranium. There is a potential of about 400 MW(e) of hydro power, of which 100 MW(e) has been developed.

TABLE 2. GROSS DOMESTIC PRODUCT

| | 1980 | 1990 | 1992 | 1993 | 1994 | Growth rate (%) 1980 to 1993 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 10,705 | 1,275,687 | 550,131 | 433,526 | | 32.9 |
| GDP (millions of constant 1990 US$) | 741,857 | 1,275,687 | 669,564 | 560,799 | 564,164 | -2.1 |
| GDP per capita (current US$/capita) | | | 148,004 | 116,790 | | |
| GDP by sector : | | | | | | |
| Agriculture 20% | | | | | | |
| Industry 40% | | | | | | |
| Services 40% | | | | | | |

Source: IAEA Energy and Economic Data Base

Table 3 shows the historical energy statistics, Fig. 1 shows the share of the primary energy sources in the corresponding energy consumption and Fig. 2 the share of the various sectors in final energy demand. Table 4 shows the historical energy balance and Fig. 3 the share of the primary energy sources in the 1993 energy production.

TABLE 3. BASIC ENERGY SITUATION

Petajoule

| | 1960 | 1970 | 1980 | 1990 | 1991 | 1992 | 1993 | Average Annual Growth Rate (%) 1960 to 1980 | Average Annual Growth Rate (%) 1980 to 1993 |
|---|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | | |
| Total[(1)] | 175 | 315 | 515 | 686 | 769 | 471 | 382 | 294 | 74 |
| Solids[(2)] | 134 | 94 | 62 | 48 | 42 | 31 | 33 | 46 | 53 |
| Liquids | 39 | 173 | 344 | 255 | 337 | 163 | 151 | 882 | 44 |
| Gases | - | 46 | 107 | 196 | 203 | 116 | 63 | ... | 59 |
| Primary electricity[(3)] | 2 | 2 | 2 | 187 | 187 | 161 | 135 | 100 | 6750 |
| Energy production | | | | | | | | | |
| Total[(1)] | 87 | 43 | 22 | 201 | 204 | 178 | 153 | 25 | 695 |
| Solids | 85 | 41 | 20 | 13 | 15 | 14 | 16 | 24 | 80 |
| Liquids | - | - | - | 1 | 2 | 3 | 2 | - | - |
| Gases | - | - | - | - | - | - | - | - | - |
| Primary electricity | 2 | 2 | 2 | 187 | 187 | 161 | 135 | 100 | 6750 |
| Net import (import-export) | | | | | | | | | |
| Total | 88 | 272 | 493 | 485 | 565 | 293 | 229 | 560 | 46 |
| Solids | 49 | 53 | 42 | 35 | 27 | 17 | 17 | 86 | 40 |
| Liquids | 39 | 173 | 344 | 254 | 335 | 160 | 149 | 882 | 43 |
| Gases | - | 46 | 107 | 196 | 203 | 116 | 63 | - | 59 |

*(1) Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
*(2) Solid fuels include coal, lignite and commercial wood.*
*(3) Primary electricity = Hydro + Geothermal + Nuclear + Wind*

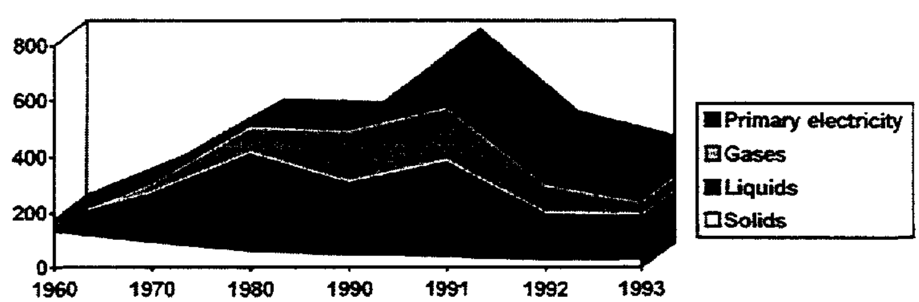


*FIG. 1. Energy consumption (PJ)*

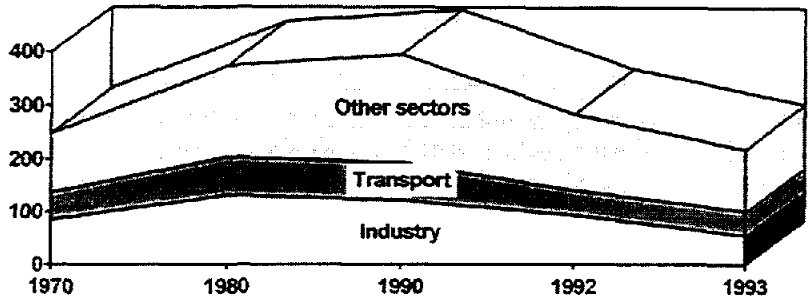


*FIG. 2. Final Energy Demand (PJ)*

TABLE 4. ENERGY BALANCE

PJ

| | 1970 | 1980 | 1990 | 1992 | 1993 |
|---|---|---|---|---|---|
| 1. Indigenous Production | 42.6 | 21.9 | 202.9 | 177.9 | 154.3 |
| 2. Import (+) | 281.6 | 495.2 | 628.5 | 320.3 | 295.6 |
| 3. Export (-) | 12.9 | 0.4 | 166.0 | 42.2 | 71.3 |
| 4. Stock Changes (±) | 4.1 | 1.6 | 20.9 | 15.5 | 3.6 |
| 5. Primary Energy Supply | 315.3 | 515.1 | 686.4 | 471.5 | 382.3 |
| 6. Net Transformation Input | 48.2 | 79.8 | 200.0 | 131.5 | 100.7 |
| 7. Energy Sector Own Use | 1.8 | 14.0 | 38.1 | 23.7 | 37.5 |
| 8. Energy Losses | 5.2 | 11.2 | 13.5 | 13.0 | 15.6 |
| 9. Non-Energy Use | 12.4 | 36.7 | 39.5 | 19.3 | 9.0 |
| 10. Final Energy Demand | 247.7 | 373.5 | 395.4 | 284.1 | 219.5 |
| 10.1 Industry | 84.4 | 131.7 | 122.2 | 93.9 | 55.3 |
| 10.2 Transport | 53.5 | 73.3 | 72.7 | 48.0 | 47.1 |
| 10.3 Other Sectors | 109.7 | 168.0 | 200.4 | 142.2 | 117.1 |
| 11. Energy per capita, GJ/cap | | | | | |
| 11.1 Primary Energy Supply | 100 | 138 | 184 | 125 | 102 |
| 11.2 Final Energy Use | 79 | 109 | 106 | 76 | 58 |

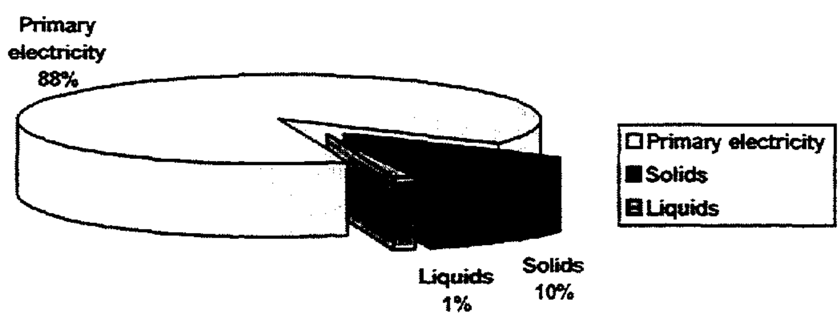


*FIG. 3. Energy production (PJ) in 1993*

## 1.4. Energy Policy

The National Energy Strategy, prepared in 1993 and approved by the Lithuanian Government in March 1994, states that there is no additional capacity needed through the year 2000. When the need for additional capacity emerges, priority should be given to investments in cogeneration plants. Determination of the site and power capacity of future power plants should be based on a comprehensive analysis of the loads in the Lithuanian electricity network and heat demand in the various towns.

The broad range of electricity demand projections is caused by an uncertainty in economic development and pace of reforms. It is advisable to keep both units of the Ignalina nuclear power plant operating regardless of the level of electricity demand. Completion of the third unit at the Kruonis pumped storage hydro plant is justified under any scenario.

The Lithuanian Power Plant (LPP) serves mainly as a long-term reserve. Therefore, this plant and combined heat and power plants should be rehabilitated to a minimal extent. On the other hand, by recent decision, LPP was selected to perform testing for a new kind of fuel for thermal plants "oremulsion", supplied by Venezuela. Import of oremulsion can play a significant role in diversifying the supply sources.

It is necessary to prepare, in the immediate future, a programme of modernisation and rehabilitation of the main equipment in the national electricity network.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Generation of electric power in Lithuania is provided by the Joint Stock Company "Lietuvos Energija" (LE) and the Ignalina Nuclear Power Station. All power generated at Ignalina is sold to LE. LE is a specific state enterprise under the Ministry of Energy with responsibility for production and transmission of power nationwide, and for supplying heat from combined production. LE sells power to seven regional network utilities, who, in turn, distribute and sell it to the end users. The network utilities are specific state enterprises but have very limited financial autonomy in relation to LE. A deficit in the budget is transferred to LE as a result of the tariff system, and investments are partly paid by the Government and partly by the municipalities.

The national transmission system in Lithuania comprises 330 kV and 110 kV grids which connect all power stations to the load centres throughout Lithuania. Electricity export interconnections already exist with Latvia, Belarus and Kaliningrad via the Interconnected Power System (IPS) of the former Soviet Union.

Although Lithuania has had some preliminary talks with Poland on possible transmission of electricity to western countries across Poland, currently there is no definite electricity export market for Lithuania. In any case, Lithuania is considering building additional transmission lines from the Kruonis hydro pumped storage unit, through Alytus, to the border with Poland.

### 2.2. Policy and Decision Making Process

The highest body of state power in the Republic of Lithuania is the Seimas (Parliament). Seimas has a number of standing committees on most sectors such as science, culture and education, but there is no specific committee for energy. According to the Energy Act of the Republic of Lithuania (Lietuvos Respublikos Energetikos Istatymas) adopted by Seimas in March 1995, the Ministry of Energy is responsible for preparing the National Energy Strategy (drafted by the Energy Agency) covering a period of not less than 20 years, and updating it every five years. From the end of 1996 the Ministry of Energy has become a part of the new Ministry of National Economy. The Strategy is approved by Seimas. Seimas is also entitled to approve the list of State energy sector enterprises.

The Government is responsible for establishment of rules for the use of energy and energy resources. It is also responsible for establishing procedures for new state or privately owned enterprises, joint ventures and foreign owned companies in the power sector.

Tariffs and other activities in the power sector are examined and controlled by the State Commission. The State Commission is proposed by the Government and approved by the President for a period of five years.

The regulatory bodies of the energy sector are the ministries and the municipalities. The main body is the Ministry of Energy (State Power Inspection was established in January 1995 subject to the Ministry of Energy) although several other ministries, such as Ministry of Finances, Ministry of Economics, Ministry of Industry and Trade, Ministry of Environmental Protection, and Ministry of Construction and Urban Development are involved to some degree in the regulation of energy supply and consumption. At the ministerial level, there is no clear distinction between institutions responsible for policy making and those responsible for regulation.

### 2.3. Main Indicators

Tables 5, 6 and 7 show the historical statistics of the electricity balance, installed capacities and energy related ratios respectively.

TABLE 5. ELECTRICITY BALANCE

TW·h

| Items | 1960 | 1970 | 1980 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|
| 1. Gross Production | 1.12 | 7.36 | 11.67 | 28.41 | 29.36 | 18.71 | 14.11 |
| 2. Import - Export (±) | 0.01 | -2.18 | -0.11 | -11.97 | -12.75 | -5.30 | -2.73 |
| 3. Gross Consumption | 1.13 | 5.18 | 11.56 | 16.44 | 16.61 | 13.41 | 11.38 |
| 4. Own Use of Power Plants | 0.01 | 0.43 | 0.66 | 2.11 | 2.22 | 1.75 | 1.55 |
| 5. Hydro Pumped Storage | - | - | - | - | - | 0.24 | 0.28 |
| 6. Net Production | *1.10* | *6.93* | *11.01* | *26.30* | *27.15* | *16.72* | *12.28* |
| 7. Losses in Network | 0.11 | 0.64 | 1.37 | 1.55 | 1.71 | 1.69 | 1.91 |
| 8. Net Consumption | 1.01 | 4.11 | 9.53 | 12.78 | 12.69 | 9.73 | 7.64 |
| 9. Electricity per capita, kW·h/cap | | | | | | | |
| 9.1 Gross Production | 403 | 2337 | 3402 | 7637 | 7850 | 4976 | 3765 |
| 9.2 Gross Consumption | 406 | 1644 | 3370 | 4419 | 4441 | 3566 | 3033 |
| 9.3 Net Consumption | 363 | 1308 | 2778 | 3435 | 3393 | 2588 | 2037 |

TABLE 6. INSTALLED CAPACITY OF THE POWER PLANTS

MW(e)

| Items | 1960 | 1970 | 1980 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|
| 1. Conventional Thermal Power Plants | 308 | 1375 | 2293 | 2655 | 2633 | 2633 | 2633 |
| 1.1 Electricity only Plant | - | 1200 | 1800 | 1800 | 1800 | 1800 | 1800 |
| 1.2 Combined Heat and Power Plants | 308 | 175 | 493 | 855 | 833 | 833 | 833 |
| 2. Nuclear Power Plant | - | - | - | 3000 | 3000 | 3000 | 3000 |
| 3. Hydro Power Plants | 104 | 98 | 107 | 106 | 106 | 106 | 106 |
| 4. Hydro Pumped Storage | - | - | - | - | - | 400 | 400 |
| TOTAL | 412 | 1473 | 2400 | 5761 | 5739 | 6139 | 6139 |
| Electricity capacity per capita, kW/cap | 0.15 | 0.47 | 0.70 | 1.55 | 1.53 | 1.63 | 1.64 |

TABLE 7. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 63 | 100 | 138 | 184 | 207 | 125 | 102 |
| Electricity per capita (kWh/capita) | 403 | 2,337 | 3,402 | 7,637 | 7,850 | 4,976 | 3,765 |
| Electricity production / Energy production (%) | 18 | 158 | 468 | 139 | 142 | 106 | 97 |
| Nuclear/Total electricity (%) | - | - | - | 60 | 58 | 78 | 87 |
| Ratio of external dependency (%) | 50 | 86 | 96 | 71 | 73 | 62 | 60 |
| Load factor of electricity plants | | | | | | | |
| - Total (%) | 94 | 95 | 96 | 85 | 88 | 55 | 42 |
| - Thermal | 94 | 95 | 96 | 83 | 90 | 27 | 10 |
| - Hydro | 75 | 86 | 94 | 82 | 68 | ... | ... |
| - Nuclear | - | - | - | 87 | 87 | 75 | 63 |

The two 1,500 MW(e) RBMK units of Ignalina, downrated to about 1,250 MW(e) for safety reasons, are supplying about 80% of the electricity consumption of Lithuania and allow export of electricity to Latvia. In fact, the thermal capacity of the Ignalina units is downrated from 4,800 MWth to 4,200 MWth, so the maximum electrical output depends on the cooling conditions.

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

The decision to build a nuclear power plant in the Baltic region for electricity supply to the Baltic States, Belarus and Kaliningrad was made by the former government of the Soviet Union at the beginning of the seventies. After the formal agreement of the Lithuanian Government, the site on the shore of Druksiai lake near the borders of Lithuania, Latvia and Belarus was selected. The construction of the first unit of the Ignalina Nuclear Power Plant (INPP) started in April 1978, the second unit followed in April 1980, and the third unit in 1985. The town of Visaginas (formerly named Snieckus) was built for the workers of the INPP. The first unit was commissioned in December 1983 and the second in August 1987. In August 1988, the construction of the third unit was suspended by the former USSR Council of Ministers. In November 1993, after Western experts expressed the opinion that unit 3 was not suitable for installation of a safer nuclear reactor, the Lithuanian Government decided to abandon the construction of unit 3 and dismantle the existing structure.

### 3.2. Current Policy Issues

Apart from the short period of regaining independence, when the slogan "down with all Soviet time monsters" was popular, there have been no strong antinuclear movements in Lithuania. The current sentiment of the public can be explained not by lack of awareness of the risks involved by the utilization of nuclear energy, but, in the face of the difficult economic conditions, by the considerably lower price of "nuclear electricity" which outweighs its possible risks.

Until December 1994, Ignalina nuclear power plant had a status of State Enterprise for Special Purpose with some restrictions on privatisation issues, after which it was excluded from the list of Special Purpose enterprises. There are strong opinions against its partial privatisation in the Parliament so this issue will be undecided for some time.

The safety level of the Ignalina nuclear power plant during the times of very limited financial resources is one of the main concerns of the Lithuanian Government. In 1993, after numerous consultations with Western, Russian and Lithuanian experts, the Ignalina Safety Enhancement Programme was developed. Main safety issues were ranked in order of importance. A Grant Agreement between the European Bank for Reconstruction and Development and the Government of Lithuania, signed in February 1994, was very helpful in the resolution of most urgent safety issues.

Currently, a substantial part of income from electricity sales is used to subsidise district heating. Residential consumers pay only part of the cost of heating. In the course of the next two years, however, a larger part of the income will be made available for safety enhancement purposes.

Financing for spent fuel and radioactive waste storage and funding for decommissioning of nuclear power plants must be resolved. New amendments to taxation laws regarding profits permitting deductions for electricity costs, are expected to be approved by Lithuanian Parliament. Resolutions should be adopted by the end of 1995.

### 3.3. Status and Trends of Nuclear Power

Table 8 shows the status of the nuclear power reactors. Both units of Ignalina nuclear power plant were operating steadily during the last few years. Nevertheless, the plant did not have good performance indicators because of the decreased demand for electricity (Table 9). Even though the share of electricity produced by nuclear means was constantly growing due to the high prices of organic fuel, the units were shut down for four weeks in the summer of 1994, when Russia proposed to repay its debts back by electricity. Another shutdown occurred in November 1994 due to a supposed threat of sabotage. Thus, the share of nuclear electricity in 1994 was less than the previous year's (Table 10 and Fig. 4.).

TABLE 8. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| IGNALINA-1 | LWGR | 1185 | INPP | Operational | MAEP |
| IGNALINA-2 | LWGR | 1185 | INPP | Operational | MAEP |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| IGNALINA-1 | 01-May-77 | 04-Oct-83 | 31-Dec-83 | 01-May-84 | |
| IGNALINA-2 | 01-Jan-78 | 01-Dec-86 | 20-Aug-87 | 20-Aug-87 | |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 9. ENERGY AVAILABILITY FACTOR

| | Year 1993 | | Year 1994 | |
|---|---|---|---|---|
| | Unit 1 | Unit 2 | Unit 1 | Unit 2 |
| Energy availability factor (%) | 35.19 | 38.22 | 33.34 | 30.51 |

Source: IAEA Power Reactor Information System

TABLE 10. NUCLEAR POWER AND TOTAL ELECTRICITY GENERATION

TW·h

| Year | 1985 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|---|---|
| Nuclear | 9.48 | 16.65 | 17.03 | 17.0 | 14.64 | 12.27 | 7.71 | 11.8 | 12.7 |
| Total | 20.96 | 29.16 | 28.40 | 29.39 | 18.72 | 14.10 | 10.02 | 13.9 | 15.2 |
| Nuclear (%) | 45.2 | 57.1 | 60.0 | 57.8 | 78.2 | 87.0 | 77.0 | 84.9 | 83.4 |

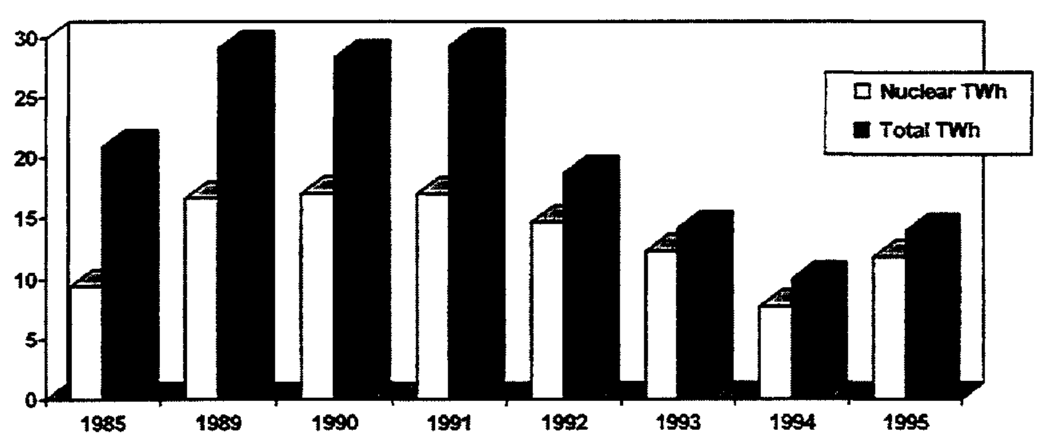


*FIG. 4. Nuclear Power and Total Electricity Generation*

On March 19, 1994, the Government of Lithuania adopted resolution No. 288 "On the National Energy Strategy", which states that the decisions on the future development of nuclear energy will be developed and approved by the year 1998. The same document approved completion of the Kruonis hydro pumped storage units 3 and 4.

In 1998, after the preparation of Ignalina Safety Analysis Report by the team of Lithuanian and foreign specialists and evaluation of the necessary further investments for safety enhancement, the Lithuanian regulatory authority (State Nuclear Power Safety Inspectorate) should take a decision whether it will extend the operating license of Ignalina unit 1.

### 3.4. Organisational Chart

See Fig. 5 of interaction between governmental and regulatory bodies and Ignalina nuclear power plant.

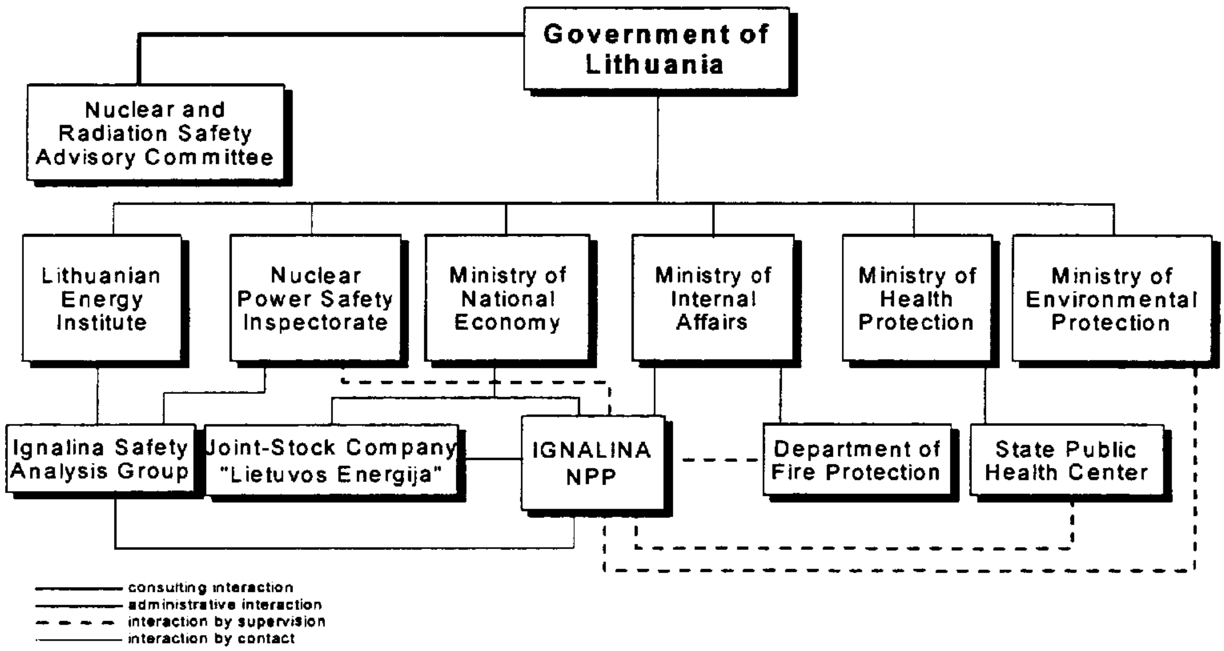


*FIG.5. Organizational Chart of Nuclear Power*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

Both units of the Ignalina nuclear power plant are of the RBMK type reactors, designed and constructed by the former USSR's Ministry for Nuclear Power Industry. Only two units of the new design RBMK-1500 were built, representing the most powerful nuclear units in the territory of the former USSR. An overview of the various institutions responsible for the design and construction of the RBMK type reactors is shown in Figure 6.

The development of the Ignalina nuclear power plant project was carried out by the All-Union Research and Development Institute for Energy Technology (VNIPIET) of Moscow, Russia, as the main designer. The institute originated the design of the reactor internals and other primary system components. The Accident Confinement System was designed by the Institute's Sverdlovsk branch in Ekaterinburg, Russia. Metal structures of the main building were designed by the Main Design Office "Leningrad Steel Design" ("Leningradstalkonstrukcija") of St. Petersburg, Russia. The turbine hall, the open distributive system, and auxiliary facilities were developed by the Kiev branch of the Atomic Energy Design Institute ("Atomenergoproekt") of Kiev, Ukraine.

The scientific supervisor of the RBMK-1500 project was the Kurchatov Atomic Energy Institute (often referred to as the Russian Research Centre "Kurchatov Institute") in Moscow, Russia. The main designer of the nuclear steam supply system was the Research and Development Institute of Power Engineering (NIKIET) in Moscow, Russia. Russia is also the main supplier of spare parts to the Ignalina nuclear power plant.

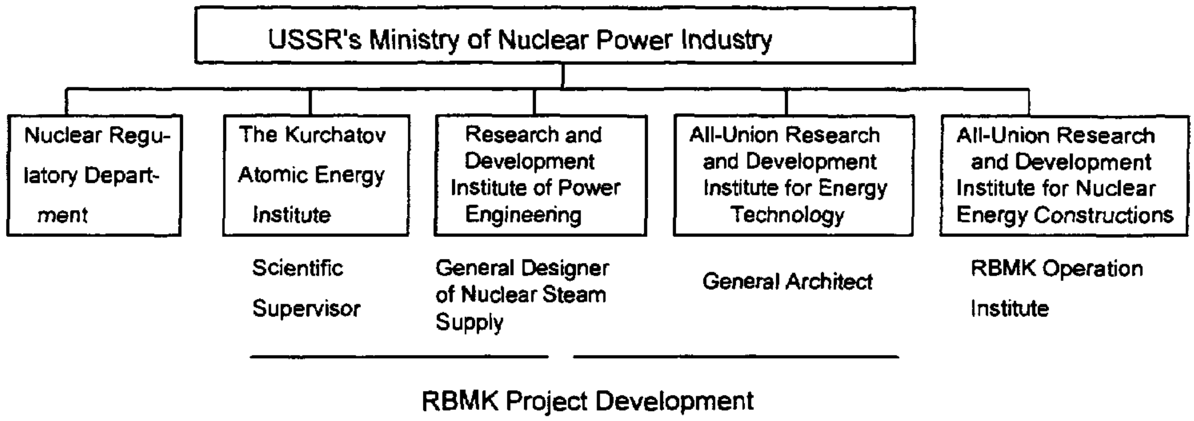


*FIG. 6. Scope of responsibility for the RBMK-type reactor projects*

### 4.2. Operation of Nuclear Power Plants

The Ignalina nuclear power plant is owned by the Republic of Lithuania through the Ministry of Energy. At the present time, INPP entitles the rights as operator of a nuclear installation. For other purposes, such as liability to foreign countries, the State is assumed to be the operator. The Ignalina nuclear power plant management was partially reorganised in 1995.

The electricity produced by Ignalina nuclear power plant is sold to the Joint Stock Company "Lietuvos Energija" on a contractual basis. The contract limits the production level of Ignalina NPP. This is necessary because of the existing surplus in generating capacity.

### 4.3. Fuel Cycle and Waste Management Service Supply

Lithuania has no fuel cycle industry. Up until now, all the nuclear fuel has been supplied by Russia. However, Lithuania is looking for new suppliers of nuclear fuel.

Originally, spent nuclear fuel from Ignalina was to be managed by central Soviet agencies for reprocessing and final disposal of the radioactive wastes. The recovered uranium and plutonium were to be retained by the central agencies in the Soviet Union. However, with the disintegration of the Soviet Union, Lithuania was obliged to find other solutions. As an interim measure, in November 1993, Lithuanian Government approved temporary storage of spent fuel in containers for forty to fifty years until more permanent solutions for final conditioning and disposal are found.

### 4.4. Research and Development Activities

All research and development activities are co-ordinated by the Energy Forecast Division and the Nuclear Energy Division of the State Enterprise "Energy Agency". Apart from the Lithuanian Energy Institute (LEI) in Kaunas (including Ignalina Safety Analysis Group) and the Institute of Physics in Vilnius, there are only small groups of persons in the research and educational institutions, who are occasionally involved with independent expertise and research. As the first step to develop better technical support, the Centre for Non-destructive Testing at Kaunas University of Technology and the Laboratory of Welding and Material Analysis at Vilnius Technical University were recently created. With the aid of the European Commission, these facilities were equipped with modern instrumentation.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Lithuania has multilateral and bilateral projects, mostly concerning safety of nuclear power plants, with several highly developed Western countries, including Sweden, Germany, the USA, the UK, France, Belgium, Italy, Switzerland, Denmark, Canada, Finland and Japan.

The main multilateral projects are the TACIS founded International RBMK Safety Review Consortium, Lord Marshall's Users Group for Soviet Designed Reactors and the IAEA extra budgetary programme on RBMK reactors. One of the most important project for Lithuania is the international project "Safety of Design Solutions and Operation of NPP's with RBMK Reactors" covering a broad range of safety related topics with unit 2 of the Ignalina NPP used as a reference plant.

Especially Sweden is an active partner in Lithuania. Three phases of the joint Lithuanian-Swedish-Russian project "Barselina", level 1 probabilistic safety analysis of the Ignalina unit 2, have been completed. This project provides a unified basis for the assessment of severe accident risks for RBMK type reactors and the preparation of remedial measures. Some of the improvements highlighted by PSA have already been implemented at the Ignalina nuclear power plant. Another project of the Lithuanian-Swedish bilateral programme is the application of modern non-destructive testing (NDT) systems for in-service inspection of the pressure boundary system. One other project is the preparation of an "Overall Plan for Radioactive Waste Management" in Lithuania by Swedish Nuclear Fuel and Waste Management Co., SKB.

There are a number of projects with the USA financed by the Department of Energy and USAID framework of Nuclear Safety Assistance Programme for Lithuania. The Ignalina Source Book was prepared and printed in 1994 in close co-operation with the University of Maryland. Brookhaven National Laboratory (BNL) and Science Application International Corporation (SAIC) from the USA together with Ignalina Safety Analysis Group (ISAG) are developing the RELAP5 model for the Ignalina nuclear power plant. BNL also assists with the development of the Ignalina Nuclear Plant Analyser, and the University of Maryland is conducting an assessment of the Accident Confinement System using the software code CONTAIN. A team of American experts, led by Gilbert/Commonwealth International Inc., is working on an improved reliability communication system between Ignalina nuclear power plant and main interested bodies for emergency situations.

GRS (Germany) and ISAG are involved in the co-operative project of Analysis of Safety Aspects of Ignalina NPP, including the studies of neutron dynamics and thermal hydraulics. A compact simulator for operator training of normal and accident scenarios was developed by CORYS (France) and TRACTEBEL (Belgium). Japan and Canada mainly provide educational and training courses in the formation of organisations, safety design, waste management, maintenance and inspection of NPP's. The Lithuanian-Italian co-operative project of seismic evaluation of the Ignalina nuclear power plant is in progress. A seismic network is to be placed in and 30 km around the plant. The British authority AEA has launched two Ignalina specific programmes: checking the reliability of the Ignalina ultrasonic inspection devices on British mock-ups during the plant operation and a leak before break analysis, including the use of a code treating a transition weld. A Swiss consortium of independent engineers evaluated the design concepts for interim storage of spent fuel elements. Finland, in association with Sweden, is working on radiation control at the Ignalina nuclear power plant.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the licensing Procedures

In 1991, just after Lithuania regained independence, the national regulatory authority - State Nuclear Power Safety Inspectorate (VATESI) - was created. The statute of VATESI was approved by the Government in October 1992. Most of the existing Soviet laws and rules, as well as earlier decisions, were accepted as valid in Lithuania. So until 1994, VATESI was not directly involved in the licensing of nuclear power plants. In autumn of 1994, VATESI, aided by Swedish experts, started the first licensing activity - licensing of spent fuel storage at the Ignalina nuclear power plant site. In 1997, VATESI is supposed to issue the license for the operation of Ignalina NPP unit 1.

According to the Nuclear Energy Law, VATESI is responsible for licensing design, construction, reconstruction and operation of nuclear power plants, storage and disposal of radioactive waste, and purchase and transportation of nuclear materials. The Ministry of Health is responsible for licensing of purchases and transportation of radioactive materials, and the Ministry of Economics for export, import and transportation of nuclear and radioactive materials and equipment. In June 1995, the Nuclear Safety Advisory Committee consisting of Lithuanian and foreign specialists proposed the creation of a Board of Governors to control the activities of VATESI. It may be created in 1997.

### 5.2. Main National Laws and Regulations

- Nuclear Energy Law (Branduolines energijos istatymas), adopted by Seimas on 14 November, 1996.

- Energy Law of Republic of Lithuania (Lietuvos Respublikos energetikos istatymas), adopted by Seimas on 28 March, 1995.

- Law on the Enforcement of Application of the Vienna Convention on Civil Liability for Nuclear Damage of 21 May 1963 and the Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention of 21 September 1988 (Istatymas del 1963m. geguzes 21 d. Vienos Konvencijos del civilines atsakomybes uz branduoline zala ir Bendro Protokolo del Vienos Konvencijos bei Paryziaus Konvencijos taikymo isigaliojimo), adopted by Seimas 30 November 1993. The Law gives the main articles of Vienna Convention and Joint Protocol the validity of the law with direct applicability before the courts. Several nuclear installations by one operator located at the same site are considered as a single nuclear installation. The liability of the operator is defined as a sum in Lithuanian currency (litas) equivalent to the minimal liability amount, referred to in Article V of Vienna Convention.

- Decree of Lithuanian Government Nr. 1403 of November 2, 1995 provides for deduction of 16.6% of internal electricity cost for plant decommissioning fund.

- Law on the amendments and supplements to the Law on taxes on profit of legal persons (Istatymas dël Lietuvos Respublikos juridiniu asmenu pelno mokescio istatymo pakeitimo ir papildymo), adopted by Seimas on April 11, 1995. Item 10, allowing the inclusion of other expenses associated to the Ignalina NPP, provided by Government decrees, is added to the earlier Law. Corresponding Government decrees on the deductions for the management of radioactive waste and increasing the rate of deductions for decommissioning fund should also be adopted by Government by the end of 1995.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related agreement INFCIRC/413 | Entry into force: | 15 October 1992 |
| • Improved procedures for designation of safeguards inspectors | Accepted | |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 22 February1995 |

*OTHER RELEVANT INTERNATIONAL TREATIES*

| | | |
|---|---|---|
| • NPT | Entry into force: | 23 September 1991 |
| • Agreement on privileges and immunities | Non Party | |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Non-Party | |
| • Agreement for the application on Safeguards in connection with the Treaty on the Non-proliferation of Nuclear Weapons | Entry into force: | 15 October 1992 |
| • Membership in IAEA | | 18 November 1993 |
| • Vienna Convention on civil liability for nuclear damage | Entry into force: | 15 December 1992 |
| • Joint protocol relating to the application of the Vienna Convention and the Paris Convention | Entry into force: | 20 December 1993 |
| • Convention on the physical protection of nuclear material | Entry into force: | 6 January 1994 |
| • Convention on early notification of a nuclear accident | Entry into force: | 17 December 1994 |
| • Convention on nuclear safety | Ratification: | 12 June 1996 |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines | Not Adopted | |
| • Acceptance of NUSS Codes | Accepted | |

Lithuania intends to deposit the Instrument of ratification of International Convention on Nuclear Safety with IAEA in the near future. There are also plans to join the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency in 1995.

*BILATERAL AGREEMENTS*

- Agreement between the Government of the Kingdom of Denmark and the Government of the Republic of Lithuania concerning information exchange and co-operation in the fields of nuclear safety and radiation protection - signed on 16 March 1993;

- Agreement between the Government of Republic of Lithuania and the Government of Canada for the co-operation in the peaceful uses of nuclear energy - signed on 17 November 1994;

- Agreement between Commissariat a l'Énergie Atomique de France and Ministry of Energy of Lithuania on the co-operation in the peaceful use of nuclear energy - signed on 26 April 1994;

- Agreement between the Government of the Republic of Lithuania and the Government of the Kingdom of Norway on early notification of nuclear accidents and on the exchange of information on nuclear facilities - signed on 13 February 1995;

- Agreement between the Government of the Republic of Lithuania and the Government of the Republic Poland on early notification of a nuclear accidents, and on co-operation in the field of nuclear safety and radiation protection - signed on 2 June 1995.

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[2] Republic of Lithuania. National Energy Strategy. Volume II. Background Material for Strategy Development. Final Report. IC Consult, ERM Energy Limited COWIconsult (with Technical Assistance of EC - PHARE) and Lithuanian Energy Institute, (December 1993).

[3] Almenas, A. Kaliatka, E. Uðpuras. Ignalina RBMK - 1500. A Source Book. Ignalina Safety Analysis Group, Lithuanian Energy Institute. Litterae Universitatis Vytauti Magni, Kaunas, (1994).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*MAIN NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Ministry of National Economy<br>Gedimino pr. 38/2, 2600 Vilnius | Tel. 370 2 61 88 96<br>Fax. 370 2 62 39 74 |

*MAIN NATIONAL REGULATORY AUTHORITY*

| | |
|---|---|
| State Nuclear Power Safety Inspectorate<br>36 Gedimino, 2600 Vilnius | Tel. 370 2 61 44 29<br>Fax. 370 2 61 44 87 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Lithuanian Energy Institute<br>3 Breslaujos, 3035 Kaunas | Tel. 370 7 75 73 04<br>Fax. 370 7 75 12 71 |
| Lithuanian Energy Institute<br>Ignalina Safety Analysis Group (ISAG)<br>3 Breslaujos, 3035 Kaunas | <br>Tel. 370 7 74 87 25<br>Fax. 370 7 75 12 71 |
| Ignalina State Nuclear Power Plant<br>Visaginas, 4761 Ignalina d. | Tel. 370 66 37029<br>Fax. 370 66 29350 |
| Joint-Stock Company "Lietuvos Energija"<br>14 Zveju, 2748 Vilnius | Tel. 370 2 75 07 93<br>Fax. 370 2 22 67 36 |
| State Public Health Center<br>Center of Radiology<br>153 Kalvariju, 2042 Vilnius | <br>Tel. 370 2 76 36 33<br>Fax. 370 2 76 52 81 |
| Ministry of Environmental Protection<br>9 A. Juozapaviciaus, 2600 Vilnius | Tel. 370 2 72 58 68<br>Fax. 370 2 72 80 20 |

# MEXICO

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MEXICO

# 1. GENERAL INFORMATION

## 1.1. General Overview

Mexico is located in the southern part of the North American continent. In the north it has a common boundary with the United Sates, in the south with Guatemala and Belize, to the east lies the Gulf of Mexico and the Caribbean sea, and to the west the Pacific Ocean. Its extreme latitudes are 32°43'N in the north and 14°33'N in the south. Its extreme longitudes are 86°46' West of Greenwich in the east and 117°08' West of Greenwich in the west. The total surface of Mexico is 1,969,270 $km^2$.

Two main features have to be taken into account regarding the climate of Mexico, in the first place the existence of two mountain ranges, one following the pacific coast and the other the Gulf of Mexico coast with a high plateau between the two ranges and, in the second place, the fact that the country is divided into two by the Tropic of Cancer. In a very broad sense, the climate south of the Tropic of Cancer is warm with an average temperature around 22°C, when the altitude above sea level is below 1,000m, and the climate is temperate with an average temperature around 15°C, above 1,000m where the altitude prevails, with a broad daily oscillation. North of the Tropic of Cancer the climate is warm during the summer and cold during the winter, with occasional snowfalls. The four traditional seasons are only felt in some parts in the north of the country. The rest divides the year in two periods: the rainy season, that goes from April to September and the dry season embracing the rest of the year.

The Laguna Verde Nuclear Power Plant is located in the coast of the Gulf of Mexico at a latitude of 19°43'30" North and a longitude of 96°23'15" West. The climate is warm and humid (koepen classification); with rain during the summer and with little precipitation during winter. The annual average humidity is 80%, during the year the temperature oscillates between a minimum of 8°C and a maximum of 39°C. The prevailing winds, specially during summer, blow from the Northeast, during winter the site is affected by winds coming from the north with velocities between 70 and 90 km. per hour. The sea water, which is used as cooling water, has an average annual temperature of 26°C, with a maximum during summer of 32°C and a minimum in winter of 21°C.

In 1993, the Mexican population reached almost 90 millions inhabitants (see Table 1) and it was estimated to grow with 1.6 million in absolute terms in 1994. The population growth rate in 1993 was 2 per cent and the population density 46 inhabitants per square kilometre.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 36.9 | 50.5 | 67.1 | 84.5 | 90.0 | 91.9 | 2.3 |
| Population density (inhabitants/$km^2$) | 18.8 | 25.8 | 34.2 | 43.2 | 46.0 | 46.9 | |
| Predicted population growth rate (%) 1993 to 2000 | | 1.8 | | | | | |
| Area (1000 $km^2$) | | 1,958.2 | | | | | |
| Urban population in 1993 as percent of total | | 74.0 | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

The total Gross Domestic Product (GDP) in 1994 was 195 billion constant 1990 US$ and its growth rate over the last 13 years was of 1.8 per cent (Table 2). A more detailed breakdown of the GDP per sector in 1993 is given in Table 3.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1993 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 37,151 | 194,766 | 175,839 | 206,531 | | 0.5 |
| GDP (millions of constant 1990 US$) | 78,680 | 149,092 | 175,839 | 188,446 | 195,042 | 1.8 |
| GDP per capita (current US$/capita) | 736 | 2,905 | 2,081 | 2,294 | | -1.8 |
| GDP by sector (1993): Agriculture 8%, Industry 28%, Services 64% | | | | | | |

Source: IAEA Energy and Economic Data Base

TABLE 3. DETAILED GDP BY SECTOR IN 1993

| Sector | % |
|---|---|
| - Farming, silviculture and fishing | 8 |
| - Mining | 2 |
| - Manufacturing industry | 20 |
| - Construction | 5 |
| - Electricity, gas and water | 1 |
| - Trade, restaurants and hotels | 24 |
| - Transport, storage and communications | 10 |
| - Financial services, insurances and real state | 14 |
| - Communal, social and personal services | 16 |

### 1.3. Energy Situation

Mexico has abundant oil, gas, coal and hydro resources (Table 4). The total proven reserves of hydrocarbons amount to 63,220 millions barrels, equivalent to 48 years of the present production. Mexico is not only energy self sufficient, but is also a net exporter of energy.

TABLE 4. ENERGY RESERVES

| | Estimated energy reserves in 1993 (Exajoule) | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium(1) | Hydro(2) | Total |
| Total amount in place | 39.80 | 255.32 | 89.10 | | 48.20 | 432.42 |

(1) *This total represents essentially recoverable reserves.*

(2) *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.*

Source: IAEA Energy and Economic Data Base

Mexico depends heavily on hydrocarbons, during 1993 the primary energy production came 72.3% from crude oil and condensates, 17.4% from natural gas, 4.4% from biomass, 3.1% from hydro, 1.5% from coal, 0.7% from geothermal fields and 0.6% from nuclear energy. Roughly half of the crude oil production is exported and half used to satisfy the internal needs. Discounting the energy resources exported, which are mainly oil and a little bit of coal and electricity, and taking into account the energy resources imported, consisting of some hydrocarbon products and some coal, the internal energy offer is divided in the following way: 56.7% crude oil and condensates, 26.4% natural gas, 7.0% biomass, 4.9. Hydro, 3.0% coal, 1.1% geothermal energy and 0.9% nuclear energy. Some of this energy goes directly into final consumption, this is the case of biomass, about 10% goes into non energy uses and the rest is transformed into electricity and secondary energy products as gasoline, fuel oil, etc.

The final energy consumption in 1993 was divided in the following way: 39.9% in transportation, 33.7% in industry, 23.8% in commercial and residential uses and 2.6% in agriculture. Table 5 shows the historical energy statistics.

TABLE 5. BASIC ENERGY SITUATION

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 0.83 | 1.73 | 3.95 | 5.05 | 5.53 | 5.77 | 8.11 | 2.75 |
| - Solids[2] | 0.04 | 0.17 | 0.25 | 0.32 | 0.36 | 0.38 | 9.70 | 3.25 |
| - Liquids | 0.61 | 0.99 | 2.60 | 3.47 | 3.65 | 3.83 | 7.53 | 2.83 |
| - Gases | 0.13 | 0.42 | 0.93 | 0.97 | 1.18 | 1.20 | 10.33 | 1.86 |
| - Primary electricity[3] | 0.05 | 0.15 | 0.18 | 0.29 | 0.34 | 0.35 | 6.09 | 4.93 |
| Energy production | | | | | | | | |
| - Total | 0.87 | 1.74 | 5.90 | 7.84 | 8.32 | 8.47 | 10.03 | 2.62 |
| - Solids | 0.04 | 0.16 | 0.21 | 0.32 | 0.30 | 0.35 | 8.92 | 3.94 |
| - Liquids | 0.63 | 0.98 | 4.48 | 6.26 | 6.55 | 6.59 | 10.35 | 2.79 |
| - Gases | 0.16 | 0.45 | 1.04 | 0.96 | 1.12 | 1.17 | 9.80 | 0.86 |
| - Primary electricity[3]) | 0.05 | 0.14 | 0.17 | 0.30 | 0.35 | 0.35 | 6.38 | 5.32 |
| Net import (import - export) | | | | | | | | |
| - Total | -0.04 | -0.07 | -1.93 | -2.74 | -2.86 | -2.64 | 20.94 | 2.29 |
| - Solids | | 0.01 | 0.03 | 0.01 | 0.02 | 0.02 | 17.12 | -2.21 |
| - Liquids | -0.01 | -0.06 | -1.85 | -2.77 | -2.93 | -2.71 | 27.42 | 2.76 |
| - Gases | -0.03 | -0.03 | -0.11 | 0.02 | 0.04 | 0.04 | 6.69 | 6.81 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

The government energy policy has three main lines: in the first place, the promotion of the rational use and saving of energy; in the second place, the production of less contaminant fuels, like unleaded gasoline and sulphur free diesel, and finally the diversification of primary energy sources, since the country relies too heavily on hydrocarbons.

Diversification has been promoted specially in the electric sector, with the inclusion of geothermal energy, nuclear energy, some solar energy in rural areas far away from electric lines and recently with the addition of some wind energy.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Due to historical reasons the electric service is provided by two governmental organizations: Central Light and Power, which serves Mexico City metropolitan area and some parts of the states of Mexico, Morelos, Hidalgo, Puebla and Tlaxcala; and the Federal Electricity Commission (CFE) which serves the rest of the country.

Almost all the generation is provided by CFE, Central Light and Power generates only a small fraction of its requirements. The peninsula of Baja California has two small independent systems, the northern one is interconnected to the United States. The rest of the country is served by an integrated system which is controlled by CFE.

Only about 6.5% of the total generation of the country is provided by some private industries for their own consumption. In the past the generation and distribution of electricity has, by law, rested in the hands of the government, however, recent law modifications allow the generation of electricity by the private sector and promote the use of cogeneration.

## 2.2. Policy and Decision Making Process

The fact that the electric energy demand grows continuously, at about six per cent per year, has represented in the past a difficult challenge to fulfil, specially regarding to the needed investments. To solve this problem some changes have been implemented in the law, in order to allow the private investors to generate stations and in this way alleviate the burden to the government, who will continue to be responsible for the investments in transmission and distribution. However, it is too early to evaluate the effect of this recent change. The government is also promoting cogeneration and the saving and rational use of electricity.

CFE is in charge of the decision making process, following the guidelines of the Ministry of Energy. It is CFE who makes the load growth projections and all the studies needed to determine the additions of generating units and new transmission lines. Normally, a 20 years period is contemplated, but only a period of 10 year is programmed and the programme is revised annually.

## 2.3. Main Indicators

From 1985 to 1993 the gross electric generation has grown 5.4 % annually on the average, going from 85,352 GW·h in 1985 to 126,566 GW·h in1993 (Table 6). At the end of 1994 the total installed generating capacity was 31,649 MWe of which 66.66% was thermal, 28.82% hydro, 2.38% geothermal and 2.13% nuclear. For the same year, the total gross generation was 135,522 GW·h, 78.3% coming from thermal energy, 14.6% from hydro, 4.1% from geothermal and 3.8% from nuclear. The corresponding average load factors were: for thermal plants 58.3%, for hydro 25.1%, for geothermal 84.9% and for nuclear 71.7%. Table 7 shows the energy related ratios from EEDB.

TABLE 6. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 10.81 | 28.71 | 66.95 | 122.45 | 133.75 | 144.28 | 9.54 | 5.64 |
| - Thermal | 5.64 | 13.70 | 49.13 | 90.84 | 97.68 | 107.46 | 11.43 | 5.75 |
| - Hydro | 5.17 | 15.01 | 16.91 | 23.54 | 26.45 | 26.59 | 6.10 | 3.28 |
| - Nuclear | | | | 2.94 | 3.74 | 4.28 | | |
| - Geothermal | | | 0.92 | 5.12 | 5.88 | 5.95 | | 14.31 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 3.05 | 7.32 | 16.99 | 28.48 | 32.39 | 35.47 | 8.97 | 5.40 |
| - Thermal | 1.69 | 3.98 | 10.77 | 19.25 | 22.75 | 24.21 | 9.70 | 5.96 |
| - Hydro | 1.36 | 3.33 | 6.06 | 7.88 | 8.24 | 9.19 | 7.77 | 3.02 |
| - Nuclear | | | | 0.65 | 0.65 | 1.31 | | |
| - Geothermal | | | 0.15 | 0.70 | 0.74 | 0.75 | | 12.21 |
| - Wind | | | | | | | | |

[1] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 7. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 22 | 34 | 59 | 60 | 61 | 63 |
| Electricity per capita (kW·h/capita) | 306 | 572 | 1,006 | 1,363 | 1,401 | 1,506 |
| Electricity production/Energy production (%) | 12 | 16 | 11 | 14 | 15 | 16 |
| Nuclear/Total electricity (%) | | | | 3 | 3 | 3 |
| Ratio of external dependency (%)[1] | -5 | -4 | -49 | -54 | -52 | -46 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 40 | 45 | 45 | 49 | 47 | 46 |
| - Thermal | 38 | 39 | 52 | 54 | 49 | 51 |
| - Hydro | 44 | 51 | 32 | 34 | 37 | 33 |
| - Nuclear | | | | 51 | 65 | 37 |

[1] *Total net import / Total energy consumption.*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

Mexico is energy self sufficient, not only that, but it is also a net exporter of energy, however it is highly dependent on hydrocarbons, almost all the energy exported is in the form of crude oil and about 90% of the energy used in the country comes from oil and gas, only about 5% comes from hydro. In order to alleviate this situation, Mexico has recently incorporated other forms of energy like geothermal, coal and, from 1990 on, also nuclear energy.

### 3.1. Historical Development

The National Commission for Nuclear Energy (CNEN) was established in 1956 to pave the way for the introduction of nuclear power and nuclear applications in Mexico. CNEN encompassed all the nuclear activities in the country (exploration for uranium, nuclear research, regulation, etc.) but the generation of electricity by nuclear means (which was the sole responsibility of the Federal Electricity Commission (CFE)) and the radioisotopes utilisation. Later on the CNEN was transformed into the National Institute on Nuclear Energy (INEN), which redefined the attributes but with very few changes.

In 1979 INEN disappeared and was substituted by three organizations: The National Institute of Nuclear Research (ININ) in charge of all the aspects related to research; Mexican Uranium (URAMEX) in charge of uranium exploration and, eventually, uranium production and the National Commission on Nuclear Safety and Safeguards (CNSNS) in charge of nuclear regulation and safeguards. In 1985 URAMEX disappeared and all its functions passed to the Ministry of Energy.

The interest of Mexico in nuclear power dates back to the early 60's and the first concrete steps were taken in 1966, when a preliminary investigation of potential sites for nuclear power stations was carried out under the auspices of CFE and the National Commission for Nuclear Energy. At the end of the 60's the government concluded that a major role might be played by nuclear power plants. In the early 1969, CFE decided to invite bids for a 600MWe nuclear power plant of a proven type and invitations to tender were sent to several manufacturers. The bids were received at the beginning of 1970, but the final decision, with up to date bids, was taken in the middle of 1972. In 1976 the construction of the Laguna Verde Nuclear Power Plant (LVNPP) was initiated, comprising two reactors of 654 MWe net each. The first unit went into commercial operation in 1990 and the second in April 1995.

### 3.2. Current Policy Issues

The National Energy Plan issued in 1990, called for the production between 3.0 and 6.9 MWe by the year 2010. However, due to several factors, including changes in the national economic situation and shifts in public opinion, the future expansion of Mexico's nuclear energy programme is uncertain. There are currently no new power facilities commissioned and no provisions have been made to start new nuclear power projects in the near future.

The Ministry of Energy is responsible for the policies and contracts regarding radioactive waste management. It has delegated some responsibilities to the Federal Electricity Commission and to ININ.

There is an interim repository managed by ININ for all low and intermediate level radioactive wastes produced in medical, industrial and other radioisotope applications. This repository will have to be replaced to a permanent one in the future.

The spent nuclear fuel from the Laguna Verde Plant is being stored in the reactor's pools, which have been re-racked to increase the original capacity in order to accommodate all the spent fuel that the reactors will produce during their expected life. This solution gives CFE the time needed to study all possibilities before taking a definitive solution, depending on future developments, specifically those regarding the final disposal of high level radioactive wastes.

### 3.3. Status and Trends of Nuclear Power

As mentioned above there is only one nuclear plant in operation with two BWR reactors of 654 MWe net each, see Table 8 for its status. For the time being there are no plans regarding new units or new plants. The National Energy Plan issued in 1990, for the time being is still valid, however it will probably be revised in the near future.

*Performance of NPP's. Share in total electricity generation.*

Laguna Verde unit 1 went into commercial operation in 1990, its performance has been quiet good since the very beginning, during 1994 generated 42,39GW·h which represented 3.08% of the total generation in the country. Unit 2 went into commercial operation in April 1955. With the two units in operation, nuclear energy is expected to account between five and six percent of the total electricity production

TABLE 8. STATUS NUCLEAR POWER PLANTS

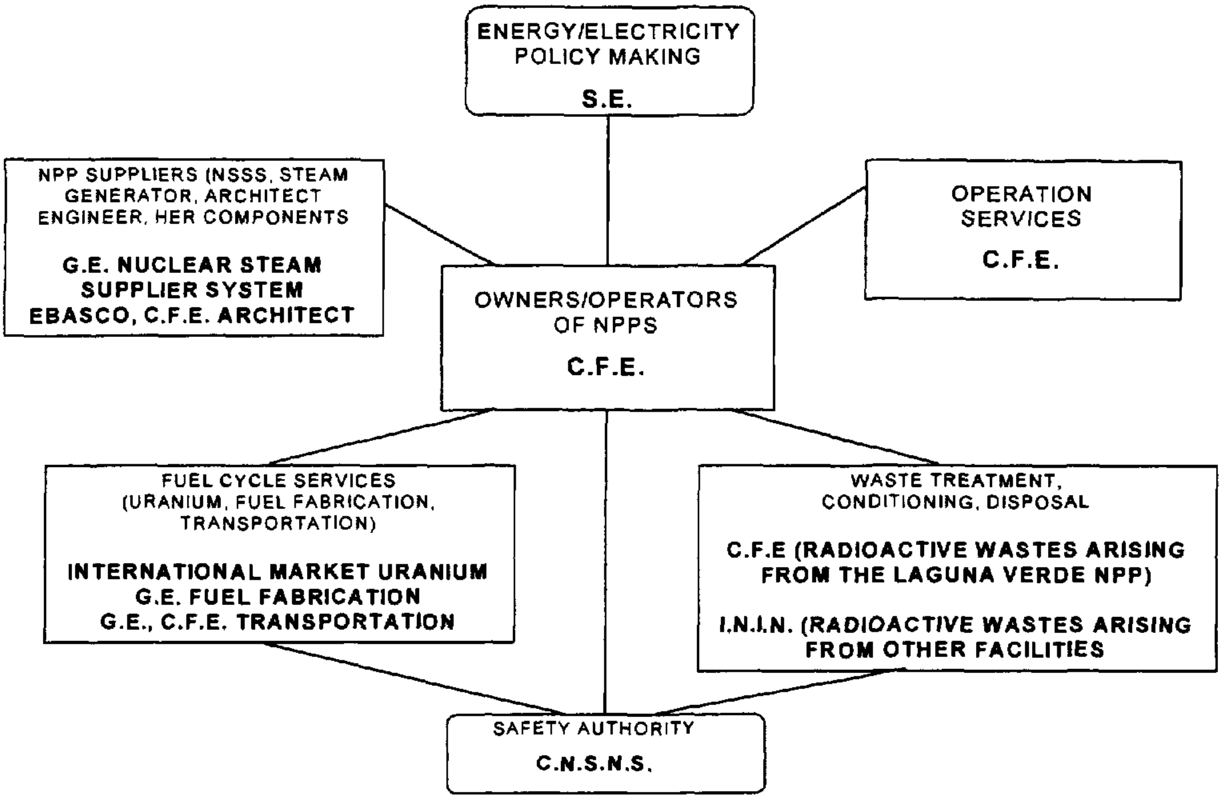
| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| LAGUNA VERDE-1 | BWR | 654 | CFE | Operational | GE |
| LAGUNA VERDE-2 | BWR | 654 | CFE | Operational | GE |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| LAGUNA VERDE-1 | 01-Oct-76 | 08-Nov-88 | 13-Apr-89 | 29-Jul-90 | |
| LAGUNA VERDE-2 | 01-Jun-77 | 06-Sep-94 | 11-Nov-94 | 10-Apr-95 | |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organizational Chart

Figure 1 shows the structure of the Mexican nuclear power sector.




| | |
|---|---|
| S.E. | Ministry of Energy |
| C.F.E. | Federal Electricity Commission |
| C.N.S.N.S. | National Commission on Nuclear Safety and Safeguards |
| I.N.I.N. | National Institute of Nuclear Research |
| G.E. | General Electric |
| EBASCO | Electric Bond and Share Company |

*FIG. 1. Organizational Chart*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of NPPs

There are no NPP's suppliers in the country. The main components of the Laguna Verde plant were acquired abroad. At the beginning, the main architect engineer for unit 1 was the Electric Bond and Share Company (EBASCO), but later on, and specially for unit 2, CFE acted as architect engineer with the advice of EBASCO and General Electric (GE).

### 4.2. Operation of NPPs

The Laguna Verde plant is owned by CFE, the operation and maintenance is done by CFE personnel. In the past, the operator training was done at several similar installations in Spain and the United States. Nowadays, the training is mainly done locally, using the simulator which has been installed at the plant's premises.

### 4.3. Fuel Cycle and Waste Management Service Supply

*Fuel Cycle*

Mexico is not producing uranium due to the low cost of uranium currently available on the world market. For the next years, the required uranium for reloads of Laguna Verde will be obtained from the world market, since currently there are no plans for producing uranium in Mexico. Some

2,000 tons of uranium reserves have been identified in Mexico, but they are too expensive to exploit considering current prices.

Uranium is bought either as hexafluoride or as concentrate that is converted to hexafluoride by Comurhex in France through a long-term contract. Enrichment is provided by the United States' Department of Energy also through a long-term contract. Fuel fabrication is currently done in the United States by General Electric (GE). Four assemblies supplied by Siemens are being tested in the fourth cycle of Unit 1 of Laguna Verde and there are plans to test also four assemblies supplied by ASEA-BROWN BOVERI (ABB-ATOM) in the near future.

A fuel fabrication pilot plant is almost ready to start operation at the National Nuclear Research Institute using technology provided by General Electric of USA. This pilot plant could produce up to 20 fuel assemblies per year for the Laguna Verde reactors, however after some experience is gained with the operation of the plant and the fuel produced, the plant will probably be shut down since it is not economical to fabricate nuclear fuel at this scale.

As for spent nuclear fuel, the current plans are to store it at the reactors' pools, which have been re-racked to increase the original capacity in order to accommodate the spent fuel that the reactors will produce during their expected operating life. This plan allows time to take a more definite decision depending on future developments in uranium availability and price, expansion of the Mexican nuclear power capacity, new technologies, etc.

*Waste Management*

A repository exists in Mexico for all the low and intermediate level wastes produced in medical and industrial facilities. This repository will be closed in the near future to avoid social problems due to the population growth in the vicinity.

For the Laguna Verde Plant, the high level waste is being stored at the plant. As for the low and intermediate level waste produced by the plant, detailed site studies are now under way at the same plant site in order to determine the engineering design basis for a "triple barrier" repository using the French approach. The repository is planned to have capacity for the waste generated during the operating life of at least four nuclear reactor units and could also include the waste generated by the medical and industrial facilities in the country.

### 4.4. Research and Development Activities

The main research centres are the National Institute of Nuclear Research (ININ) and the Electric Research Institute (IIE).

### 4.5. International Co-operation in the Field of Nuclear Power Development and Implementation

*Research and development activities carried out jointly with other countries.*

1. Agreement of co-operation between the Mexican Electric Research Institute and the Electrical Power Research Institute of the United States of America (USEPRI) for the development and application of the RETRAN-3 Code for NPP's operational transient analysis.

2. Agreement of co-operation between the Mexican Electric Research Institute and the USEPRI in the development and application of the R & R Workstation for NPP's probabilistic risk analysis applications.

3. Agreement of co-operation between the Mexican Electric Research Institute and the USEPRI in the development and application of the MAAP-3 Code for NPP's severe accidents analysis.

4. Agreement of co-operation between the Mexican Electric Research Institute and the USEPRI in

the development and application of the CPM-3 Code for the Nuclear data library generation for advanced fuels.

5. Agreement of co-operation between the Mexican Electric Research Institute and the Rensselear Polytechnic Institute of the United States for the development and application of the April Code for NPP's severe accidents analysis.

6. Agreement of co-operation between the Mexican Electric Research Institute and the Cuban Institute for Hydrography for the development of the Northwest Caribbean Sea Oceanographic Chart.

## 5. NUCLEAR LAWS AND REGULATIONS

### 5.1. Regulatory Framework

The licensing consist of two steps, the first one concludes with the granting of the "Construction Permit" and the second step with the "License for Commercial Operation". The process starts with the application to build a NPP, by the utility (in Mexico up to now there is a national owned company, called Federal Electricity Commission), presenting to the National Regulatory Body (National Commission on Nuclear Safety and Safeguards) the application itself and the preliminary studies of:

- Siting;
- Environmental impact;
- Quality assurance programme during construction phase.

If these documents satisfy the scope required by CNSNS, the utility is required to present the technical information on the NPP to be built, this information includes the construction procedures and fundamental safety systems to cope with the operational transients and postulated accidents. This information is evaluated by the CNSNS's technical personnel and a set of questions is transmitted to the utility, before the pouring of any concrete at the site. During the Laguna Verde experience, three "Provisional Construction Permits" were granted to CFE before the so called "Definitive Construction Permit" issue. This limited work authorisation has been eliminated in the present procedure for future NPPs.

During the construction itself, the regulatory body inspects the construction of the NPP and has the legal authority to stop the work if the agreed standards are not fulfilled. After the evaluation of the documentation, the regulatory body can issue the "Technical Basis" to grant the construction permit, addressed to the Ministry of Energy, being this the authority allowed by nuclear law, to grant the permit.

At certain stage of the construction and before the start of the pre-operational test period, the utility is required to present to the regulatory body the technical information related with:

- Final design of the station.
- Final site studies.
- Final environmental impact studies.
- Quality assurance programme to the operating phase.
- Final studies on plant performance during transients and postulated accidents.
- Set of operating procedures.
- Operations personnel training programme.
- Pre-operational and start-up test programme.
- Proposed technical specifications.

If these process documents are not clear enough in any technical subject, the regulatory body generates questions to clarify any topic. As a result of this process the regulatory body issues the following documents:

- Permit to load the fuel.
- Set of technical specifications.

The technical basis to grant the operation license, is addressed to the Ministry of Energy, because according the nuclear law, this is the Authority who can grant this kind of documents.

After the fuel load the regulator remains to monitor the performance of the low power test period and any change of power ( 0 to 5%, 5 to 10%, 10 to 25%, 25 to 50%m 50 to 75% and 75 to 100%), the engineers of the national body review the test results and evaluate possible discrepancies between the acceptance criteria and test results.

**5.2. Main National Laws and Regulations**

*Essential legal texts regulating nuclear power in the country*

- Constitution of Mexico, Article 27 in force.
- Regulatory Law of Article 27 of the Constitution on Nuclear Matters, published in the official gazette on February 4, 1985.
- Law on Third Party Liability for Nuclear Damage, published in the official gazette on December 31, 1974.
- Radiological Safety Regulations, published in the official gazette on November 8, 1988.
- General Act on Ecological Balance and Environmental Protection, published in the official gazette on January 28, 1988.
- Mexican Official Guidelines NOM-012-STPS-1993, on health and safety at work in premises where ionising sources are handled, stored or carried, published in the official gazette on June 15, 1994.

*Mechanisms in place for financing decommissioning and waste disposal*

The mechanisms in force to finance decommissioning and radioactive waste management are the following:

- For wastes proceeding form radioisotope applications, its storage cost is recuperated from the generators of this kind of wastes.
- For low and intermediate level radioactive wastes proceeding from the Laguna Verde Nuclear Power Plant (LVNPP), they will be stored in a repository using the French approach. This repository will be located in the same site.
- For high level radioactive wastes, technology progresses and the future nuclear program are being expected in order to make a decision for these kind of wastes

The final disposal of radioactive wastes management is a responsibility of the State, in the case of wastes proceeding from LVNPP the Federal Electricity Commission will be in charge of financing its storage. For decommissioning, the State through CFE will be in charge of financing this process.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT and Tlatelolco related safeguards agreement | | |
| • Improved procedures for designation of safeguards inspectors | Accepted: | 27 February 1989 |
| • ARCAL | Entry into force: | April 1988 |

*OTHER RELEVANT INTERNATIONAL TREATIES*

| | | |
|---|---|---|
| • Agreement on the privileges and immunities of the IAEA | Entry into force: | 19 October 1983 |
| • Vienna Convention on civil liability for nuclear damage | Entry into force: | 25 July 1989 |
| • Convention on early notification of nuclear accidents | Entry into force: | 10 June 1988 |
| • Convention on the physical protection of nuclear material | Entry into force: | 4 May 1988 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 10 June 1988 |
| • NPT | Entry into force: | 21 January 1969 |
| • Tlatelolco | Entry into force: | 20 September 1967 |
| • Convention on nuclear safety | Not yet ratified | |
| • ZANGGER Committee | Non-member | |
| • Nuclear export guidelines | Non-member | |
| • Acceptance of NUSS codes | Summary: Codes should be used as guidelines in preparation and application of national requirements. Mexican nuclear safety legislation is in conformity with codes | 11 April 1990 |

- Standard agreement concerning technical assistance to Mexico: — Entry into force: 23 July 1963
  Parties:
  - United Nations Organization (ONU).
  - International Labour Organization (ILO).
  - Food and Agriculture Organization of the United Nations (FAO).
  - United Nations Educational Scientific and Cultural Organization (UNESCO).
  - International Civil Aviation Organization (ICAO).
  - World Health Organization (WHO).
  - International Telecommunications Union (ITU).
  - World Meteorological Organization (WMO).
  - International Atomic Energy Agency (IAEA).
  - Universal Postal Union (UPU).

| | | |
|---|---|---|
| • Transfer of enriched uranium for a research reactor<br>Parties: Mexico, USA, IAEA | Entry into force: | 18 December 1963 |
| • Lease of source material for a subcritical assembly<br>Parties: Mexico, USA, IAEA | Entry into force: | 20 June 1966 |
| • Lease of source material for a subcritical facility<br>Parties: Mexico, USA, IAEA | Entry into force: | 23 August 1967 |
| • Transfer of a training reactor and enriched uranium<br>Parties: Mexico, Germany, IAEA | Entry into force | 21 December 1971 |
| • Second supply agreement for transfer of enriched uranium for a research reactor<br>Parties: Mexico, USA, IAEA | Entry into force: | 4 October 1972 |
| • Supply of uranium enrichment services<br>Parties: Mexico, USA, IAEA | Entry into force: | 12 February 1974 |
| • Second supply agreement for supply of uranium enrichment services for a second reactor unit<br>Parties: Mexico, USA, IAEA | Entry into force: | 14 June 1974 |
| • Transfer of title to natural uranium<br>Parties: Mexico, USA, IAEA | Entry into force: | 23 May 1989 |

| | | |
|---|---|---|
| • Plan of operation for a UN Special Fund project in Latin America (Eradication of Mediterranean Fruit Fly). Parties: Mexico, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, UN Special Fund, IAEA | Entry into force: | 29 July 1965 |
| • Plan of operation for a UNDP project in Latin America, Amendment N1 1. Parties: Mexico, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, UN Special Fund, IAEA | Entry into force: | 31 July 1968 |
| • Preliminary study of a nuclear electric power and desalting plant. Parties: Mexico, USA, IAEA | Entry into force: | 7 October 1965 |
| • Agreement concerning provision of a dose assurance service by IAEA to irradiation facilities in its Members States (Exchange of letters). Parties: Mexico, India, Syria, Argentina, Philippines, Malaysia, Belgium, Chile, Switzerland, Egypt, Hungary, Thailand, South Africa, Korea, Republic of, Algeria, Netherlands, Lebanon, Singapore, Denmark, Yugoslavia, Brazil, China | Entry into force: | 18 September 1985 |

*BILATERAL AGREEMENTS*

- Agreement between the Government of the United Mexican States and the Government of Australia concerning co-operation in peaceful uses of nuclear energy and the transfer of nuclear material. Signed on 28 February, 1992, entered into force 1 Oct 1992.

- Agreement between the Government of the United Mexican States and the Government of Canada for Co-operation in the peaceful uses of nuclear energy. Signed in 16 November, 1994, entered into force on 9 May 1995.

## ANNEX I. DIRECTORY OF THE MAIN ORGANISATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NUCLEAR ENERGY AUTHORITIES*

| | |
|---|---|
| Ministry of Energy (SE).<br>Av. Insurgentes Sur N1 552,<br>Col. Roma Sur,<br>México, D.F. | <br><br>Tel.: +525-564-97-56<br>Fax: +525-574-10-10 |
| Federal Electricity Commission (CFE).<br>Salamanca N1 102,<br>Col. Roma,<br>México, D.F. | <br><br>Tel.: +525-229-54-90<br>Fax: +525-525-22-35 |
| National Commission on Nuclear Safety<br>and Safeguards (CNSNS).<br>Dr. Barragán N1 779,<br>Col. Narvarte,<br>México, D.F. | <br><br>Tel.: +525-590-41-81<br>Fax: +525-590-61-03<br>Email: cnsns1@servidor.unam.mx |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| National Institute of Nuclear Research (ININ).<br>Carretera Federal México-Toluca Km. 36.5,<br>Salazar, Edo. de México | Tel.: +525-521-94-02<br>Fax: +525-521-37-98<br>Email: velezo@redvax1.dgca.unam.mx |
| Electric Research Institute (IIE).<br>Av. Reforma N1 113,<br>Col. Palmira,<br>Temixco, Morelos | <br><br>Tel.: 91 (73) 18-38-11<br>Fax: 91 (73) 18-25-21 |

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# THE NETHERLANDS

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THE NETHERLANDS

# 1. GENERAL INFORMATION

## 1.1. General Overview

The Netherlands is a small, flat country in north-west Europe situated on the North Sea shore with a maritime climate. The country is densely inhabited and the population growth is nearly constant. In 1994, the Netherlands had a population of 15.3 million with the population density of 409 inhabitants per square kilometre. Its growth rate was estimated at 0.6 % (Table 1).

The Netherlands is the 'Gateway to Europe' for trade and distribution, with harbours in Rotterdam and Amsterdam.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 11.5 | 13.0 | 14.1 | 15.0 | 15.3 | 15.4 | 0.6 |
| Population density (inhabitants/km²) | 307.5 | 349.1 | 378.9 | 400.5 | 409.2 | 412.1 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.6 |
| Area (1000 km²) | 37.3 |
| Urban population in 1994 as percent of total | 89.0 |

Source: IAEA Energy and Economic Database

## 1.2. Economic Indicators

In 1994, Netherlands's total Gross Domestic Product (GDP) was 574 billion guilders with the per capita Gross Domestic Product (GDP) of 37.560 Dfl. Gross Domestic Product (GDP) per sector was: Industry 103 billion guilders; Government 48 billion guilders; and households 423 billion guilders. Gross Domestic Product (GDP) growth rate was 1.8%. The historical Gross Domestic Product (GDP) data are shown in Table 2.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 34,049 | 172,290 | 283,525 | 298,941 | 319,843 | 4.5 |
| GDP (millions of constant 1990 US$) | 176,380 | 234,973 | 283,525 | 296,026 | 303,765 | 1.9 |
| GDP per capita (current US$/capita) | 2,613 | 12,181 | 18,962 | 19,569 | 20,793 | 3.9 |

| GDP by sector (1992): | |
|---|---|
| Agriculture | 4% |
| Industry | 28% |
| Services | 68% |

Source: IAEA Energy and Economic Database

## 1.3. Energy Situation

After the former USSR, the USA and Canada, the Netherlands is the world's fourth biggest producer of natural gas. The importance of energy in the Netherlands emerges from the possession of an important energy resource: natural gas (Table 3). Total energy consumption in the Netherlands consists of natural gas (48%), oil (35%), coal (14%), and nuclear energy and renewable energy resources (3%).

The country's primary energy production has increased from 14 Mtoe in 1950 to the current level of 68 Mtoe. Energy independence has risen from 65% in 1950 (dominated by coal) to almost 100% (more than 90% of natural gas). Table 4 shows the historical energy situation.

Electricity constitutes 12.3% of the total domestic energy consumption (64.4 TW·h, in 1992, including 3.7 TW·h autoproduction supplied to the public grid). In recent years, electricity demand has grown at a rate of 3 to 4% per year.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro (2) | Total |
| Total amount in place | 14.56 | 0.67 | 65.93 | | 0.07 | 81.23 |

(1) *This total represents essentially recoverable reserves.*

(2) *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.*

Source: IAEA Energy and Economic Database

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total(1) | 0.91 | 2.02 | 2.92 | 2.96 | 2.91 | 3.04 | 5.98 | 0.28 |
| - Solids(2) | 0.45 | 0.21 | 0.16 | 0.45 | 0.37 | 0.36 | -5.09 | 6.10 |
| - Liquids | 0.45 | 1.10 | 1.12 | 0.96 | 0.82 | 0.99 | 4.68 | -0.86 |
| - Gases | 0.01 | 0.72 | 1.61 | 1.43 | 1.59 | 1.55 | 27.15 | -0.28 |
| - Primary electricity(3) | | | 0.04 | 0.12 | 0.14 | 0.14 | 19.10 | 9.77 |
| Energy production | | | | | | | | |
| - Total | 0.46 | 1.33 | 3.51 | 2.74 | 3.11 | 3.00 | 10.69 | -1.10 |
| - Solids | 0.37 | 0.13 | | | | | -26.00 | 6.16 |
| - Liquids | 0.08 | 0.08 | 0.07 | 0.17 | 0.14 | 0.18 | -0.93 | 7.53 |
| - Gases | 0.01 | 1.12 | 3.40 | 2.54 | 2.93 | 2.78 | 32.00 | -1.43 |
| - Primary electricity(3)) | | | 0.04 | 0.03 | 0.04 | 0.04 | | -0.22 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.57 | 1.20 | -0.09 | 0.62 | 0.37 | 0.55 | 8.56 | -13.42 |
| - Solids | 0.07 | 0.07 | 0.16 | 0.43 | 0.35 | 0.36 | 4.24 | 6.25 |
| - Liquids | 0.50 | 1.53 | 1.54 | 1.30 | 1.36 | 1.42 | 5.80 | -0.57 |
| - Gases | | -0.40 | -1.79 | -1.11 | -1.34 | -1.23 | | -2.63 |

(1) *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*

(2) *Solid fuels include coal, lignite and commercial wood.*

(3) *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*

Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

Since gas and oil make up a very large share of the energy supplies in the Netherlands, the country's energy policy is aimed at decreasing the long-term oil and gas dependence to more acceptable levels. Coal, gas, oil, nuclear and wind sources have their own potentials and limitations. Selecting the best energy package is one of the major challenges of Netherlands's energy policy. One of the tasks of this policy is to ensure that future generations will also be able to meet their energy requirements. Creating the conditions for an affordable, reliable and clean energy supply, today and tomorrow, is regarded as the key objective of Dutch energy policy. As a result, its main elements are: encouragement of energy conservation; diversification of primary fuels in order to minimise price and supply risks; and, development of domestic energy resources. In 1995, the government has prepared an "Energy white paper", which was presented to Parliament at the year-end.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Under the present Electricity Act of 1989 the structure of the electricity supply sector was characterized by a separation of distribution and supply (no vertical integration) and some efficiency incentives. An evaluation of this Act was made in 1995 and the conclusions were put down in an annex of the White Paper on Electricity Policy 1996. The Dutch government is working on a fundamental reorganization of the sector. A new Electricity Act is planned to come into force on 1 January 1998.

The present Electricity Act of 1989 was a first initiative to change the structure of the electricity sector. The Act transformed the structure of the electricity supply sector. It includes rules for the production, transmission and distribution of electricity. Generally, production and distribution are each carried out by separate companies rather than by vertically integrated companies.

Electricity is distributed by approximately 35 companies who are permitted to produce electricity by unconventional means like cogeneration, windmills etc. The Law also includes rules for the production of electricity by private firms and persons, who have the right to sell their excess capacity to the distribution companies at average avoided costs.

### 2.2. Decision Making Process

Planning and production in the electricity sector are co-ordinated by a central body, the N.V. Samenwerkende Elektriciteits-produktiebedrijven (SEP), which draws up planning schemes. A typical scheme covers the next ten years of production, based on demand forecasts. The four electricity production companies, EPON (N.V. Elektriciteits-Produktiemaatschappij Oost- en Noord-Nederland), EPZ (N.V. Elektriciteits-Produktiemaatschappij Zuid-Nederland), EZH (N.V. Elektriciteitsbedrijf Zuid-Holland), and UNA (N.V. Energieproduktiebedrijf UNA), in turn, implement the decisions of the planning schemes. Every two years a new scheme is drawn by SEP in co-operation with the production companies and the distribution sector for final approval by the Ministry of Economic Affairs.

The majority of Dutch electricity (about 85%) is generated by the four producers. Each producer has a production license granted by the Ministry of Economic Affairs. SEP is responsible for the merit order dispatching of the production units, on the basis of lowest variable costs, as well as for high voltage transmission of electricity. SEP also takes care of active pooling of production costs. Lastly, SEP imports electricity on behalf of the public supply sector.

### 2.3. Main Indicators

In the Netherlands, the share of electricity in total energy consumption is 12.3%. In 1993, installed electricity generation capacity in the Netherlands amounted to 14 458 MW(e). Electricity production by fossil fuelled plants was to 73 TW·h, and by nuclear means 3.7 TW·h. Presently, electricity imports are about 14% (8.9 TW·h) of the total electricity production, while nuclear electricity is about 7%. Table 5 shows the historical electricity production and the installed capacity and Table 6 the energy related ratios.

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

In 1968, the first nuclear power plant, at Dodewaard, was connected to the grid. The original goal of the Dodewaard facility was to gain practical knowledge and experience with nuclear power in order to determine whether commercial application of nuclear power would be feasible. Later in

1971, the Borssele nuclear power plant began operation. Decisions taken by the Dutch Government and Parliament in 1974 and 1975, to expand the number of nuclear power plants were subsequently deferred pending resolution of debates on the issue. Similar decisions taken in 1985 and 1986 were also suspended, following the Chernobyl accident. Since that time, the Netherlands Government has initiated various studies and research programmes, especially in the field of nuclear safety and on radioactive waste. In the mean time, nuclear energy is held as viable option for the future, especially in view of increased environmental concerns.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 16.52 | 40.86 | 64.81 | 71.87 | 76.99 | 79.68 | 7.07 | 1.49 |
| - Thermal | 16.52 | 40.49 | 60.61 | 68.40 | 73.02 | 75.61 | 6.72 | 1.59 |
| - Hydro | | | | 0.12 | 0.09 | 0.10 | | |
| - Nuclear | | 0.37 | 4.20 | 3.30 | 3.70 | 3.70 | | -0.90 |
| - Geothermal | | | | | | | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 5.26 | 10.16 | 17.29 | 17.44 | 17.60 | 18.35 | 6.13 | 0.42 |
| - Thermal | 5.26 | 10.11 | 16.80 | 16.85 | 16.92 | 17.65 | 5.97 | 0.36 |
| - Hydro | | | | 0.04 | 0.04 | 0.04 | | |
| - Nuclear | | 0.05 | 0.50 | 0.50 | 0.50 | 0.50 | | 0.09 |
| - Geothermal | | | | | | | | |
| - Wind | | | | 0.05 | 0.14 | 0.16 | | |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Database

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 80 | 155 | 207 | 198 | 191 | 198 |
| Electricity per capita (kW·h/capita) | 1,449 | 2,978 | 4,360 | 5,217 | 5,520 | 5,660 |
| Electricity production/Energy production (%) | 35 | 28 | 17 | 24 | 23 | 25 |
| Nuclear/Total electricity (%) | | 1 | 7 | 5 | 5 | 5 |
| Ratio of external dependency (%)[(1)] | 62 | 59 | -3 | 21 | 13 | 18 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 36 | 46 | 43 | 47 | 50 | 50 |
| - Thermal | 36 | 46 | 41 | 46 | 49 | 49 |
| - Hydro | | | | 38 | 28 | 31 |
| - Nuclear | | 86 | 96 | 75 | 84 | 84 |

[(1)] *Total net import / Total energy consumption*
Source: IAEA Energy and Economic Database

### 3.2. Current Policy Issues

On 15 November 1993, the Government sent a dossier on Nuclear Energy to Parliament. This dossier was compiled to assist the newly elected cabinet in reaching a decision on whether to expand the use of the nuclear power in the Netherlands. The dossier examined the most important issues confronting the Dutch society, such as the safe application of nuclear energy, the risks involved, the radioactive waste problem, other environmental aspects, and, finally the possible misuse of nuclear technology. The objectives presented in the nuclear energy dossier included:

i) maintaining nuclear competence with a research programme on reactor safety, with emphasis on new reactor concepts;
ii) evaluating environmental effects of the entire nuclear fuel cycle in order to obtain information on the desirability of nuclear energy;

iii) continuing research on the relationship between information on nuclear energy and the public attitudes ("Energy monitoring");
iv) creating a new generic programme on the retrievable disposal of radioactive waste;
v) formulating an additional programme on the transmutation of actinides and other long lived isotopes;
vi) continuing international co-operation in the research programmes mentioned above.

During the autumn of 1994, when the new cabinet took over, discussions took place in Parliament whether the lifetime of the Borssele nuclear power plant should be extended by three years from 2004 till 2007. Year 2004 was the original date for the reactor's decommissioning before Borssele's shareholders applied for a three year life extension in order to justify a 450 million-guilder safety related backfit program. The previous government had issued licenses for the backfit work - which had already begun. This made it difficult for the present government to withdraw the permission. But, on 23 November 1994, Dutch Parliament passed a resolution calling on the government to "waive plans to permit lifetime extension" for Borssele. Meanwhile, the Minister of Economic Affairs had been negotiating with the electricity producers (SEP) for a politically and economically acceptable compromise. Finally, the Dutch government and the electricity producers agreed, in December 1994, that the Borssele nuclear plant is to be shut down at the end of 2003. In exchange, SEP will be compensated 70 million guilders allowing it to complete the safety-related backfit program. The updating and modification work of the Borssele plant are running as scheduled. There are, however, appeals (among others Greenpeace) against the license which will be heard within a year's time. The license for the updating and modification of the Dodewaard plant was issued in July of 1995.

On 3 October 1996 the board of directors of the Dutch utility SEP (N.V. Samenwerkende electriciteits-produktiebedrijven) decided to shut the Dodewaard reactor permanently in the near future, with a tentative closure date in spring 1997. The decision was taken by SEP because it could no longer justify continued operation of the uneconomic plant in light of impending European electricity market deregulation. Furthermore SEP concluded that the perspective of a positive decision by the Dutch government on nuclear energy in the Netherlands in the foreseeable future had ceased to exist.

Dodewaard which began operation in 1969, was built by General Electric Co. as a unique design with natural circulation and an isolation condensor, features that have led its promoters to bill it as the prototype of a future passively safe BWR. Originally planned to shut on 1 January 1995, its life was extended once to 1 January 1997 and again last year 2004.

N.V.GKN, the SEP daughter company that operates Dodewaard, initiated an upgrading project in connection with that life extension, work on which was to have begun in 1997. SEP plans to finish initial decommissioning activities by 2003 and mothball the plant for 40 years before complete dismantling.

At the end of 1995 the Netherlands Minister of Economic Affairs sent a White Paper to Parliament of the energy policy for the Netherlands in the years to come. This White paper outlines what steps should be taken towards a more sustainable energy economy which is needed on the one hand in order to secure a reliable long-term energy supply and on the other hand in order to respond to the threatening climate problem. The main objective of Dutch energy policy is to achieve an energy efficiency improvement by one-third in the next 25 years and a 10% share of renewables in total primary energy consumption by the year 2020. This in order to reach stabilization of $CO_2$ emissions which should not exceed at that time the level of 1990. Furthermore the markets for electricity and gas will be opened up while the responsibilities of the government will be restricted.

### 3.3. Status and Trends of Nuclear Power

Dodewaard and Borssele supply 7% of total public electricity needs in the Netherlands. There are no nuclear power plants under construction nor are there any committed or planned ones. Table 7 shows the status of these power plants. Both nuclear power plants are performing well: they are among the top in the world in terms of availability for use. The average load factor of the Borssele plant is about 79%, while Dodewaard's is even better.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| BORSSELE | PWR | 449 | EPZ | Operational | KWU |
| DODEWAARD | BWR | 55 | GKN(NL) | Operational | GE |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| BORSSELE | 01-Jul-69 | 20-Jun.-73 | 04-Jul-73 | 26-Oct.-73 | 2004 |
| DODEWAARD | 01-May-65 | 24-Jun.-68 | 18-Oct.-68 | 15-Jan-69 | 28-March-1997 |

Source: IAEA Power Reactor Information System, yearend 1996

The main purpose of the Dodewaard nuclear power plant was for conducting nuclear experiments for commercial applications. Dodewaard plant was the only reactor in the world which is cooled by natural circulation. It made Dodewaard nuclear power plant most suitable for verification experiments on a commercial scale.

The percentage of nuclear electricity generation of the total capacity is 3% (505 MW(e)). Nuclear share of total electricity generation amounts to 4.8% (3.7 TW·h/77 TW·h). No new construction of nuclear plants is foreseen in the near future.

In the Netherlands, nuclear energy is used exclusively for producing electricity. Compared with countries such as Belgium and France, nuclear energy plays a modest role in the Netherlands. In evaluating the desirability of nuclear energy, the Netherlands considers the environmental effects as well as aspects of risk, safety and the problem of radioactive waste. This means studying the effects of the entire fuel cycle. Such a study has shown that there are no factors present which might prohibit the use of nuclear energy in the Netherlands.

Even though Dutch public attitudes toward nuclear energy indicate opposition to construction of new nuclear power plants, there are differing views on nuclear energy as an option in itself. Demand for new centralised power plants in the next ten years is not foreseen. However, each electricity generating option poses its own problems. The availability of information on these problems tends to influence public opinion.

The intervening ten year period could be used for development of more advanced and innovative nuclear power reactors. Such development could win sufficient public support, since the enhanced safety features of new reactor designs can be communicated to the general public in a more objective manner. Until then, use of the existing nuclear power plants will be maintained.

Late 1995, the Ministry of Economic Affairs issued a White Paper on Energy Policy for the Netherlands in the years to come. Although at the moment no increase of the nuclear capacity is foreseen, a nuclear capability will be maintained in case a nuclear plant would be desirable in the next ten years.

### 3.4. Organizational Chart

Not provided for this report.

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

The entire Dodewaard plant and 70% of the Borssele plant were manufactured in the Netherlands.

| | |
|---|---|
| Supplier of Dodewaard: | General Electric (GE) |
| Supplier of Borssele: | Kraftwerk Union (KWU)/Siemens |

### 4.2. Operation of Nuclear Power Plants

Operator of the Dodewaard plant is NV GKN: Joint Nuclear Power Plant the Netherlands Ltd.

Operator of the Borssele plant is NV EPZ: The Electricity Generating Company for the southern Netherlands.

ECN (Netherlands Energy Research Foundation) runs an education and training programme. Personnel, such as reactor operators and radiation specialists, from the Netherlands and from other countries that do not have such training facilities are trained there.

### 4.3. Fuel Cycle and Waste Management Service Supply

Uranium enrichment in the Netherlands is carried out by Urenco Nederland B.V. Urenco Nederland B.V. belongs to a multinational company, Urenco Ltd, located at Marlow, which has three shareholders: UCN NV (Ultra Centrifuge Netherlands) in the Netherlands, Uranit in Germany and INFL in the UK. The Netherlands government owns the majority of the shares (99%) in UCN.

Uranium enrichment is the most important part of the fuel cycle for the Netherlands and is a major international success for the country. The total uranium enrichment market share of Urenco in the Western world is about 10%.

Urenco has contracts in the EC countries, Switzerland, the United States, Republic of Korea, and Japan. Urenco enrichment plants are located at Almelo in the Netherlands, Capenhurst in the UK, and Gronau in Germany. Urenco Limited at Marlow, the holding company, has the prime responsibility of providing marketing and contract administration services. Manufacturing of centrifuges is centred at Almelo while research and development work is centred in Jülich (Germany).

Several years ago, Urenco sought to expand its business with a centrifuge enrichment plant in the US. Thus, Urenco formed a Joint venture, Louisiana Energy Services, which is now in the late stages of the plant license application process with the US Nuclear Regulatory Commission. The license was to be granted at the end of 1995. However, the decision on actual plant construction will depend on the prevailing business and financial conditions.

NV Covra, a Central Organization for radio-active Waste Management Ltd, is the only organization authorised to store radioactive waste. Covra is a private company in which the major radioactive waste producers in the Netherlands (i.e. Dodewaard, Borssele, ECN) are shareholders (30% each). The Netherlands government owns 10% of the Covra shares.

Of the total low level and intermediate level nuclear waste, 65% comes from research laboratories and hospitals, and 35% arises from nuclear electricity production. The reprocessed waste that will be returned from France and the United Kingdom at the turn of the century is not included here.

The government has formulated a policy on radio-active waste governing long-term interim storage and the conditions for permanent disposal. A safe storage facility at Borssele has been granted a license for interim storage and is now partially built. Once the interim storage period is over, waste which cannot be recycled must be disposed of in a more permanent manner. Based on research, the safe disposal of radioactive waste in salt formations is, theoretically, technically feasible. However, due to high public opposition to the geological disposal of radioactive waste in the Netherlands, the definitive disposal in rock salt cannot be seen as an immediate prospect. The government has, in any case, decided that the disposal of radioactive material in the near surface repository should not be irreversible.

It is not yet clear whether other alternatives, in addition to geological disposal and measures to reduce the half-life concentrations of radioactive waste, for waste disposal will become available in the near future. However, the transmutation of actinides by means of nuclear reactions is an interesting option and deserves further study.

The availability of the Covra facility offers a possibility for the long-term storage (up to 100 years) of radioactive waste in the Netherlands, and possibly even longer. This will provide the government time and opportunity to seek more permanent solutions which are both technically feasible and publicly acceptable. Nuclear waste is a global problem. In countries where nuclear energy has been used for military purposes, this problem has acquired an added dimension. Since nuclear waste is present throughout the world, the international community as a whole is responsible for seeking and finding appropriate solutions. The Netherlands government will therefore continue to work towards these solutions, both at national and international level.

### 4.4. Research and Development Activities

Institutes which contributed to nuclear research funded by the Netherlands government:

- ECN is the Netherlands Energy Research Foundation in Petten. ECN's nuclear research covers a very important part of its research programme. ECN is working in intensive co-operation with the EU and the US at the Euratom Joint Research Centre at Petten in a High Flux Reactor HFR (55 MW). By special arrangement with the European Commission, ECN and other Netherlands's research centres and industry can make use of about half the irradiation capacity at HFR. ECN has its own Low Flux Reactor (30 kW) and a laboratory for radiation research (LSO). This laboratory contains some hot-cells in which radioactive materials are manipulated.

- KEMA is the research institute of the Netherlands electricity producers at Arnhem.

- NUCON is an engineering consultancy specialising in Nuclear Technology in Amsterdam.

- IRI is an Inter-University Reactor Institute at Delft. IRI has a 2 MW research reactor (HOR) for educational purposes and does research on reactor physics, neutron beam physics and radiochemistry.

- GKN - a Joint Nuclear Power Plant the Netherlands Ltd.

- HTS - Hoogovens Technical Services.

- FOM is a foundation for fundamental research on matter at Nieuwegein. The main physics research aimed at thermonuclear fusion is done here.

ECN, KEMA, NUCON and IRI participate in the so-called "PINC-programme". The objective of this programme is to maintain Dutch competence on nuclear energy. Within the programme, much emphasis is placed on new reactor concepts.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Since the early days of the Netherlands nuclear program, international co-operation has been considered a necessity by all those involved. Since the joint exploitation of the Halden research reactor (together with Norway) in the 1950's and 1960's until the Urenco co-operation in uranium enrichment of the present day, the Netherlands' nuclear activities have been undertaken in close co-operation with other countries. A strong interest in multilateral co-operation on nuclear energy matters within intergovernmental organizations complements the orientation toward practical co-operation with others.

Present emphasis is on the development of passively safe light water reactors. Dutch institutes co-operate both with German institutes (SWR600/1000) through the 4th Framework Programme of the EU and with the US institutes (SBWR). Dodewaard's operation (BWR) is part of both. HFR at Petten, owned by EU's Joint Research Centre (JRC), is also involved at ECN together with Germany.

The Netherlands and Germany also co-operate in the area of subsurface radioactive waste disposal. Research in this area has been performed in Germany's Asse salt mine. In the future, transmutation of actinides (including plutonium) and other long-lived fission products may replace geological disposal. In this innovative area, Dutch institutes (as well as HFR) are involved in co-operation with JRC, French and Belgian institutes. Finally, interest has been expressed in a technology assessment of inherently safe nuclear reactors (e.g., HTGR).

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

Licensing and regulatory activities are the responsibilities of the Ministry of Economic Affairs, the Ministry for Public Housing, Planning and the Environment, the Ministry of Social Affairs and Employment, and the Ministry of Public Health, Welfare and Sport. In the Netherlands, basic legislation governing nuclear activities is contained in the Nuclear Energy Act of 1963, which has been amended on several occasions.

The Nuclear Energy Act prohibits the possession or transfer of fissile materials and ores without joint authorisation from the above mentioned Ministries. Similar authorisation is required to construct, bring on-line, operate or alter any facility in which nuclear energy may be released or in which fissile materials may be manufactured or processed, or are stored.

The general procedure for applying for a license is laid down in Section 3 of the Decree of September 1969 on nuclear installations, fissile materials and ores. Detailed conditions may be attached to the license concerning protection of people and property, national security, storage and surveillance of fissile materials and ores, and supplies. By way of exception, no license is required for possession of non-irradiated fissile materials containing only natural or depleted uranium or thorium in quantities not exceeding 100 grams of each of these elements, and no plutonium.

### 5.2. Main National Laws and Regulations

Electricity Act, Stb. 1989, no. 535
Nuclear Energy Act, Stb. 1963, no. 82, latest change: Stb. 993, no. 238
The Decree on the export of strategic materials 1963, Stb. no. 128

Other relevant laws and regulations:

- Laws:
  - Algemene Wet bestuursrecht, Stb. 1994, nr.1.
  - Wet milieubeheer, Stb. 1992, nr. 414.
  - Wettelijke aansprakelijkheid exploitanten nucleaire schepen, Stb. 1973, nr. 536
  - Wet aansprakelijkheid kernongevallen, Stb. 1979, nr. 225
  - Wet houdende machtiging tot deelneming in het aandelenkapitaal van de COVRA, Stb. 1986, nr. 627
  - Wet op de economische delicten (Stb. 1988, nr. 227)
- Decrees:
  - Definitiebesluit Kernenergiewet (KEW), Stb. 1969, nr. 358
  - Kerninstallaties, splijtstoffen en ertsen, Stb. 1969, nr. 403
  - Registratie splijtstoffen en ertsen, Stb. 1969, nr. 471
  - Registratie radioactieve stoffen/kosten keuringsdiensten KEW, Stb. 1969, nr. 472
  - Taakvervulling ambtenaren keuringsdiensten, Stb. 1969, nr. 474
  - Besluit inwerkingtreding, Stb. 1969, nr. 514
  - Uitvoering art. 22, vierde lid KEW, Stb. 1979, nr. 140
  - Geheimhoudingsbesluit, Stb. 1971, nr. 420
  - Besluit ongevallen kerninstallaties, Stb. 1976, nr. 138
  - Bijdragenbesluit KEW 1981, Stb. 1981, nr. 455
  - Besluit stralenbescherming KEW, Stb. 1986, nr. 465
  - Vrijstellingsbesluit landsverdediging, Stb. 1987, nr. 30
  - Vervoer splijtstoffen, ertsen en radioactieve stoffen, Stb. 1987, nr. 403
  - Uitvoering art. 33, vierde lid KEW, Stcrt. 1991, nr. 24
  - Besluit financieel verkeer strategische goederen (Stb. 1981, nr. 118)
  - Besluit afgifte verklaringen strategische goederen (Stb. 1981, nr. 118)
- Regulations and decisions:
  - Toezicht naleving KEW, Stcrt. 1969, nr. 239
  - Aanwijzing eerste kantoren, Stcrt. 1969, nr. 241
  - Aangifte splijtstoffen en ertsen, Stcrt. 1969, nr. 240
  - Aanwijzing landen KEW, Stcrt. 1969, nr. 240
  - Nadere aanwijzing toezichthoudende ambtenaren, Stcrt. 1969, nr. 244
  - Opsporingsbevoegdheid, Stcrt. 1969, nr. 248
  - Aanwijzing Kernenergiecentrale Borssele, Stcrt. 1976, nr. 91
  - Aanwijzing kernenergiecentrale Dodewaard, Stcrt. 1976, nr. 91
  - Aanwijzing Hoge Flux Reactor Petten, Stcrt. 1981, nr. 137
  - Aanwijzing kerncentrales Doel (België), Stcrt. 1981, nr. 181
  - Alarmregeling Hoge Flux Reactor Petten, Stcrt. 1981, nr. 181
  - Alarmregeling kerncentrales Doel (België), Stcrt. 1981, 235
  - Biologische werkzaamheid geabsorbeerde stralingsdosis, Stcrt. 1983, nr. 6
  - Richtlijnen voor de erkenning van opleidingen deskundigen radioactieve stoffen en toestellen, Stcrt. 1984, nr. 227
  - Aanwijzing kerninstallaties Studiecentrum kernenergie Mol (België), Stcrt. 1985, nr. 157
  - Alarmregeling Studiecentrum kernenergie Mol (België), Stcrt. 1985, nr. 157
  - Besluit waarschuwingssignalering radioactieve stoffen, Stcrt. 987, nr. 25
  - Besluit Classificatieregeling 1986, Stcrt. 1987, nr. 60
  - Besluit Regeling effectief dosisequivalent, Stcrt. 1987, nr. 60
  - Alarmregeling kernenergiecentrale Borssele, Stcrt. 1987, nr. 141
  - Alarmregeling kernenergiecentrale Dodewaard, Stcrt. 1987, nr. 141

- Regeling erkenning opleidingen deskundigen radioactieve stoffen en toestellen, Stcrt. 1987, nr. 176
- Regeling aanvraag vergunning en aangifte toestellen KEW, Stcrt. 1987, nr. 176
- Regeling aangifte radioactieve stoffen, Stcrt. 1987, nr. 176
- Erkenning COVRA N.V. als ophaaldienst voor splijtstoffen en ertsen bevattende stoffen, Stcrt. 1987, nr. 176
- Aanwijzing kernenergiecentrale Emsland (BRD), Stcrt. 1988, nr. 73
- Alarmregeling kernenergiecentrale Emsland (BRD), Stcrt. 1988, nr. 73
- Beschikking toezichthoudende ambtenaren, Stcrt. 1988, nr. 228
- Regeling inzake toepassing geheimhoudingsbesluit KEW, Stcrt. 1989, nr. 52
- Besluit tot uitvoering art. 33 Wet aansprakelijkheid Kernongevallen, Stb. 1990, nr. 455
- Bijdrageregeling verwijdering radioactieve stoffen bevattende bliksemopvangers, Stcrt. 1991, nr. 188
- Besluit wijziging vergunningverlening KEW, Stcrt. 1991, nr. 223
- Regeling inzake wijziging alarmregeling Kernenergiecentrale Borssele, Stcr. 1992, nr. 2
- Regeling aanwijzing rookmelders Kernenergie 1993, Stcrt. 1993, nr. 78
- Vrijstellingsregeling militaire zendingen (nietlandbouwgoederen) 1966, Stcrt. nr. 93
- Vrijstellingsregeling klein grensverkeer (nietlandbouwgoederen) 1963, Stcrt. nr. 133

Decommissioning and waste disposal strategies including their associated costs have been determined. Funds are being raised from the proceeds from the electricity tariffs.

### 5.3. International, Multilateral and Bilateral Agreements

The following is a list (status at January 1995) of International Conventions and Bilateral Agreements signed/ratified by the Kingdom of the Netherlands in the field of Nuclear Co-operation.

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Statute of the International Atomic Energy Agency (IAEA) | Entry into force:<br>Ratification date: | 26 October 1956<br>20 July 1957 |
| • Convention on third party liability in the field of nuclear energy | Entry into force:<br>Ratification date: | 29 July 1960<br>29 December 1979 |
| • Additional Protocol to the convention of 31 January 1963 supplementary to the convention Third Party Liability | Entry into force:<br>Ratification date: | 28 January 1964<br>28 September 1979 |
| • NPT related agreement INFCIRC/193 | Entry into force: | 21 Feb.1977 |
| • Improved procedures for designation of safeguards inspectors | Proposals rejected but agreed to special procedure | 16 Feb.1989 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | |
| • Convention on physical protection of nuclear material | Entry into force: | 6 September 1991 |
| • Amendment to the convention on third party liability in the field of nuclear energy | Entry into force:<br>Ratification date: | 16 November 1982<br>1 August 1991 |

| | | |
|---|---|---|
| • Amendment of the IAEA statute | Entry into force:<br>Ratification date: | 27 September 1984<br>11 July 1985 |
| • Convention on early notification of a nuclear accident | Entry into force:<br>Ratification date: | 26 September 1986<br>23 September 1991 |
| • Joint protocol relating to the application of the Vienna and the Paris conventions | Entry into force:<br>Ratification date: | 21 September 1988<br>1 August 1991 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 24 October 1991 |
| • Convention on civil liability for nuclear damage and joint protocol | Entry into force:<br>Entry into force: | 28 December 1979<br>27 April 1992 |
| • Convention on nuclear safety | Entry into force; | 20 September 1994 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | Summary: Serve as basis for national requirements. Design, Operation and QA Codes (once adapted) introduced into regulatory framework | 6 Sept.1989 |
| • Partial Test-Ban Treaty | Entry into force: | 14 Sept. 1964 |

*OTHER RELEVANT INTERNATIONAL TREATIES*

| | | |
|---|---|---|
| • European Atomic Energy Community | Entry into force:<br>Ratification date: | 25 March 1957<br>13 December 1957 |
| • EURATOM | Member | |
| • Security control in the field of nuclear energy | Entry into force:<br>Ratification date: | 20 December 1957<br>9 July 1959 |
| • European Company for the chemical processing of irradiated fuels (Eurochemic) | Entry into force:<br>Ratification date: | 20 December 1957<br>9 July 1959 |
| • Establishment at Petten of the Joint Nuclear Research Centre | Entry into force:<br>Ratification date: | 25 July 1961<br>30 October 1962 |
| • Civil liability in the field of maritime carriage of nuclear material | Entry into force:<br>Ratification date: | 17 December 1971<br>1 August 1991 |

*MULTILATERAL AGREEMENTS*

| | | |
|---|---|---|
| • Netherlands, Germany and England on collaboration in the development and exploitation of the gas centrifuge process for producing enriched uranium | Entry into force:<br>Ratification date: | 4 March 1970<br>18 June 1971 |

| | | |
|---|---|---|
| • Netherlands, Germany, United Kingdom and the USA regarding protection of information transferred into the USA in connection with the initial phase of a project for the establishment of a uranium enrichment installation in the USA based upon the gas centrifuge process developed within the three countries | Entry into force: | 4 November 1990 |
| • Netherlands, Germany, United Kingdom and the USA regarding the establishment, construction and operation of a uranium enrichment installation in the USA | Entry into force:<br>Ratification date: | 8 July 1993<br>21 March 1993 |

*BILATERAL AGREEMENTS*

| | | |
|---|---|---|
| • Kingdom of the Netherlands and Brazil Application of safeguards to proposed exports to Brazil of uranium enriched in the Kingdom of the Netherlands by Urenco | Entry into force: | 1 September 1978 |
| • Kingdom of the Netherlands and Germany concerning exports of enriched uranium to Brazil | Entry into force: | 4 September 1978 |
| • Kingdom of the Netherlands and the United Kingdom concerning reprocessing of certain quantities of irradiated nuclear fuel | Entry into force:<br>Ratification date: | 12 September 1978<br>30 June 1981 |
| • Kingdom of the Netherlands and France concerning reprocessing of certain quantities of irradiated nuclear fuel | Entry into force:<br>Ratification date: | 29 May 1979<br>17 August 1981 |
| • Extension of the agreement of 4 April 1990 regarding protection of information transferred into the United States | Entry into force:<br>Ratification date: | 5 April 1991<br>7 July 1992 |

## REFERENCES


[1] Dossier on Nuclear Energy of 15 November 1993 (TK '93-'94, 21.666 nr. 8).

[2] IEA, Energy Balances and Key Indicators.

[3] Nederlandse Staatswetten: Editie Schuurman en Jordens Kernenergiewet nr. 88, zevende druk and Elektriciteitswet 1989 nr. 125.

[4] World Bank World Tables 1995.

[5] EEDB/IAEA.

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL AUTHORITIES*

Ministry of Economic Affairs
Bezuidenhoutseweg 30
Postbus 20101
2500 EC 's-Gravenhage, the Netherlands
Tel.: +31-70-379.89.11
Fax: +31-70-347.40.81

Ministry of Social Affairs and Employment
Anna van Hannoverstraat 4
P.O. Box 90801
2509 LV The Hague, the Netherlands
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Fax: +31-70-333.40.33

Ministry of Housing, Spatial Planning
and the Environment (VROM)
Rijnstraat 8
P.O. Box 20951
2500 EZ The Hague, the Netherlands
Tel.: +31-70-339.39.39
Fax: +31-70-339. 13.55

Directorate-general of the Environment
Radiation Protection and Nuclear Safety Division
Rijnstraat 8
P.O. Box 30945
2500 GX The Hague, the Netherlands
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Fax: +31-70-339.13.14

*OTHER ORGANIZATIONS*

Netherlands Energy and Research Foundation
(ECN)
Westerduinweg 1
P.O. Box 1
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Fax: +31-224-56.34.90/56.44.80

COVRA
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4455 TW Nieuwdorp
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Fax: +31-113-61.39.50

KEMA N.V.
Utrechtseweg 310
P.O. Box 9035
6800 ET Arnhem, the Netherlands
Tel.: +31-26-356.91.11
Fax: +31-26-351.80.92/351.56.06

SEP N.V.
Utrechtseweg 310
Postbus 575
6800 EN Arnhem, the Netherlands
Tel.: +31-26-372. 11.11
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Radarweg 60
P.O. Box 58026
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# PAKISTAN

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# 1. GENERAL INFORMATION

## 1.1. General Overview

Pakistan is situated in South Asia. It lies between 23 and 37 degrees North latitude and 61 and 76 degrees East longitude. It is one of the fast emerging developing countries. According to the World Development Report 1994, it is currently ranked as the 107th country in terms of its Gross National Product per capita among the total 132 countries whose profiles are available.

In 1993, the population was about 133 million and the population density 167 inhabitants per square kilometre (Table 1). The growth rate in 1993 was 2.8%

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 50.0 | 65.7 | 85.3 | 121.9 | 132.9 | 136.6 | 3.4 |
| Population density (inhabitants/km$^2$) | 62.7 | 82.5 | 107.1 | 153.2 | 167.0 | 171.6 | |
| Predicted population growth rate (%) 1993 to 2000 | | 2.7 | | | | | |
| Area (1000 km$^2$) | | 796.1 | | | | | |
| Urban population in 1993 as percent of total | | 34.0 | | | | | |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

The historical Gross Domestic Product (GDP) statistics are shown in Table 2 and some basic indicators in Table 3.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 10,116 | 23,723 | 39,464 | 48,363 | 51,199 | 5.6 |
| GDP (millions of constant 1990 US$) | 13,068 | 21,941 | 39,464 | 46,120 | 47,984 | 5.7 |
| GDP per capita (current US$/capita) | 154 | 278 | 324 | 364 | 375 | 2.2 |
| GDP by sector (1993): Agriculture 26% | | | | | | |
| Industry 26% | | | | | | |
| Services 49% | | | | | | |

Source: IAEA Energy and Economic Data Base

TABLE 3. BASIC INDICATORS

| Indicator | Period/year | |
|---|---|---|
| Average annual rate of inflation | 1970-80 | 13.4% |
| | 1980-92 | 7.1% |
| Life expectancy at birth | 1992 | 59 yr. |
| Adult illiteracy Female | 1990 | 79% |
| Total | 1990 | 65% |

Source: World Development Report 1994

### 1.3. Energy Situation

Pakistan does not have adequate natural energy resources (Table 4.). In order to increase the economic development and improve the quality of life, Pakistan has to import large quantities of oil to meet its energy requirements. Pakistan spent about 21% of its export earnings on energy imports in 1993 and the amount is consistently increasing.

TABLE 4. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 15.35 | 1.18 | 25.33 | | 14.46 | 56.32 |

[1] *This total represents essentially recoverable reserves.*
[2] *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1992) by a factor of 10.*
Source: IAEA Energy and Economic Data Base

The main sources of energy supply in Pakistan are oil and gas which together constitute more than 80% of total commercial supply. The contribution of coal is very small (about 6.6%), and that of nuclear and LPG, virtually negligible. During Pakistan's Sixth Five Year Plan (1983-1988), energy consumption increased at a rate of 6.6% per year compared to a Gross Domestic Product (GDP) growth rate of 6.8. The historical energy statistics are given in Table 5.

TABLE 5. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 0.19 | 0.47 | 0.72 | 1.43 | 1.64 | 1.74 | 6.99 | 6.50 |
| - Solids[2] | 0.07 | 0.18 | 0.20 | 0.33 | 0.35 | 0.36 | 5.82 | 4.22 |
| - Liquids | 0.09 | 0.17 | 0.20 | 0.46 | 0.54 | 0.60 | 3.95 | 8.28 |
| - Gases | 0.02 | 0.10 | 0.23 | 0.47 | 0.55 | 0.58 | 12.31 | 6.68 |
| - Primary electricity[3] | 0.01 | 0.03 | 0.08 | 0.17 | 0.21 | 0.19 | 13.60 | 6.09 |
| Energy production | | | | | | | | |
| - Total | 0.07 | 0.31 | 0.53 | 1.04 | 1.20 | 1.22 | 10.78 | 6.08 |
| - Solids | 0.02 | 0.16 | 0.20 | 0.30 | 0.32 | 0.33 | 10.99 | 3.82 |
| - Liquids | 0.02 | 0.02 | 0.02 | 0.11 | 0.13 | 0.12 | 1.45 | 13.47 |
| - Gases | 0.02 | 0.10 | 0.23 | 0.47 | 0.55 | 0.58 | 12.31 | 6.68 |
| - Primary electricity[3]) | 0.01 | 0.03 | 0.08 | 0.17 | 0.21 | 0.19 | 13.60 | 6.09 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.13 | 0.18 | 0.20 | 0.39 | 0.45 | 0.52 | 2.31 | 6.99 |
| - Solids | 0.04 | 0.02 | 0.01 | 0.03 | 0.03 | 0.03 | -7.12 | 9.07 |
| - Liquids | 0.09 | 0.17 | 0.19 | 0.36 | 0.42 | 0.49 | 4.06 | 6.88 |
| - Gases | | | | | | | | |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

The government announced a comprehensive energy policy in 1994. Included is a 23 billion-US-dollar five-year crash programme to generate energy by exploiting the oil, gas, coal and hydro-electric potential in such a way that balance is attained in contribution from each of these resources. The government's target is to make investment of 11 billion US dollars in the public sector projects and provide 12 billion US dollars to private sector projects.

A package of attractive incentives has been designed by the government to encourage private investments in energy projects. These include abolishing the import license fees and duties as well as enforcing tax free import of machinery. To ensure marketability of privately produced electricity, the government has agreed to buy the bulk of this electricity at a standard flat rate of 0.65 US dollar per kWh. The price has been fixed in foreign exchange market to remove any uncertainty about the par value of the Pakistani Rupee. The government's revised policy is not to use public sector funds for power production, except for hydro generation in limited cases, in the remote regions to the North. This indicates that private sector funding will be needed for setting up new Nuclear Power Plants.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

There are three basic utilities:

- WAPDA (Water and Power Development Authority, Public Sector):
  - Planning and Execution of generation, transmission, and distribution of electricity;
  - Execution of irrigation, water storage, and soil drainage schemes;
  - Prevention of water logging and carrying out reclamation of water logged and saline lands;
  - Flood control.

- KESC (Karachi Electric Supply Corporation, Limited Co.):
  - Majority of its shares are held by the Public Sector, however, privatisation is underway;
  - Generation, transmission and distribution of power to Karachi and Uthal in Sind, and Bela district in Balochistan).

- KANUPP (Karachi Nuclear Power Plant, Public Sector):
  - Pakistan Atomic Energy Commission (PAEC) is the owner and operator of KANUPP;
  - Energy is sold to KESC at the station bus-bars.

Table 6 shows the size of the power plants and transmission lines of the utilities and Figure 1 the breakdown of the power plants in total generation.

TABLE 6. POWER PLANTS AND GRID OF UTILITIES

| Utilities | Installed Capacity (MW(e)) | | | Transmission |
|---|---|---|---|---|
| | Thermal | Hydro | Nuclear | Type |
| WAPDA | 4718 | 4726 | 0 | 500, 220 kV |
| KESC | 1738 | 0 | 0 | 220, 132 kV |
| KANUPP | 0 | 0 | 137 | 132 kV |

Source: Pakistan Energy Yearbook 1994, an official publication of the Ministry of Petroleum & Natural Resources, Government of Pakistan, April 1995.

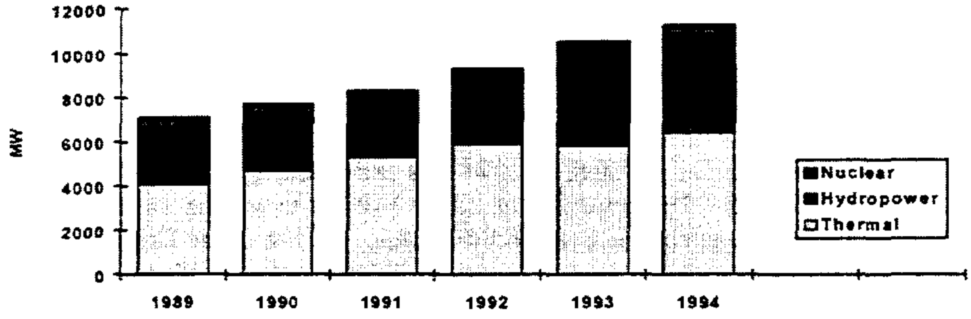


*FIG. 1. Installed Generating Capacity of Electric Power*

## 2.2. Decision Making Process

The National Economic Council (NEC) is the supreme economic body responsible for ensuring balanced development of the country. It was created in December 1962 under Article 145 of the Constitution of Pakistan. NEC is headed by the Chief Executive (President or Prime Minister) of the country. Its members include Federal Ministers of economic ministries, the Governors/Chief Ministers of the provinces, and the Deputy Chairman of the Planning Commission. The Planning Commission is the chief instrument for formulating the national plans.

The Energy Wing of the Planning Commission estimates the energy demand on the basis of information obtained from all utilities. It integrates this information at the national level to formulate a unified short and long term national energy policy.

Within the energy sector, the nuclear power area is handled exclusively by the Pakistan Atomic Energy Commission (PAEC), which also carries out its own energy studies and suggests to the Energy Wing the proper time for incorporation of new nuclear power units with a view towards ensuring an appropriate mix of resources for electricity generation. The Energy Wing forwards the suggestions to the National Economic Council. NEC has overall control of planning and approves all plans and policies relating to electricity sector development, and makes the energy policy. The Executive Committee of the National Economic Council (ECNEC) supervises the implementation of energy policy laid down by the Government.

Due to the chronic shortage of electricity, the Government announced a comprehensive energy policy in 1994. The new policy encourages private funding for setting up power plants. The Government has guaranteed to buy the bulk of this electricity at a standard flat foreign exchange rate. The choice of site, fuel, and the type of plant depends solely on the entrepreneur. A Private Power and Infrastructure Board has been set up under the Ministry of Water and Power to assess, evaluate, and co-ordinate the private sector power generation projects. The new policy has made the entire process of setting up power plants by the private sector much simpler and has transformed it virtually into a one-window operation.

The Ministry of Water and Power also looks after the day to day affairs pertaining to the various utilities and bodies in the energy sector.

## 2.3. Main Indicators

Table 7 shows the historical electricity production statistics and installed capacities and Table 8 the energy related ratios. Pakistan's installed generation capacity of WAPDA, according to its 1993-94 annual report, is estimated at 9,472 MW(e) (hydro 4,726 MW(e) and thermal 4,746 MW(e)). The installed generation capacity of KESC is 1,738 MW(e), while the effective capacity is 1,550 MW(e), all of which is thermal. Nuclear power, i.e., KANUPP, adds another 137 MW(e). The hydro capacity is largely seasonally dependent, decreasing to less than 2,000 MW(e) when the water level in the dams gets low. WAPDA's thermal generation is impacted due to ageing of the plants which has reduced the effective generation capacity to approximately 3,755 MW(e). This lower generation capacity, vis-à-vis the installed capacity, has resulted in load shedding which adversely effects the economy.

The electricity demand at the start of 1994 was estimated to be 13,300 MW(e), while only 11,319 MW(e) was installed. This shortfall of 2,000 MW(e) is costing an enormous amount of money to the national exchequer because of load shedding. With a Gross Domestic Product (GDP) growth rate of 6%, and an estimated income elasticity of demand of 1.35 during 1990's and 1.20 beyond 2000, the annual growth rate of electricity demand till the year 2000 is forecasted to be 8.1%, and later to decrease to 7.2% from 2000 - 2010. Future electricity demand will have to be filled with new power plants based on imported oil, coal or nuclear power or an appropriate mix of these (Table 9).

TABLE 7. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 2.21 | 8.73 | 14.97 | 43.88 | 55.21 | 57.15 | 10.05 | 10.04 |
| - Thermal | 1.53 | 5.81 | 6.26 | 26.53 | 33.73 | 37.19 | 7.31 | 13.58 |
| - Hydro | 0.68 | 2.91 | 8.71 | 16.93 | 21.11 | 19.44 | 13.60 | 5.90 |
| - Nuclear | | | | 0.42 | 0.37 | 0.52 | | 48.70 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 0.66 | 2.33 | 3.50 | 9.06 | 12.39 | 13.17 | 8.72 | 9.94 |
| - Thermal | 0.40 | 1.67 | 1.79 | 6.03 | 7.64 | 8.32 | 7.74 | 11.59 |
| - Hydro | 0.25 | 0.67 | 1.57 | 2.90 | 4.63 | 4.73 | 9.55 | 8.20 |
| - Nuclear | | | 0.14 | 0.13 | 0.13 | 0.13 | | -0.65 |

[1] *Electricity losses are not deducted*

Source: IAEA Energy and Economic Data Base

TABLE 8. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 4 | 7 | 8 | 12 | 12 | 13 |
| Electricity per capita (kW·h/capita) | 44 | 124 | 172 | 351 | 404 | 406 |
| Electricity production/Energy production (%) | 31 | 25 | 27 | 40 | 43 | 44 |
| Nuclear/Total electricity (%) | | | | 1 | 1 | 1 |
| Ratio of external dependency (%)[1] | 69 | 39 | 28 | 27 | 27 | 30 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 38 | 43 | 49 | 55 | 51 | 50 |
| - Thermal | 43 | 40 | 40 | 50 | 50 | 51 |
| - Hydro | 31 | 50 | 63 | 67 | 52 | 47 |
| - Nuclear | | | | 38 | 34 | 47 |

[1] *Total net import / Total energy consumption.*

Source: IAEA Energy and Economic Data Base

TABLE 9. PROJECTED REQUIREMENTS OF ELECTRICITY GENERATION CAPACITY (MW(e)) IN THE YEARS 2000 AND 2010

| | 2000 | 2010 |
|---|---|---|
| Projected Capacity | 22,000 | 44,000 |
| Expected Capacity | | |
| Hydro | 6,500 | 13,500 |
| Gas | 3,000 | 3,000 |
| Indigenous Coal | 500 | 500 |
| Total | 10,000 | 19,500 |
| Shortfall | 12,000 | 24,500 |

Source: PAEC, ASAG

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

Pakistan's fossil fuel resources have remained limited while its hydro resources show seasonal variation and are confined to the northern part of the country. This fragile resource base has made it essential for Pakistan to opt for nuclear power generation.

Pakistan started constructing of its first Nuclear Power Plant (KANUPP) in 1966 at Karachi and commissioned it in 1971. The contract for a turnkey project of 125 MW(e) CANDU (PHWR) reactor was awarded to the Canadian General Electric (CGE). In 1975, Canada refused to authorise supply of more fuel and spares for this plant due to nuclear non-proliferation concerns. Thereafter, the Pakistan Atomic Energy Commission undertook fuel fabrication on an emergency basis and has been producing locally made fuel since 1981.

Work is in progress on Pakistan's second Nuclear Power Plant at Chashma, which is a 300 MW(e) PWR reactor being supplied on turnkey basis by China. A study is now in progress under the Technical Co-operation Programme of the Agency to identify the optimal role of nuclear power in the medium-to-long term supply of electricity in Pakistan.

### 3.2. Current Policy Issues

Pakistan was among the first few developing countries to enter the field of peaceful uses of nuclear energy for power generation. Unfortunately, development of nuclear power in the country was constrained due to shortage of financial resources and a low level of technical expertise available. However, this situation has improved considerably as a result of many years of a sustained and rigorous programme of training, research and development in the nuclear field. Pakistan now has the technical capability to take on increased domestic role in nuclear power plants. The modest nuclear energy programme is geared toward supplanting the shortage of electricity. On the direction of the Government, a study is now being conducted by PAEC with the help of IAEA, to identify an optimal role of nuclear power in the future electricity generation mix of the country.

### 3.3. Status and Trends of Nuclear Power

The Canadian manufactured KANUPP unit, 125 MW(e) PHWR, at Karachi, generated nearly 0.31 TW·h in 1996. The availability factor in 1994 exceeded 85%. Nuclear power provides only about 1% of electricity generation in Pakistan. In 1992, Pakistan awarded a turnkey contract to China for a 300 MW(e) PWR, which is an improved version of the Qinshan unit put into operation in China in 1993. Construction work at this Chashma Nuclear Power Plant (CHASNUPP-1) started in December 1992, and is on schedule. Commissioning of this plant is expected by September 1998, with commercial operation commencing in March 1999. Discussions of supplying a second Qinshan type unit are under way (Table 10).

TABLE 10. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| KANUPP | PHWR | 125 | PAEC | Operational | CGE |
| CHASNUPP 1 | PWR | 300 | PAEC | Under Constr. | CNNC |
| CHASNUPP 2 | PWR | 300 | PAEC | Planned | |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| KANUPP | 01-Aug.-66 | 01-Aug.-71 | 18-Oct.-71 | 01-Oct.-72 | |
| CHASNUPP 1 | 01-Aug.-93 | 01-Sept.-98 | 25-Oct.-98 | 25-Mar-99 | |
| CHASNUPP 2 | | | | | |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organizational Chart

Figure 2 shows the organizational chart for nuclear energy development in Pakistan.

In Pakistan, the responsibility for matters pertaining to atomic energy rests with the Pakistan Atomic Energy Commission (PAEC). PAEC has a Chairman and four full-time working Members, and reports to the Pakistan Atomic Energy Council. The Council has 22 members and is headed by the Minister in charge of Nuclear Energy. Since the inception of PAEC, this portfolio has always been retained by the various Prime Ministers of Pakistan or by the Executive Head of the government. PAEC not only carries out research in nuclear matters and materials, but also operates the nuclear power plant(s), and the various agriculture and medical centres utilising nuclear techniques. It also represents Pakistan's membership in IAEA.

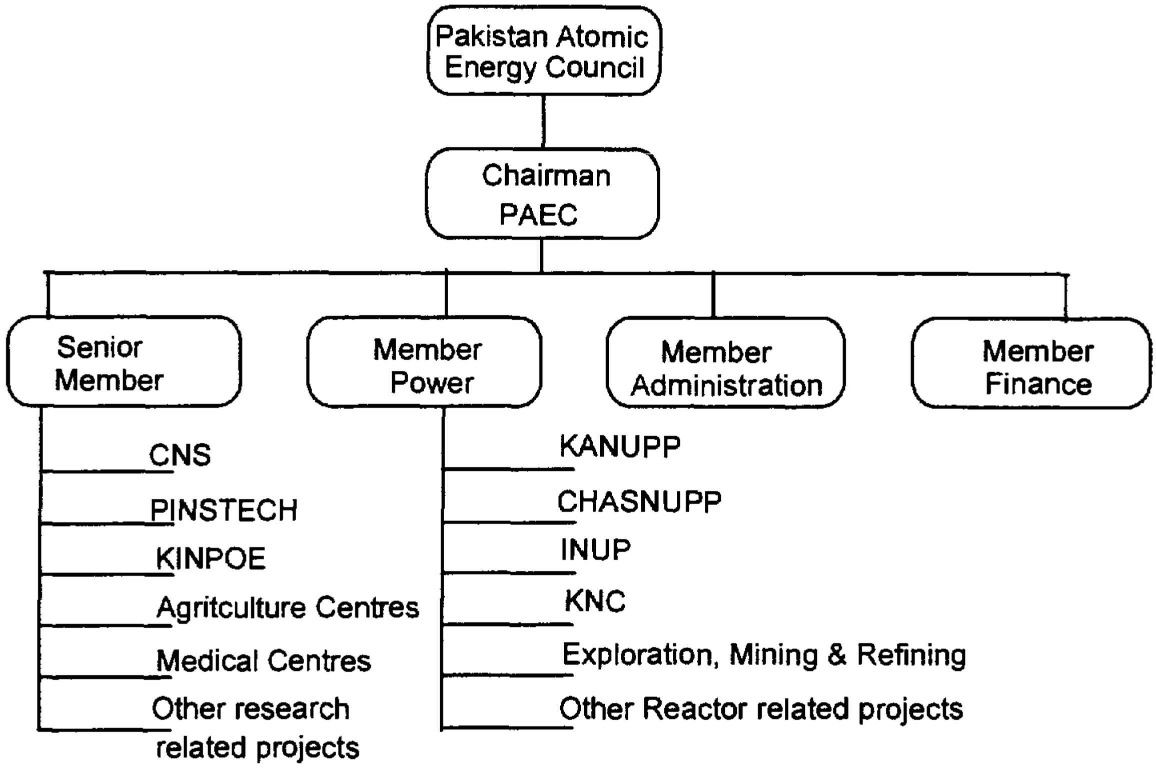


*FIG. 2. Organizational Chart for Nuclear Energy Development in Pakistan*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of Nuclear Power Plants

Pakistan has not yet achieved full self reliance in the construction, fabrication and installation of nuclear power plants. However, it now has the technical capability to presume an increased domestic role in nuclear power plants.

### 4.2. Operation of Nuclear Power Plants

PAEC is responsible for the long term planning, development, generation, and operation of nuclear power plants in Pakistan. In support of the overall nuclear power programme in the country, the National Centre for Non-Destructive Testing (NCNDT) and the Pakistan Welding Institute (PWI) under PAEC have been set up. The centre and institute will support the quality assurance programme for nuclear power plants, particularly concerning the in-service inspections for selected components of KANUPP, and improvement of the quality of welding in the country. Other PAEC research centres (e.g., PINSTECH) provide valuable backup research and analytical services as required.

### 4.3. Fuel Cycle and Waste Management Service Supply

*Fuel Fabrication Facilities*

KNC Fuel Fabrication Plant

*Radioactive Waste Storage Facilities*

| | | |
|---|---|---|
| KANUPP Site | Interim | Low and Medium Level |
| PINSTECH Site | Interim | Low Level |

### 4.4 Research and Development Activities

*Research Reactors Facilities*

| | | | |
|---|---|---|---|
| PARR-1 | Swimming Pool | 10 Mw(e) | AMF, USA |
| PARR-2 | Tank in Pool | 30 kW | CIAE, People's Republic of China |

*Research Institutes/Centres*

- PINSTECH (Pakistan Institute of Nuclear Science and Technology)
  Basic/Applied Research in Physics, Materials, Safety, Radioisotope Applications and Radiation Protection

- CNS (Centre for Nuclear Studies)
  Reactor Safety, Instrumentation & Control (Master's Degree Courses in Nuclear Engineering

- KINPOE (Kanupp Institute of Nuclear Power Technology)
  NPP Operation and Reactor Safety (Master's Degree Courses in Nuclear Power Technology)

- INUP (Institute for Nuclear Power)
  Indigenization and Design of NPP

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

As part of its commitment toward ensuring and continuously enhancing the operating safety of KANUPP, Pakistan is an active member in various international organization in the field of nuclear energy, and exchanges operating data regularly. During the last two years, the Fuel Channel Integrity Assessment Programme (FCIA) was undertaken with the help of IAEA and Canada. An independent review of KANUPP steam generators was also carried out under contract by a Canadian utility. An IAEA seismic safety review mission inspected the plant in 1993. The preliminary findings of the above mission are eminently satisfactory. The KANUPP is a member of WANO and COG.

The 300 MW(e) Chashma nuclear power plant, which is under IAEA safeguards, is expected to enter commercial operation in early 1999. Naturally, PAEC expects to share its operating information with other NPP operators.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

In Pakistan, nuclear regulatory matters are overseen by the Directorate of Nuclear Safety and Radiation Protection (DNSRP), headed by a Director-General. However, the ultimate nuclear regulatory authority, which sets policy and nuclear safety standards, is the Pakistan Nuclear Regulatory Board (PNRB). The Board has nine members. This Board is currently headed by the Chairman of PAEC who is also a member of PNRB. The Director-General of DNSRP also serves as a member and ex-officio Secretary (Figure 3 ) and as such looks after day to day matters pertaining to nuclear safety and regulation.

Member Finance and Member Administration of PAEC are also shared by PNRB. The remaining five Members are eminent scientists/engineers, none of whom can have, by charter, any existing connection with PAEC during their tenure on PNRB. This composition ensures that the external technical members have the majority vote over the members with PAEC affiliations.

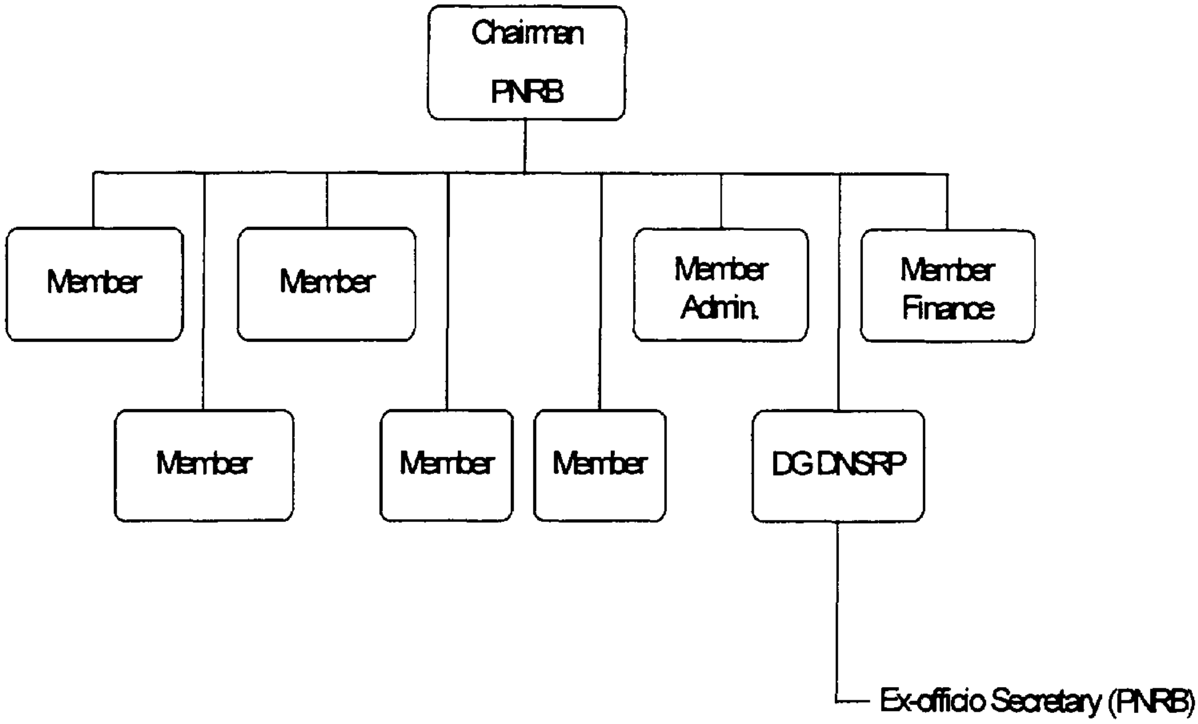


*FIG. 3. Organizational Chart of Pakistan Nuclear Regulatory Board (PNRB)*

The governmental organization responsible for licensing Nuclear Power Plants and other nuclear installations is the Directorate of Nuclear Safety and Radiation Protection (DNSRP). The licensing procedure in Pakistan follows the IAEA guidelines and safety requirements. Accordingly, nuclear power plants in Pakistan are to be designed in accordance with the IAEA-NUSS Rev. 1 issued in 1988.

The licensing procedure is comprised of the following three stages:

- Registration of Site;
- Issuance of Construction License;
- Issuance of Operating License.

**5.2. Main National Laws and Regulations**

- Pakistan Nuclear Safety and Protection Ordinance 1984
- Pakistan Nuclear Safety and Protection Regulations 1990

After the promulgation of the Pakistan Nuclear Safety and Radiation Ordinance in 1984, and Nuclear Safety and Radiation Protection Regulations in 1990, preparation of regulatory documents started in 1990. The first document, prepared in 1990, was the "Procedure for Licensing of Nuclear Power Plants in Pakistan", which provides the basis for the licensing of nuclear power plants in Pakistan. Similarly, "Procedure for licensing of Research Reactors in Pakistan" was prepared in 1991.

**5.3. International, Multilateral and Bilateral Agreements**

Pakistan became a Member State of the International Atomic Energy Agency (IAEA) in 1957 and has actively participated in virtually all of the Agency's activities. Pakistan has benefited from the IAEA's Technical Assistance and Co-operation Programme (TACP), and has also provided training through TACP, for many scientists and engineers from other developing countries.

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Technical Assistance related | | |
| INFCIRC | Entry into force: | |
| /34 | Research reactor | 5 March 1962 |
| /116 | NPP Project | 17 June 1968 |
| • Safeguards related | | |
| INFCIRC | Entry into force: | |
| /135 | Canada | 17 October 1969 |
| /239 | France | 18 March 1976 |
| /248 | Supply of U-concentrate | 2 March 1977 |
| /393 | Supply of miniature source reactor from PRC | 10 September 1991 |
| /418 | Supply of nuclear power Station from PRC | 24 February 1993 |
| • Improved procedures for designation of safeguards inspectors | Prefers the present system. Letter of: | 20 December 1988 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 22 September 1994 |
| • RCA | Entry into force: | 3 September 1987 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Non-Party | |
| • Agreement on privileges and immunities | Entry into force: | 16 April 1963 |
| • Convention on physical protection of nuclear material | Non-Party | |
| • Convention on early notification of a nuclear accident | Entry into force: | 12 October 1989 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 12 October 1989 |
| • Conventions on civil liability for nuclear damage and joint protocol | Non-Party | |
| • Convention on nuclear safety | Signature: | 20 September 1994 |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines | Not adopted | |
| • Acceptance of NUSS Codes | No Reply | |
| • Partial Test-Ban Treaty | Signature: | 14 August 1963 |

*BILATERAL AGREEMENTS*

| | | |
|---|---|---|
| • Agreement For Providing Assistance on Nuclear Safety Review of Chashma Nuclear Power Project | China | 1992 |
| • Agreement For Providing Assistance in Nuclear Safety Inspections for Chasm Nuclear Power Project | China | 1994 |

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## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Pakistan Atomic Energy Commission<br>(PAEC)<br>P.O. Box 1114<br>Islamabad<br>Pakistan | Tel.: +92-51-9204276<br>Fax: +92-51-824908<br>Telex: 5725 ATCOM PK<br>Cable: ATOMCOM, ISLAMABAD |
| Directorate of Nuclear Safety and<br>Radiation Protection (DNS&RP)<br>Pakistan Atomic Energy Commission,<br>P.O. Box 1912<br>Islamabad<br>Pakistan | Tel.: +92-51-92004417<br>Fax: +92-51-9204112<br>Telex: 5725 ATCOM PK |

# RUSSIAN FEDERATION

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# RUSSIAN FEDERATION

## 1. GENERAL INFORMATION

### 1.1. General Overview

Russia is a large country occupying the eastern part of Europe and the northern part of Asia. In the north the country is bounded by the Arctic Ocean, Finland being the farthest north-west neighbour. In the west and southwest, the country is surrounded by the new independent states, the former republics of the Soviet Union. In the south and southeast, Russia has a common border with Kazakstan, Mongolia, China and North Korea. The eastern border of the country is the Pacific Ocean, here Japan and the Alaska state of the USA are the nearest neighbours.

The total area of Russia is about 17,075 million $km^2$. The country consists of a large number of administrative units: regions (provinces) and republics. The regions of the country differ widely in territory, natural conditions, the structure and national composition of the population, and economic development. The climate of country is marked by very wide regional variations. A significant part of north-eastern Russia falls within the frigid zone, while the Black Sea region has semitropical conditions.

Russia is abundant in energy resources of various kinds. The energy sector is a well developed and important part of the national economy, producing about 10% of national Gross Domestic Product (GDP). Totally up to 95% of the country's energy consumption is met by fossil fuel. Despite its rich oil, gas and coal potential Russia was one of the first countries to master nuclear energy for peaceful uses. In 1954, the Obninsk Nuclear Power Plant was commissioned and connected to the grid.

According to the latest statistics, the population of Russia amounts to about 150 million (Table 1). The average population density is about 8.7 inhabitants per $km^2$. This number greatly varies around the country: from more than 100 inhabitants per $km^2$ for some regions in the European part of Russia through less than one for large territories in Siberia and the far north-east.

TABLE 1. POPULATION INFORMATION

| Year | Population, millions | | | | | Population Density, |
|---|---|---|---|---|---|---|
| | TOTAL | Urban | Rural | Men | Women | inhab/$km^2$ |
| 1985 | 143.8 | 104.1 | 39.7 | 66.9 | 76.9 | 8.42 |
| 1986 | 145.1 | 105.7 | 39.4 | 67.7 | 77.4 | 8.50 |
| 1987 | 146.3 | 107.1 | 39.2 | 68.4 | 77.9 | 8.57 |
| 1988 | 147.4 | 108.4 | 39.0 | 69.0 | 78.4 | 8.63 |
| 1989 | 148.0 | 109.2 | 38.8 | 69.4 | 78.6 | 8.72 |
| 1990 | 148.5 | 109.8 | 38.7 | 69.7 | 78.8 | 8.70 |
| 1991 | 148.7 | 109.7 | 39.0 | 69.9 | 78.8 | 8.71 |
| 1992 | 148.6 | 109.7 | 38.9 | 69.8 | 78.8 | 8.70 |
| 1993 | 148.4 | 109.6 | 38.8 | 69.7 | 78.7 | 8.70 |

### 1.2. Economic Indicators

The historical data presented in Table 2 clearly reflect the economic crisis accompanying the process of economic transition reforms. The Gross Domestic Product (GDP) values have been declining since 1990. Lately, there has been some improvement in the macro-economic parameters, but it is still too early to assert that the recovery from the crisis has begun. Fig. 1 shows the GDP structure in 1993.

## 1.3. Energy Situation

Fossil fuels are the base for the Russian energy sector. Table 3 gives the 1993 consumption of the primary energy resources in million ton oil equivalent and Table 4 the historical energy data in exajoules. The share of nuclear energy in the energy supply is only 2%. Hydro energy, which currently is the only meaningful renewable energy resource in Russia amounts to about 3%.

## 1.4. Energy Policy

"The Energy Strategy of Russia" states priorities as well as means for the radical revision of structural and technological policies that pertain to the nation's energy supply for the period 1995-2010. Its main goal is to achieve the European level of per capita energy consumption and ecological safety of population. Emphasis is placed upon the complex approach towards the solution of regional energy supply problems.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | | | | | | |
| GDP (millions of constant 1990 US$) | | 585,153 | 591,407 | | | |
| GDP per capita (current US$/capita) | 343,787 | 525,217 | 591,407 | 413,814 | 351,742 | -2.8 |
| GDP by sector : | | | | | | |
| Agriculture 9% | | | | | | |
| Industry 51% | | | | | | |
| Service 40% | | | | | | |

Source: IAEA Energy and Economic Data Base

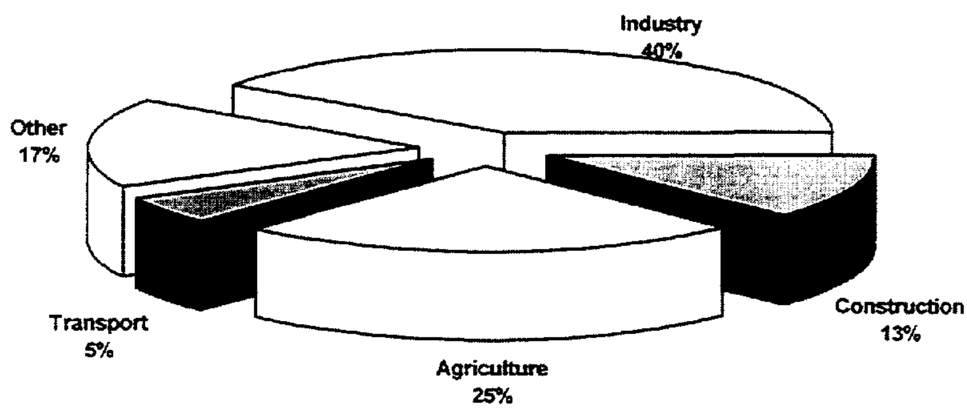


*FIG. 1. Gross Domestic Product (GDP) structure in 1993.*

TABLE 3. CONSUMPTION OF PRIMARY ENERGY RESOURCES IN 1993

| Energy Source | mln toe |
|---|---|
| Coal | 141 |
| Liquid Fuel | 351 |
| Natural Gas | 498 |
| Nuclear | 27 |
| Hydro | 38 |
| Other | 14 |

TABLE 4. ENERGY STATISTICS Exajoule

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Energy consumption | | | |
| - Total[1] | 34.4 | 32.31 | 28.28 |
| - Solids[2] | 7.7 | 7.17 | 6.26 |
| - Liquids | 9.5 | 8.71 | 6.53 |
| - Gases | 14.5 | 13.77 | 13.04 |
| - Primary electricity[3] | 2.7 | 2.66 | 2.45 |
| Energy production | | | |
| - Total | 48.2 | 44.83 | 41.93 |
| - Solids | 7.8 | 7.00 | 6.18 |
| - Liquids | 16.7 | 14.72 | 13.22 |
| - Gases | 20.9 | 20.28 | 19.89 |
| - Primary electricity[3]) | 2.8 | 2.84 | 2.65 |
| Net import (import - export) | | | |
| - Total | -13.5 | -12.16 | -12.75 |
| - Solids | | 0.03 | 0.06 |
| - Liquids | -7.3 | -6.54 | -6.60 |
| - Gases | -6.2 | -5.65 | -6.21 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

The prognosis of energy sector development in the near future is based on:

- overcoming the national economic crisis and subsequent rise;
- new investment strategy;
- new price and taxation policies;
- privatisation and denationalisation;
- modernisation of national laws and regulation in energy sector.

The structural policy of the energy sector for the next 10-15 years aims:

- enhancement of the efficiency of natural gas utilisation and an increase its share of domestic consumption, especially in ecologically strained regions;
- in-depth processing and comprehensive utilisation of hydrocarbon raw materials;
- enhancement of the coal quality, as well as the stabilisation of coal production volumes;
- reversal of the decline in, and moderate expansion of, oil production;
- intensification of local and renewable energy resources development (hydro and wind power, peat, etc.);
- priority in electricity generation development based on competitive and ecologically clean power plants;
- safety and reliability enhancement of the first generations' NPPs and development of new advanced nuclear power plants.

The new technological energy policy is oriented toward:

- radical enhancement of both the cost effectiveness and the energy efficiency of all stages of the extraction, conversion, distribution, and utilisation of energy resources;
- effective decentralisation of the energy supply;
- ecological and accident safety, as well as the reliability of the energy supply, and;
- development of qualitatively new technologies for the stable evolution of power industry: ecologically clean coal-fired power plants, safe nuclear power plants, efficient processes for the utilisation of new sources of power, etc.

Regional energy policy takes into account the existing principal differences of energy supply conditions and structures of fuel resources of various parts of Russia. Regional energy self-governing and self-consistency is envisaged as a major challenge, i.e., sustaining the unified national energy sector through the development of federal energy systems: electricity, gas and oil supply networks.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

The National Electricity Supply System consists of the Unified Electricity System (UES), the Regional Electricity System "VOSTOK" and the Isolated Local Electricity Systems.

- **Unified Electricity System.** This system is the main part of large integrated electricity system of the former Soviet Union and the predominant part of the national electricity grid. It covers the European part of Russia and a large part of Siberia with six large Regional Electricity Systems that include 63 Local Electricity Systems. UES generated 1,022 TW·h or 95.6% of total electricity generation in 1991. Large regional UES systems are:
  - Central Power Pool (~29% of total capacity );
  - Middle Volga Power Pool (~10% of total capacity);
  - Ural Power Pool (~ 23% of total capacity);
  - Northwest Power Pool (~ 15% of total capacity);
  - North Caucasus Power Pool (~ 5% of total capacity);
  - Siberia Power Pool (~18% of total capacity).

- **Regional Electricity System "VOSTOK".** This system operates separately from the main grid. It covers the far eastern part of Russia and consists of four Local Electricity Systems generating 45.2 TW·h or 4.2% of total electricity generation in 1991. There is a limited amount energy exchange between the two main country systems.

- **Isolated Local Electricity Systems.** There are five rather small systems situated in remote regions where communication with the rest of the country is difficult. Despite their small size, they are very important locally. In 1991, these systems generated 1.3 TW·h or 0.1% of total electricity generation.

At present, all electricity distribution systems are owned by joint-stock companies with 50% government participation. The basic structure of the national electricity sector is presented in Figure 2. Federal and regional energy commissions are responsible for energy planning.

### 2.2. Decision Making Process

- Pricing and taxation constitute the core of the new energy policies. The liberalisation of oil, petroleum products and coal prices, which was undertaken in mid-1993, was not extended to the products of the so-called natural monopolies: natural gas, electric power, and heat from centralised sources. Prices for these energy sources are currently set by the federal regional government agencies responsible for the functions of the fuel and energy sector.

- The creation of a competitive environment within the fuel and energy sector of the national economy will be directed towards reducing production costs and increasing the quality of energy-related services. This will be accomplished though industry denationalisation, primarily through the joint-stock companies.

- A system of incentives and conditions for the conservation of energy, as well as the increase in energy production efficiency, is needed in order to realise Russia's vast potential for energy conservation.

- Economic policies will be focused on the promotion of investment activities.

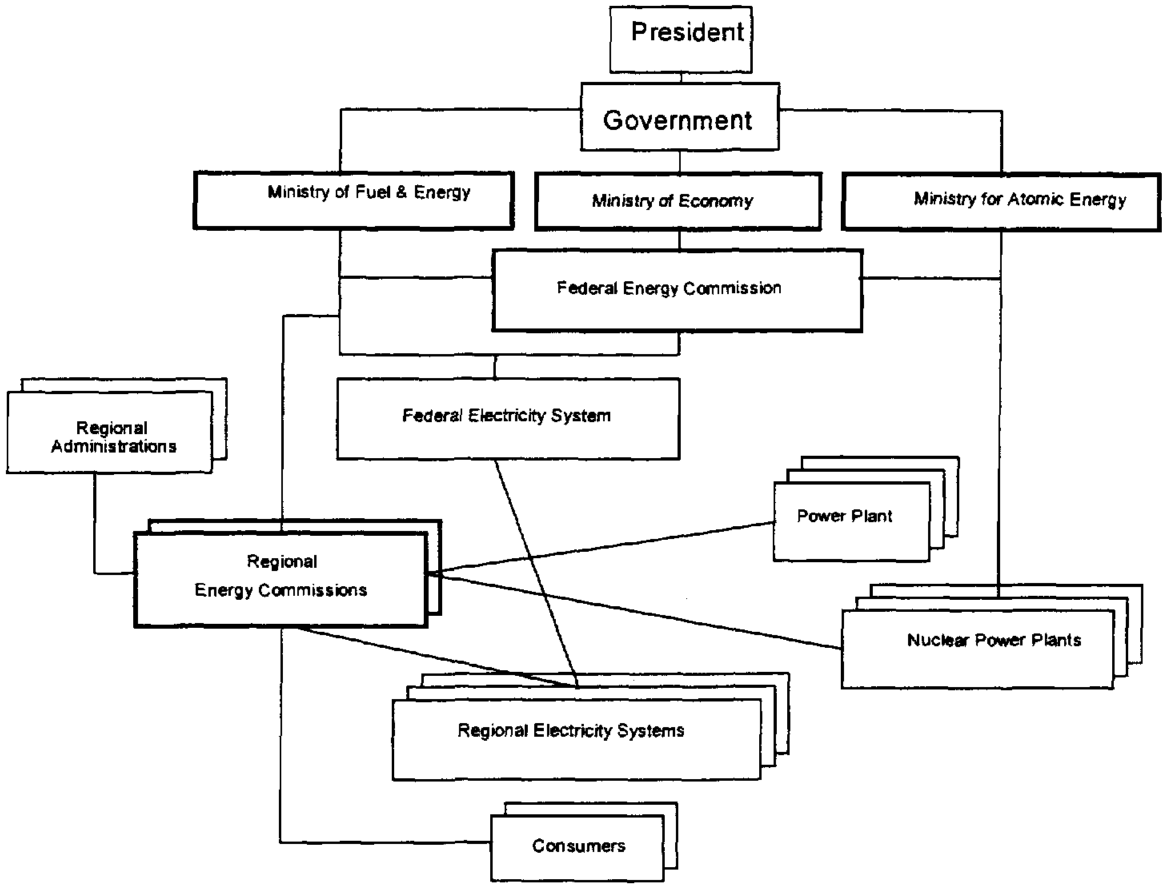


*FIG. 2. Basic Structure of the National Electricity Sector*

### 2.3. Main Indicators

Table 5 shows the historical electricity production data and installed capacities and Table 6 the energy related ratios.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1980 | 1985 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | |
| - Total[1] | 805 | 962 | 1082 | 1068 | 1011 | 956 | 876 |
| - Thermal | 622 | 703 | 797 | 780 | 718 | 661 | 601 |
| - Hydro | 129 | 160 | 167 | 168 | 172 | 175 | 177 |
| - Nuclear | 54 | 99 | 118 | 120 | 120 | 119 | 98 |
| - Geothermal | | | | | | 0.03 | 0.03 |
| Capacity of electrical plants (GW(e)) | | | | | | | |
| - Total | | | 196 | 196 | 196 | 213 | 215 |
| - Thermal | | | 135 | 135 | 135 | 150 | 151 |
| - Hydro | | | 41 | 41 | 41 | 43 | 44 |
| - Nuclear | | | 20 | 20 | 20 | 20 | 20 |
| - Geothermal | | | | | | 0.01 | 0.01 |

[1] *Electricity losses are not deducted.*

Source: IAEA Energy and Economic Database

TABLE 6. ENERGY RELATED RATIOS

| | 1970 | 1980 | 1990 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 160 | 250 | 260 | 232 | 219 | 192 |
| Electricity per capita (kW·h/capita) | | | 7,200 | 6,230 | 5,885 | 5,386 |
| Electricity production/Energy production (%) | | | 18 | 19 | 19 | 19 |
| Nuclear/Total electricity (%) | 18 | 17 | 18 | 13 | 13 | 12 |
| Ratio of external dependency (%)[1] | | | | -39 | -38 | -45 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 51 | 56 | 58 | 54 | 51 | 47 |
| - Thermal | 53 | 59 | 61 | 54 | 50 | 45 |
| - Hydro | 47 | 42 | 44 | 45 | 46 | 46 |
| - Nuclear | 44 | 64 | 68 | 72 | 69 | 56 |

[1] *Total net import / Total energy consumption*

Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

1937 Commencement of active experimental studies on the structure of atomic nuclei. Production of "pulse" amount of neptunium and plutonium in Leningrad Radium Institute.

1939 The start of research into the feasibility of achieving a nuclear chain reaction. Installation of the largest cyclotron in Europe in the Leningrad Physical and Technical Institute.

1940 Discovery of phenomenon of spontaneous nuclear fission in uranium. Theoretical demonstration by Soviet scientists of the feasibility of energy release from a uranium nuclear fission chain reaction.

1942 Recommencement of work on the atomic problem interrupted by the outbreak of the war.

1943 Creation of a special physics laboratory - the No. 2 Laboratory in Moscow (now the Russian Scientific Centre "Kurchatov Institute").

1945 Establishment of a governmental interdepartmental body - the First Chief Administration - to co-ordinate all work in the field of atomic science and technology.

1945/46 Technology mastering and organization of the production of metallic uranium and high-purity reactor graphite to start up the first experimental reactor.

1946 Achievement of a controlled uranium fission chain reaction at the No. 2 Laboratory.

1948 Start up of the first industrial nuclear reactor.

1949 Testing of the Soviet Union's first atomic bomb.

1953 Establishment of the USSR Ministry of Medium Machine Building as the authority dealing with nuclear science and technology.

1954 Start up of the world's first nuclear power plant in Obninsk.

1957 Ratification of the Charter of IAEA by the USSR.

1964 Commissioning of the first commercial water-moderated, water-cooled vessel-type (WWER) reactor at Novo-Voronezh. Commissioning of the first commercial boiling water cooled graphite moderated reactor with nuclear superheating of the steam at Beloyarsk.

1970 Establishment of the International Nuclear Information System (INIS) with the active participation of the USSR.

1973 Commissioning of the first commercial water cooled graphite-moderated channel-type (RBMK) reactor at Leningrad.

1973 Commissioning of the world's first prototype-scale fast breeder reactor (BN-350) in Aktau for electricity generation and desalinated water production.

1976 Completion of the first nuclear central heating and power plant at Bilibino in the far north-eastern part of Russia.

1977 Start up of the RT-1 plant for reprocessing of spent nuclear fuel.

1980 Start up of a commercial power generating unit powered by BN-600 fast reactor at Beloyarsk. Commissioning of the 1000 MW(e) water moderated, water cooled reactor (WWER-1000).

1984/86 Commissioning of the Zaporozhie and Balakovo NPP's with WWER-1000 serial reactors with full compliance to the new safety regulation.

1986 Accident at unit 4 of Chernobyl NPP. Ministry for Atomic Energy is organized to be responsible for Nuclear Power Plants operation.

1989 Reorganization of the Ministry of Medium Machine Building and Ministry for Atomic Energy as the USSR Ministry of Atomic Energy and Industry.

1992 Establishment of Ministry for Atomic Energy of the Russian Federation (Minatom of Russia, also known as Ministry for Nuclear Power) which replaced the USSR Ministry of Atomic Energy and Industry.

## 3.2. Current Policy Issues

*Ownership in the Nuclear Sector*

The Ministry for Atomic Energy adopted a restructuring approach for the privatisation of the nuclear industry and a number of joint-stock companies have been established with 51% share retained by state.

*Financial Situation*

The national economical crisis led to the fact that the Russian nuclear industry is now facing serious financial problems. State funding has dwindled while electricity non-payment problems have reduced revenues from nuclear electricity generation. Minatom responded to the financial challenges with a variety of measures, particularly, by increasing the export of nuclear-related production and services.

The current nuclear policy in Russia was formulated by the Minatom in the 1992 "Nuclear Power and its Fuel Cycle" report. Its main objectives through the year 2000 are as follows:

i) assuring the safety of operating nuclear plants including those constructed in accordance with old regulations and the safety enhancement of nuclear power plants under construction;
ii) development of improved new-generation plants;
iii) feasibility studies on the advanced reactor concepts;
iv) R&D work on closed nuclear fuel cycle;
v) R&D efforts on decommissioning of nuclear power plants;
vi) development of cost-effective and environmentally safe spent fuel and radioactive waste management technology;
vii) safe operation of the research reactors, critical assemblies and other nuclear facilities;
viii)remodeling research centres, experimental facilities and industrial units which support the nuclear industry development programme.

**3.3. Status and Trends of Nuclear Power**

Table 7 shows the current status of the Russian nuclear power plants. In the former Soviet Union, there were 10 nuclear reactors under construction at the late 80s. However, the construction of all new nuclear power plants was interrupted in 1989-1990, partly due to negative public opinion. Today, economical difficulties play a more significant role. In fact, only unit 5 of Kursk NPP and unit 3 of Kalinin NPP are currently under construction.

The production of electricity from nuclear power plants has remained relatively stable throughout the period of economic transition with an average load factor of 67% from 1990 to 1993. Table 8 shows the NPPs electricity generation share for this period and Table 9 the operational facts of the NPPs in 1993.

The Concept of the Nuclear Power Development Programme in the Russian Federation was approved by the Ministry for Atomic Energy Board on July 14, 1992. This concept determines the general goal of the Programme, the main objects within the determined time period, the main stages of programme implementation, and primary nuclear power plant projects. It considers conditions for the nuclear power plant fuel supply and proposes various options of nuclear power development assuming decommissioning of the first and second generation power units of 9 GW of installed power.

The general goal of the Programme, as determined by the Concept, envisages replacement of decommissioned nuclear and fossil fuelled plants with improved and safer third generation nuclear power plants. The Concept also assumes that the energy situation will favour a large-scale nuclear power development by 2030 with 30 to 35% share of total electricity production and 40 to 50% in the European part of the country.

- Nuclear power development projections up to year 2010 (see Table 10) and beyond assume the following main stages:
- 1993-2000: a stage of renovation, with nuclear power units in operation being modernised, their safety enhanced, and total capacity but slightly increased through new construction;
- 2000-2010: the stage that should be characterised by industry growth on the basis of units of a new generation; work should begin by shutting down those units that have completed service life;
- after 2010: a stage that is seen as a period of large-scale nuclear power growth combining evolutionary developments in traditional technologies with the development of new ones.
- The leading 3rd generation medium and large scale power units of improved safety now include NP-500, NP-1000, VPBER-600, AST-500M (all of PWR design) and MKER-800 (LWGMR) reactors.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| BALAKOVO-1 | WWER | 950 | REA | Operational | | 01-Dec-80 | 12-Dec-85 | 28-Dec-85 | 23-May-86 | |
| BALAKOVO-2 | WWER | 950 | REA | Operational | | 01-Aug.-81 | 02-Oct.-87 | 08-Oct.-87 | 18-Jan-88 | |
| BALAKOVO-3 | WWER | 950 | REA | Operational | | 01-Nov.-82 | 16-Dec-88 | 25-Dec-88 | 08-Apr.-89 | |
| BALAKOVO-4 | WWER | 950 | REA | Operational | | 01-Apr.-84 | 03-Apr.-93 | 11-Apr.-93 | 22-Dec-93 | |
| BELOYARSKY-3 | FBR | 560 | REA | Operational | | 01-Jan-69 | 26-Feb.-80 | 08-Apr.-80 | 01-Nov.-81 | |
| BILIBINO UNIT A | LWGR | 11 | REA | Operational | | 01-Jan-70 | 11-Dec-73 | 12-Jan-74 | 01-Apr.-74 | |
| BILIBINO UNIT B | LWGR | 11 | REA | Operational | | 01-Jan-70 | 07-Dec-74 | 30-Dec-74 | 01-Feb.-75 | |
| BILIBINO UNIT C | LWGR | 11 | REA | Operational | | 01-Jan-70 | 06-Dec-75 | 22-Dec-75 | 01-Feb.-76 | |
| BILIBINO UNIT D | LWGR | 11 | REA | Operational | | 01-Jan-70 | 12-Dec-76 | 27-Dec-76 | 01-Jan-77 | |
| KALININ-1 | WWER | 950 | REA | Operational | | 01-Feb.-77 | 10-Apr.-84 | 09-May-84 | 12-Jun.-85 | |
| KALININ-2 | WWER | 950 | REA | Operational | | 01-Feb.-82 | 25-Nov.-86 | 03-Dec-86 | 03-Mar-87 | |
| KOLA-1 | WWER | 411 | REA | Operational | | 01-May-70 | 26-Jun.-73 | 29-Jun.-73 | 28-Dec-73 | |
| KOLA-2 | WWER | 411 | REA | Operational | | 01-Jan-73 | 30-Nov.-74 | 09-Dec-74 | 21-Feb.-75 | |
| KOLA-3 | WWER | 411 | REA | Operational | | 01-Apr.-77 | 07-Feb.-81 | 24-Mar-81 | 03-Dec-82 | |
| KOLA-4 | WWER | 411 | REA | Operational | | 01-Aug.-76 | 07-Oct.-84 | 11-Oct.-84 | 06-Dec-84 | |
| KURSK-1 | LWGR | 925 | REA | Operational | | 01-Jun.-72 | 25-Oct.-76 | 19-Dec-76 | 12-Oct.-77 | |
| KURSK-2 | LWGR | 925 | REA | Operational | | 01-Jan-73 | 16-Dec-78 | 28-Jan-79 | 17-Aug.-79 | |
| KURSK-3 | LWGR | 925 | REA | Operational | | 01-Apr.-78 | 09-Aug.-83 | 17-Oct.-83 | 30-Mar-84 | |
| KURSK-4 | LWGR | 925 | REA | Operational | | 01-May-81 | 31-Oct.-85 | 02-Dec-85 | 05-Feb.-86 | |
| LENINGRAD-1 | LWGR | 925 | LENNPP | Operational | | 01-Mar-70 | 12-Sep-73 | 21-Dec-73 | 01-Nov.-74 | |
| LENINGRAD-2 | LWGR | 925 | LENNPP | Operational | | 01-Jun.-70 | 06-May-75 | 11-Jul.-75 | 11-Feb.-76 | |
| LENINGRAD-3 | LWGR | 925 | LENNPP | Operational | | 01-Dec-73 | 17-Sep-79 | 07-Dec-79 | 29-Jun.-80 | |
| LENINGRAD-4 | LWGR | 925 | LENNPP | Operational | | 01-Feb.-75 | 29-Dec-80 | 09-Feb.-81 | 29-Aug.-81 | |
| NOVOVORONEZH-3 | WWER | 385 | REA | Operational | | 01-Jul.-67 | 22-Dec-71 | 27-Dec-71 | 29-Jun.-72 | |
| NOVOVORONEZH-4 | WWER | 385 | REA | Operational | | 01-Jul.-67 | 25-Dec-72 | 28-Dec-72 | 24-Mar-73 | |
| NOVOVORONEZH-5 | WWER | 950 | REA | Operational | | 01-Mar-74 | 30-Apr.-80 | 31-May-80 | 20-Feb.-81 | |
| SMOLENSK-1 | LWGR | 925 | REA | Operational | | 01-Oct.-75 | 10-Sep-82 | 09-Dec-82 | 30-Sep-83 | |
| SMOLENSK-2 | LWGR | 925 | REA | Operational | | 01-Jun.-76 | 09-Apr.-85 | 31-May-85 | 02-Jul.-85 | |
| SMOLENSK-3 | LWGR | 925 | REA | Operational | | 01-May-84 | 01-Dec-89 | 17-Jan-90 | 30-Jan-90 | |
| KALININ-3 | WWER | 950 | REA | Under Constr. | | 01-Oct.-85 | | | | |
| KURSK-5 | LWGR | 925 | REA | Under Constr. | | 01-Dec-85 | | | | |
| SOUTH URALS 1 | FBR | 750 | MAYAK | Under Constr. | | 01-Jan-93 | | | | |
| SOUTH URALS 2 | FBR | 750 | REA | Under Constr. | | 01-Jan-93 | | | | |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 7. CONTINUED. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| BELOYARSKY-4(BN-800) | FBR | 750 | REA | Planned | | | | | | |
| BILIBINO E | LWGR | 31 | REA | Planned | | | | | | |
| BILIBINO F | LWGR | 31 | REA | Planned | | | | | | |
| BILIBINO G | LWGR | 31 | REA | Planned | | | | | | |
| BN-1600 | FBR | 1500 | REA | Planned | | | | | | |
| SOUTH URALS 3 | FBR | 750 | REA | Planned | | | | | | |
| BELOYARSKY-1 | LWGR | 102 | REA | Shut Down | | 01-Jun.-58 | 01-Sep-63 | 26-Apr.-64 | 26-Apr.-64 | 01-Jan-83 |
| BELOYARSKY-2 | LWGR | 146 | REA | Shut Down | | 01-Jan-62 | 10-Oct.-67 | 29-Dec-67 | 01-Dec-69 | 01-Jan-90 |
| NOVOVORONEZH-1 | WWER | 197 | REA | Shut Down | | 01-Jul.-57 | 17-Dec-63 | 30-Sep-64 | 31-Dec-64 | 16-Feb.-88 |
| NOVOVORONEZH-2 | WWER | 336 | REA | Shut Down | | 01-Jul.-64 | 23-Dec-69 | 27-Dec-69 | 14-Apr.-70 | 29-Aug.-90 |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 8. NPP ELECTRICITY GENERATION SHARE

| | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|
| Electricity generated at NPP's in Russia ($10^9$ kWh) | 118.0 | 120.0 | 119.6 | 119.2 |
| Total electricity generated ($10^9$ kWh) | 1056.3 | 1047.0 | 1010.5 | 938.1 |
| NPP electricity generation share (%,) | | | | |
| Total | 11.2 | 11.4 | 11.8 | 12.7 |
| Central Power Pool | 21.7 | 21.3 | 22.7 | 23.9 |
| Middle Volga Power Pool | 10.9 | 13.6 | 17.9 | 16.4 |
| Northwest Power Pool | 46.7 | 47.4 | 43.9 | 47.8 |

TABLE 9. STATUS OF NUCLEAR POWER PLANTS - OPERATIONAL FACTS IN 1993

| NPP, Unit | Capacity Installed, MW(e) | Electricity Generation, $10^6$ kWh | Availability Factor, % | Load Factor, % |
|---|---|---|---|---|
| Balakovo | 4000 | 16009.5 | 61.61 | 49.78 |
| 1 | 1000 | 3493.7 | 47.28 | 39.88 |
| 2 | 1000 | 3932.2 | 47.34 | 44.89 |
| 3 | 1000 | 4751.9 | 62.34 | 54.25 |
| 4 | 1000 | 3831.7 | 89.49 | 65.16 |
| Kalinin | 2000 | 11336.0 | 73.19 | 64.70 |
| 1 | 1000 | 5190.7 | 67.35 | 59.25 |
| 2 | 1000 | 6145.3 | 79.04 | 70.15 |
| Kola | 1760 | 10254.7 | 77.32 | 66.51 |
| 1 | 440 | 2145.2 | 64.36 | 55.65 |
| 2 | 440 | 2332.7 | 72.69 | 60.52 |
| 3 | 440 | 2738.7 | 78.05 | 71.05 |
| 4 | 440 | 3038.1 | 94.17 | 78.82 |
| Novovoronezh | 1834 | 11147.0 | 77.99 | 69.38 |
| 3 | 417 | 1974.3 | 66.62 | 51.22 |
| 4 | 417 | 2853.9 | 82.20 | 74.04 |
| 5 | 1000 | 6318.8 | 85.14 | 72.13 |
| Beloyarsk | 600 | 4220.2 | 80.58 | 80.29 |
| 3 | 600 | 4220.2 | 80.58 | 80.29 |
| Bilibino | 48 | 256.1 | 81.85 | 60.90 |
| 1 | 12 | 63.9 | 85.40 | 60.78 |
| 2 | 12 | 63.5 | 80.63 | 60.41 |
| 3 | 12 | 64.8 | 82.41 | 61.64 |
| 4 | 12 | 65.9 | 78.97 | 75.12 |
| Kursk | 4000 | 22396.0 | 81.28 | 63.92 |
| 1 | 1000 | 4984.2 | 92.97 | 56.89 |
| 2 | 1000 | 5026.3 | 84.16 | 57.38 |
| 3 | 1000 | 6155.0 | 73.49 | 70.26 |
| 4 | 1000 | 6230.5 | 74.46 | 71.12 |
| Leningrad | 4000 | 22267.0 | 65.87 | 63.55 |
| 1 | 1000 | 7107.4 | 83.95 | 81.13 |
| 2 | 1000 | - | - | - |
| 3 | 1000 | 7797.7 | 90.94 | 89.01 |
| 4 | 1000 | 7361.9 | 88.58 | 84.04 |
| Smolensk | 3000 | 21299.0 | 83.42 | 81.05 |
| 1 | 1000 | 6851.5 | 80.03 | 78.21 |
| 2 | 1000 | 7204.8 | 85.53 | 82.25 |
| 3 | 1000 | 7242.7 | 84.69 | 82.68 |
| Total | 21242 | 119185.7 | 75.56 | 67.22 |

Fast reactor development has been demonstrated by the BN-800 (LMR) design. The concept of utilisation of released weapon-grade plutonium is under development at the nuclear complex "MAYAK", including a MOX fuel fabrication plant and three to four BN-800 reactors. Studies are under way for selecting the optimal reactor design for utilisation of this weapon-grade plutonium.

TABLE 10. OPTIONS OF NUCLEAR POWER DEVELOPMENT IN THE -POWER SECTOR OF RUSSIA (INSTALLED CAPACITY GW)

| Options | 1996-2000 | 2001-2005 | 2006-2010 |
|---|---|---|---|
| Minimum | 23.3 | 21.6 | 25.5 |
| Reference | 26.5 | 28-31 | 30-34 |
| Maximum | 26.5 | 30.7 | 39.5 |

### 3.4. Organizational Chart

Figure 3 shows the institutional organization of the nuclear industry in Russia.

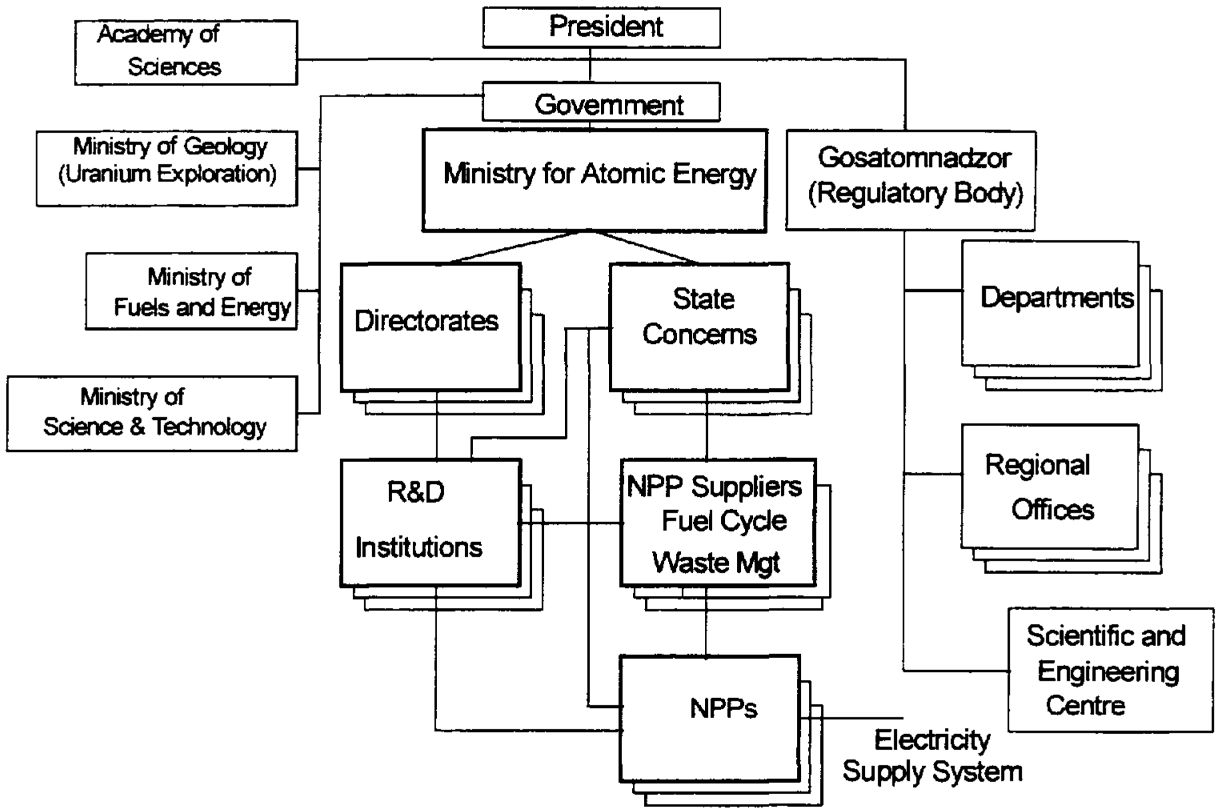


*FIG. 3. Institutional Organization of Nuclear Industry in Russia*

- departments of the Gosatomnadzor (Regulatory body):

  - science and engineering;
  - NPP nuclear and radiation safety;
  - research reactor nuclear and radiation safety;
  - nuclear power plant design and construction supervision;
  - nuclear equipment production supervision;
  - radiation safety supervision;
  - nuclear and radiation safety regulating.

- directorates of the Ministry for Atomic Energy:

  - design and investment;
  - information, nuclear materials and installations protection;
  - nuclear ammunition design and testing;
  - nuclear ammunition production;
  - nuclear chemistry;
  - science and technology;
  - nuclear reactor development and designing;
  - nuclear physics and fusion;
  - nuclear power advancement;
  - information and public relation.

- state concerns under the Ministry for Atomic Energy:

  - Atomredmetzoloto (uranium mining);
  - TVEL (fuel fabrication);
  - Rosenergoatom (nuclear utility company);
  - Progress (construction and industrial holding company);
  - Atomstroi (construction company);
  - Spetsatommontazh (industrial company);
  - Spetsstroimaterialy (construction materials for nuclear industry);
  - Tekhsnabexport (export company);
  - Eleron (security technology company).

## 4. NUCLEAR POWER INDUSTRY

In this chapter, only the major nuclear industry organizations are listed. These organizations are mainly within the Ministry for Atomic Energy. However, a few institutions, like the Kurchatov Institute, involved in nuclear related activities are not within the Minatom. There are also some academic institutes as well as organizations within the Ministry for Marine Ship-Building (involved in nuclear powered ice-breaker design) and others (including some small private-owned companies).

### 4.1. Supply of Nuclear Power Plants

*Architect engineers:*

- All-Russia Scientific Research and Design Institute of Power Technology (VNIPIET), St. Petersburg;
- Institute "Atomenergoproekt" (AEP), and its branches in Moscow, St. Petersburg, Nizhny Novgorod;
- State Institute of Construction and Design (GSPI), Moscow.

*NSS main suppliers:*

- "Atommash", an open-end joint stock company - NSS WWER-1000, BN and AST, Volgodonsk;
- "Izhorskie zavody", an open-end joint stock company - NSS WWER-1000 and WWER-440, St. Petersburg;

*Main component suppliers:*

- "Leningradskiy metallicheskiy zavod", an open-end joint stock company - turbines for NPP's, St. Petersburg;
- "Podolskiy mashinostroitelniy zavod",, an open-end joint stock company - steam generators, separators, piping, etc., Podolsk.

### 4.2. Operation of Nuclear Power Plants

The State Enterprise "Rosenergoatom", under the Ministry for Atomic Energy, is a nuclear power plant operating organization in the Russian Federation. It operates eight Russian nuclear power plants (Leningrad Nuclear Power Plant is an independent utility in the Minatom structure). "Rosenergoatom" performs the following functions:

- construction and operation of NPPs in the territory of the Russian Federation;
- maintenance and repair activity;
- operation and emergency planning;
- technical supervision and support;
- financial activity;

- public relations;
- international co-operation;
- research and development (R&D) effort.

### 4.3. Fuel Cycle and Waste Management Service Supply

"Atomredmetzoloto" is a production complex dealing with supplying of uranium, rare and precious metals and other materials used in nuclear power. The company consists of mining and processing enterprises and organizations in six newly-independent CIS countries - Russia, Ukraine, Kazakstan, Uzbekistan, Kyrghyzstan and Tajikistan.

Uranium Enrichment Complex: Russian plants - located at Ekaterinburg (former Sverdlovsk), Tomsk, Angarsk and Krasnoyarsk - for uranium isotope enrichment are high-technology facilities based on the fifth generation of gas centrifuges. The capacity of enrichment industry meets all the requirements for nuclear fuel in Russia and the CIS countries.

"TVEL", an open-end joint stock company, is a self-sufficient interstate production and economic complex of enterprises of the Russian Federation, Kazakstan, Ukraine and Estonia. The company's main line of work are nuclear fuel production and fabrication of metals, alloys and other materials used in nuclear power. Its manufacturing facilities are located in Russia, Ukraine, Kazakstan and Estonia.

### 4.4. Research and Development Activities

*Fundamental Research*

- Institute of Theoretical and Experimental Physics, Moscow;
- Institute of High Energy Physics, Protvino;
- Institute of Innovation and Thermonuclear Research, Troitsk.

These are major nuclear industry research centres that carry out extensive fundamental theoretical and experimental investigations into the properties of the atomic nucleus and elementary particles, plasma and laser physics, thermonuclear fusion, development of new types of accelerator and reactor technology, and equipment and facilities for physical research.

*Applied Research and Development (R&D)*

- The Russian Scientific Centre (RSC) "Kurchatov Institute", Moscow;
- The State Scientific Centre "Institute of Physics and Power Engineering" (SSC FEI), Obninsk;
- The State Scientific Centre "All-Russian Inorganic Materials Research Institute" (SSC VNIINM), Moscow;
- The State Scientific Centre Nuclear Reactor Research Institute (SSC NIIAR), Dimitrovgrad;
- Research and Development Institute of Power Engineering (NIKIET), Moscow.

All are major scientific centres in the field of nuclear science and technology. Theoretical and experimental research on nuclear and particle physics, neutron physics, thermophysics, hydraulics, material science, nuclear safety performed at these institutes has received world-wide recognition.

The All-Russian Research Institute for Nuclear Power Plant Operation (VNIIAES) of Moscow, is the scientific centre for Russian nuclear operating organizations. Principal attention is paid to assuring safe operation of the 1st and 2nd generation nuclear power plants.

*Major reactor and NSSS design and research*

- Experimental Design Bureau "Gidropress" (OKB GP), Podolsk;
- Experimental Design Bureau of Machine Building (OKBM), Nizhny Novgorod.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

At present, Russia has agreements on co-operation in nuclear power with the USA, the UK, Germany, France, Italy, Canada, Korea, countries of Eastern and Central Europe and new independent states of the former Soviet Union republics. Current areas of international co-operation include research in nuclear reactor design and safety, nuclear fuel cycle, handling radioactive wastes, fundamental research in physics, nuclear industry conversion and nuclear non-proliferation.

On 27 November 1992, the United States, Japan, the EC and Russia signed an Agreement on Establishing an International Scientific and Technological Centre in Moscow. Canada, Sweden and other countries have already shown their interest in joining the Centre's activity, which is directed at conversion of the defence industry armament to the peaceful use of safe and ecologically clean nuclear energy.

Since the mid-1980's, western countries have been active in nuclear safety co-operation with Russia. An increasing number of agreements have been signed and this co-operation has proved to be mutually beneficial. Today, Russia has bilateral nuclear co-operation agreements with many countries on exchange of experience, information, personnel training, technology transfer and other nuclear related activities.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Procedures

The Russian Federal Supervision of Nuclear and Radiological Safety (Gosatomnadzor) is the Nuclear Regulatory Body of the Russian Federation with the headquarters in Moscow and seven regional offices throughout the country.

The following regulations determine the procedure for nuclear power plant licensing:

- Regulations on the order of special permission issued by Gosatomnadzor of Russia for examination of design and other materials and documents, substantiating safety of nuclear and radiologically dangerous installations and works: RD-03-12-94.
- Regulations on arranging and carrying out examination of design and other materials and documents, substantiating safety of nuclear and radiologically dangerous installations and works: RD-03-13-94.
- Regulations on the order of issuing of special temporary permissions for designing nuclear and radiologically dangerous installations and works: RD-03-14-94.

The stages of obtaining the temporary permission (license) for NPP unit operation can be represented in brief as follows:

i) License demand (submission of application documents);
ii) Gosatomnadzor decision on the demand control;
iii) Analysis of substantiating materials of demand;
iv) Inspection at the NPP;
v) Conclusion on substantiating materials examination;
vi) Conclusion on NPP inspection;
vii) General conclusion on obtaining temporary permission (license);
viii)License (temporary permission).

### 5.2. Main National Laws and Regulations

In the near future, the main laws controlling nuclear power in Russia will be the law "About utilisation of atomic energy" and the law "About state policy in the field of radioactive waste management". Final approval of the law "About utilisation of atomic energy" is conditioned by the problems related with property rights in the nuclear industry, nuclear safety and radioactive materials treatment. Presently, several documents serve for this purpose.

Technical regulations created by Gosatomnadzor of Russia, which are in force today, are the legal framework for nuclear energy utilisation. These regulations and rules address the aspects of safety assurance during site selection, designing, construction, operation, and decommissioning of nuclear installations. All regulating documents developed by Gosatomnadzor have been compiled into a "List of main scientific and technical documents, used by Gosatomnadzor for safety regulation and supervision during production and utilisation of atomic energy, handling of nuclear materials, radioactive substances and articles on their base", P-01-01-92, Gosatomnadzor of Russia, 1992.

Some aspects of nuclear related activity are regulated by decrees of the President or Government of the Russian Federation.

Decrees of the President:

- "About the control of export of nuclear materials, equipment and technologies" of 27 March 1992;
- "About the utilities with nuclear power plants " of 7 September 1992;
- "About privatisation of enterprises under the authority of Ministry for Atomic Energy, and their management in a market economy " of 15 April 1993, etc.

Decrees of the Government:

- "About approval of documents, regulating export of equipment and materials and of corresponding technology, used for nuclear purposes" of 29 May 1992;
- "About measures of protection of the population living adjacent to nuclear power installations" of 15 October 1992, etc.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Unilateral safeguards submission (Voluntary offer) INFCIRC/327 | Entry into force: | 10 June 1985 |
| • Improved procedures for designation of safeguards inspectors | Waiver proposal accepted by U.S.S.R. on | 15 September 1988 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Not applicable | |

*OTHER RELEVANT INTERNATIONAL TREATIES*

| | | |
|---|---|---|
| • NPT | Entry into force: | 5 March 1970 |
| • Agreement on privileges and immunities | Entry into force: | 1 July 1966 |

| | | |
|---|---|---|
| • Convention on physical protection of nuclear material | Entry into force: | 8 February. 1987 |
| • Convention on early notification of a nuclear accident | Entry into force: | 24 January 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 26 February. 1987 |
| • Vienna convention on civil liability for nuclear damage | Signature: | 8 May 1996 |
| • Joint protocol | Non-Party | |
| • Convention on nuclear safety | Acceptance: | 12 July 1996 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | Summary: A good basis for national safety standards. Taken into account in preparation of regulatory/ technical documents. Best form of application in USSR being studied: | 30 December 1988 |
| • Nuclear Suppliers Group | Member | |
| • World Association of Nuclear Operators (WANO) | Member | |

*BILATERAL AGREEMENTS*

Bilateral agreements on peaceful use of atomic energy have been signed with USA, UK, Germany, France, Italy, Canada, Republic of Korea, Switzerland and some other countries.

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[13] On the Activity Related to the Future Development of the Russian Electric Energy Sector in the New Economic Conditions, Energy Construction, Vol 11, (1994) (in Russian).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITIES*

| | |
|---|---|
| Ministry of Atomic Energy<br>Staromonetny pereulok 26<br>Moscow | Tel.: 239 4908<br>Fax: 230 2420<br>Telex: 411888 MEZON SU |
| Committee on External Relations | Fax: 230 2420 |
| Federal Nuclear and Radiation Safety Authority<br>Taganskaya ulitsa 34<br>Moscow | Tel.: 272 0349<br>Fax: 278 0098<br>Tlx: 411743 SYVIN SU |
| State Supervisory Committee<br>for Nuclear Safety and Radiation Protection | Fax: 095 278 8090 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Consortium of Russian Nuclear Power Plants<br>"ROSATOMENERGO" | Tel.: 095-220 6404<br>Fax: 095-200 2273 |
| Institute of Physics and Power Engineering | |
| All-Russia Scientific Research and Design<br>Institute of Power Technology -VNIPIET<br>Dibunovskaya Str.<br>St. Petersburg | Tel.: (812) 239 01 34<br>Fax: (812) 239 18 98 |
| Institute "Atomenergoproekt" (AEP)<br>"Atomenergoproekt"<br>Bakunin Str. 7<br>Moscow | Tel.: (095) 261 41 87 |
| "Atommash"<br>Krasnoarmeyskaya Str. 206<br>Volgodonsk<br>Rostov reg. | |
| "Izhorskie zavody"<br>Kolpino-1, Lenin Str. 1<br>St. Petersburg | Fax: (812) 463 92 69 |
| "Rosenergoatom"<br>Kitaisky pr. 7<br>Moscow | Tel.: (095) 220 63 01<br>Fax: (095) 220 44 88 |

"Atomredmetzoloto"
Bolshaya Ordynka Str. Tel.: (095) 239 44 11
Moscow Fax: (095) 239 46 79

TVEL Concern, Inc.
Bolshaya Ordynka Str. Tel.: (095) 239 43 55
Moscow Fax: (095) 233 10 59

The Russian Scientific Centre (RSC) "Kurchatov Institute"
Kurchatov Sq. 1
Moscow Tel.: (095) 196 92 41

The State Scientific Centre "Institute of Physics and Power Engineering" (SSC FEI)
SSC FEI
Bondarenko Sq. 1 Tel.: (08439) 9 82 50
Obninsk, Kaluga region Fax: (095) 230 23 26

The State Scientific Centre "All-Russian Inorganic Materials Research Institute" (SSC VNIINM)
Rogov Str. 5a Tel.: (095) 190 82 97
Moscow 123060 Fax: (095) 196 41 68

The State Scientific Centre "Nuclear Reactor Research Institute" (SSC NIIAR)
Box M-5881
Dimitrovgrad Tel.: (84235) 3 52 80
Ulyanovsk Region Fax: (84235) 3 56 48

All-Russian Research Institute for Nuclear Power Plant Operation (VNIIAES)
Ferganskaya Str. 25 Tel.: (095) 377 00 75
Moscow Fax: (095) 274 00 73

Research and Development Institute of Power Engineering (NIKIET)
P.O.Box 788
Moscow Fax: (095) 975 20 19

Experimental Design Bureau of Machine Building (OKBM)
Burnakovsky pr. 15 Tel.: (8312) 46 21 32
Nizhny Novgorod Fax: (8312) 41 87 72

Experimental Design Bureau "Gidropress" (OKB GP)
Ordzhonikidze Str. 24
Podolsk
Moscow region Tel.: (095) 137-90-96

# SLOVAKIA

**SLOVAKIA**

## 1. GENERAL INFORMATION

### 1.1. General Overview

The size of the Slovak Republic is 49,036 $km^2$ with 40% of the area situated up to an elevation of 300 m, 45% at the elevation between 300 and 800 m, and 15% at the elevation above 800 m. The lowest point is the mouth of Bodrog river at the elevation of 94 m and the highest situated point is Gerlachov peak at the elevation of 2655 m. Agricultural surface covers 49.9% from the entire Slovak surface, and forest surface 40.6%. The longest dimension in the east-west direction is 428 km and in the north-south direction is 195 km. Slovakia is The Slovak Republic is a new country situated in Central Europe. It was established on January 1, 1993. It is situated between 16°50'04" and 22°34'20" of east longitude, and between 47°35'55" and 49°36'54" of northern latitude (Figure 1). situated in mild zone. The average annual temperature - a long-term average between 1901 and 1950 in Bratislava is 10.1°C and the average rainfall is 670 mm. Table 1 shows typical parameters from the Meteorological stations Jaslovské Bohunice and Mochovce.

As of December 31, 1995, there were 5.4 millions inhabitants representing 110 inhabitants per $km^2$ (Table 2). 2.1 millions people were economically active, out of which 0.93 millions in industry and transport, 0.20 millions in agriculture, 0.48 millions in trade and services, and 0.49 millions in non-productive spheres.

TABLE 1. SELECTED PARAMETERS FROM THE METEOROLOGICAL STATIONS JASLOVSKÉ BOHUNICE AND MOCHOVCE

| | Jaslovské Bohunice | Mochovce |
|---|---|---|
| Elevation above sea | 176 m | 261 m |
| Average annual temperature | 9,3 °C | 9,1 °C |
| Average annual humidity | 76% | 75% |
| Average annual rainfall | 548 mm | 560 mm |
| Dominant wind direction | north-west | north-west |
| Wind velocity | 3,4 m/s | 1,7 m/s |

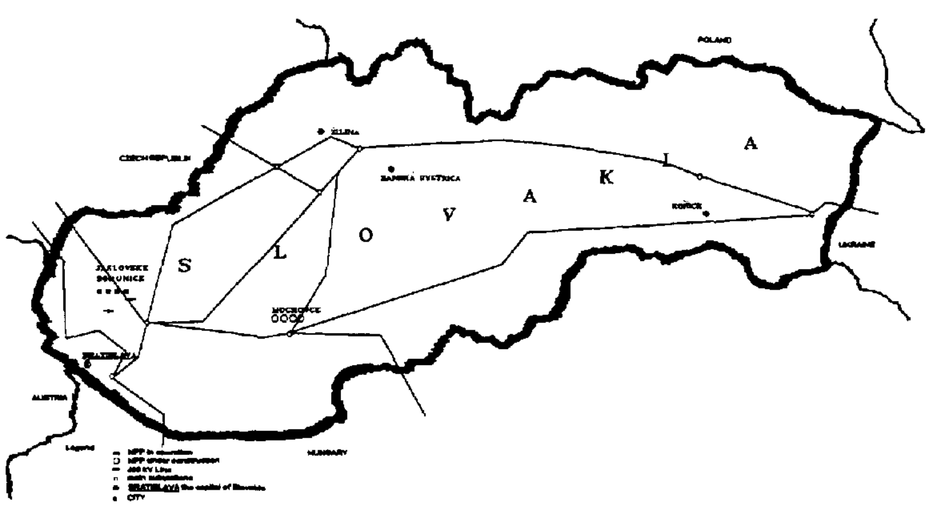


*FIG. 1. Map of Slovak Republic*

TABLE 2. POPULATION INFORMATION

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Population (millions) | 5.3 | 5.3 | 5.3 |
| Population density (inhabitants/km²) | 108.0 | 108.4 | 108.8 |
| Predicted population growth rate (%) 1993 to 2000 | 0.4 | | |
| Area (1000 km²) | 49.0 | | |
| Urban population in 1993 as percent of total | 58.0 | | |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

The current and expected development of the Gross Domestic Product (GDP) in constant 1990 prices is shown in Table 3 and the 1995 energy consumption in Figure 2. The growth rate of GDP in 1995 was 7.4%. The GDP per capita value in current prices was 95,930 Sk. The 1995 Gross Domestic Product (GDP) in billion Slovak crowns and the 1995 final energy consumption in PJ are shown by sector in Table 4 and Figure 3.

TABLE 3. GROSS DOMESTIC PRODUCTION (GDP)

| | 1990 | 1992 | 1993 | 1994 |
|---|---|---|---|---|
| GDP (millions of current US$) | 13,571 | 10,710 | 11,056 | 9,309 |
| GDP (millions of constant 1990 US$) | 13,571 | 10,785 | 10,340 | 10,840 |
| GDP per capita (current US$/capita) | | 2,023 | 2,081 | 1,746 |
| GDP by sector : | | | | |
| Agriculture: 8% | | | | |
| Industry 56% | | | | |
| Services 36% | | | | |

Source: IAEA Energy and Economic Database

TABLE 4. CURRENT AND EXPECTED DEVELOPMENT OF GROSS DOMESTIC PRODUCT (GDP) IN CONSTANT 1990 PRICES

| Year | Development of GNP | | Final energy consumption | Energy requirements |
|---|---|---|---|---|
| | billion Sk | interannual index | PJ | PJ/billion Sk |
| 1990 | 243.6 | 100.0 | 729 | 3.0 |
| 1991 | 208.3 | 85.5 | | |
| 1992 | 203.3 | 97.6 | | |
| 1993 | 196.8 | 96.8 | 555 | 2.8 |
| 1994 | 206.0 | 104.7 | | |
| 1995 | 221.2 | 107.4 | 586 | 2.6 |
| 2000 | 254.1 | 114.9 | 639 | 2.6 |
| 2005 | 294.6 | 115.9 | 666 | 2.3 |
| 2010 | 341.9 | 116.1 | 698 | 2.1 |

1 PJ (petajoule) = $10^{15}$ Joule 1 USD ≅ 30 Sk

1 TW·h (terawatthour) = $10^{12}$ Wh = $3.6\times10^{-3}$ PJ

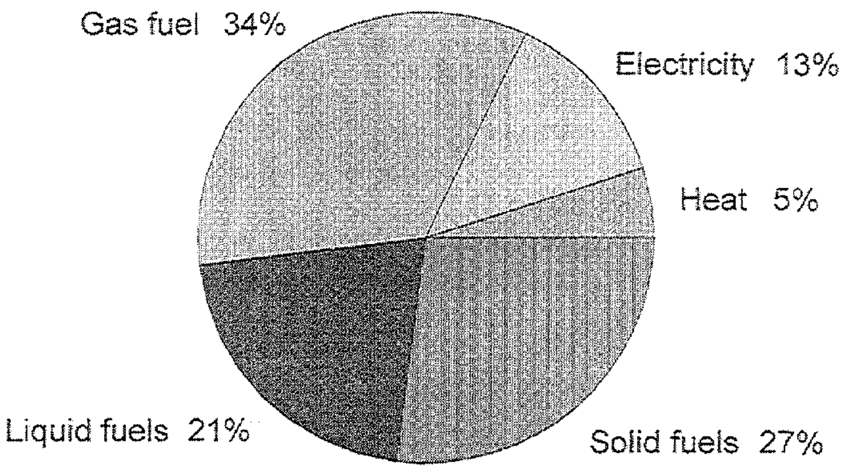


*FIG. 2. 1995 Energy Consumption*

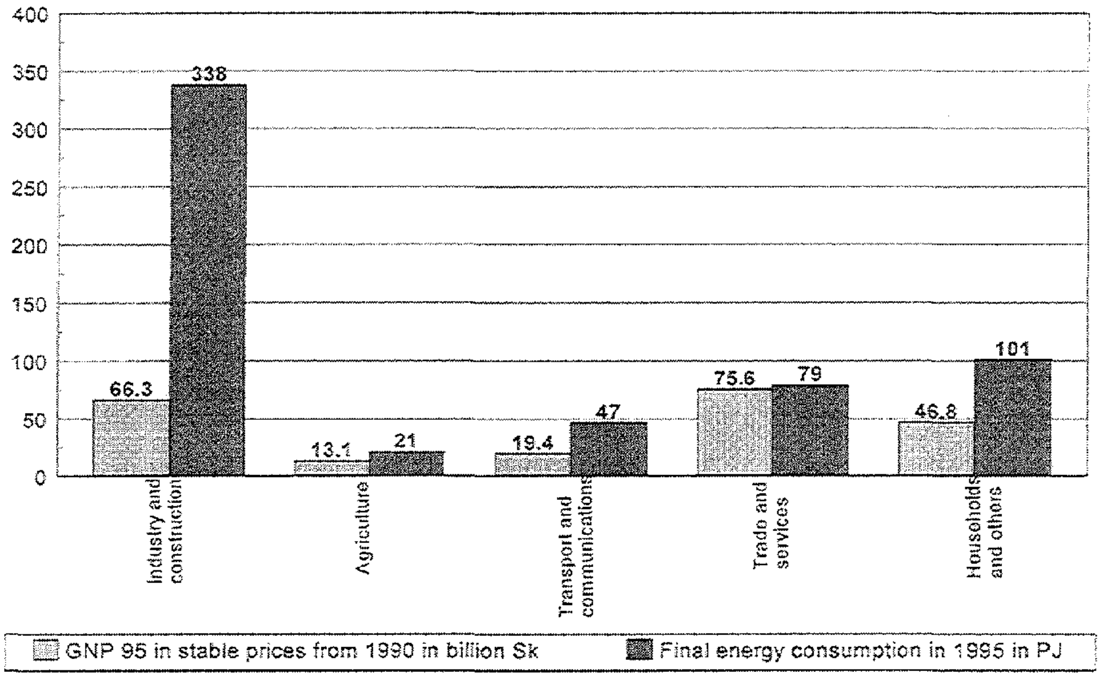


*FIG. 3. GNP by Sector*

### 1.3. Energy Situation

Slovakia has at its disposal only a limited amount of domestic energy resources, i.e. brown coal, oil, natural gas and renewable resources (Table 5). The energy potential of renewable resources in Slovakia is approximately 5% from the total annual consumption of primary energy resources (Table 6). Table 7 shows the 1995 energy balance and Table 8 the historical development of the primary energy sources.

TABLE 5. RESOURCES OF FOSSIL FUELS IN SLOVAKIA INCLUDING PROJECTED RESOURCES

| Geological resources | | Total amount | out of which balance reserves | |
|---|---|---|---|---|
| | | | totally | deposits mined |
| Coal | Mt | 2,135 | 763 | 348 |
| out of which: anthracite | Mt | 8 | 2 | 0 |
| brown coal | Mt | 765 | 421 | 283 |
| lignite | Mt | 1,362 | 340 | 65 |
| Oil | Mt | 10 | 1 | 1 |
| Natural gas | bil.m$^3$ | 29 | 11 | 8 |

as of January 1, 1996

TABLE 6. POTENTIAL OF RENEWABLE ENERGY RESOURCES IN SLOVAKIA

| Resources | PJ/a |
|---|---|
| Geothermal energy | 7.2 |
| Forest biomass | 11.6 |
| Small hydro power plants | 2.6 |
| Solar energy | 4.9 |
| Wind energy | 1.1 |
| Biogas from waste | 4.3 |
| Communal and industrial waste | 3.6 |
| Total | 35.3 |

TABLE 7. ENERGY BALANCE) IN 1995

Petajoule

| | Solid | Liquid | Gas | Total fossil | Heat | Electricity | Total |
|---|---|---|---|---|---|---|---|
| Natural resources | 46 | 3 | 11 | 60 | 124 | 18 | 202 |
| Fraction of consumption* | 21 | 2 | 5 | 10 | | | |
| Import | 174 | 225 | 200 | | 0 | 14 | 613 |
| Export | -1 | -76 | 0 | | 0 | -9 | -86 |
| Changes in storage | 2 | -9 | 10 | | 0 | 0 | 3 |
| Consumption | 221 | 143 | 221 | 585 | 124 | 23 | 732 |

* in %

TABLE 8. CONSUMPTION OF PRIMARY ENERGY RESOURCES

Petajoule

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| Solids | 360 | 310 | 274 | 275 | 269 | 228 |
| Liquid | 197 | 171 | 150 | 130 | 137 | 156 |
| Gases | 224 | 212 | 214 | 205 | 202 | 221 |
| Nuclear | 132 | 129 | 121 | 120 | 132 | 125 |
| Electricity | 28 | 22 | 20 | 19 | 18 | 23 |
| PEZ total | 941 | 844 | 779 | 749 | 758 | 753 |
| PEZ per capita | 178 | 159 | 147 | 141 | 142 | 142 |

### 1.4. Energy policy

The main goal is to achieve a necessary assurance in obtaining energy resources and to focus the Slovak energy economy on effective and environmentally friendly technologies of electricity generation, on higher use of renewables and secondary resources of energy, and on introduction of energy-saving production technologies and consumers, in which way a gradual reduction of the energy demands and of the absolute energy consumption will be provided.

The Energy Concepts for Slovakia Till 2005 accepted by the Government decision No. 562/1993 define the principle objectives of and bases for the energy policy, analyse the current conditions of power economy and specify the strategy for assuring fuels and energy for the economy. These Energy Concepts were developed for the first time for the conditions of independent, national energy system. The philosophy of the concepts is based on a rational approach to both generation and consumption of electricity. The concepts in their basic variant assume:

i) to complete the Mochovce nuclear power plant;
ii) to upgrade and backfitt gradually the system power plants;
iii) to phase out gradually the V-1 Bohunice nuclear power plant Units 1 and 2 and the Nováky coal power plant Units 3 and 4;
iv) to improve the use of hydro power potential and use significantly more natural gas for electricity and heat production by means of modern gas and steam-gas sources.

In the second realistic variant, the completion of the Mochovce nuclear power plant Units 3 and 4 by 2010 is not considered. The missing output would be added by steam-gas sources and by contracted imports of output and energy.

The Energy Concepts follow the concepts of industrial policy according to which the 1990 level of energy consumption will be reached between 2000 and 2003. A gradual restoration of the economic growth is expected with the increase of electricity consumption by approximately 2% annually. The approach to the assurance of resources that will meet the requirements of consumption has been changed drastically.

The fundamental strategic goal of the energy policy is to ensure fuel and energy for all consumers. The energy shall be:

i) produced with the lowest costs and impacts on the environment;
ii) transported to the consumer safely and reliably and in the quality required;
iii) used in the field of generation, transport and consumption as effective as possible.

The variants analysed show an energy deficit following 2000. The delay in the Mochovce completion and the delay in the backfitting of sources at the end of their life-times (power plants Nováky and Vojany) brings nearer to 1998 the deadline when the system becomes unable to operate reliably. Even with an acceptable reliability, the electric grid has no sufficient rotating reserve sources almost in the entire time period reviewed. Each new source that will be introduced in operation will thus contribute to the improvement of the dynamic performance of the electric grid.

The completion of four Mochovce units becomes a key issue with regard to both ecology and policy for ensuring future energy sources

One of energy policy priorities is to restore sound environment by reducing emissions of polluting materials in line with the accepted multilateral Convention on Remote Atmosphere Pollution from 1979 in Geneva, the protocols from Helsinki and Sofia on reduction of $SO_2$ and $NO_x$ emissions, as well as the Declaration from the Hague. The following commitments resulted for Slovakia from the above documents:

i) to reduce $SO_2$ emissions by 30% in comparison with 1990 till 1993;
ii) not to exceed the level of annual $NO_x$ emissions in 1987 by the end of 1994;
iii) to reduce $CO_2$ production by 20% against 1988 till 2005.

These specified tasks (only I) and ii)) in the power industry have been fulfilled up to now and there are expectations for their further successful fulfilment within the framework of the accepted "Energy Concepts of the Slovak Republic Till 2005". Table 9 shows the emissions of steam power plants from SE a.s.

TABLE 9. EFFLUENTS INTO THE ENVIRONMENT FROM STEAM POWER PLANTS OF SE A.S.

Thousands tons

| Pollutant | 1990 | 1993 | 1995 |
|---|---|---|---|
| $SO_2$ | 176.6 | 104.6 | 69.6 |
| $NO_x$ | 32.7 | 24.5 | 25.3 |
| $CO_2$ | 8195.5 | 6785.8 | 6883.6 |

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the electricity sector

The dominant producer of electricity in Slovakia has been the utility Slovak Power Plants (SE) Inc. which is a national property fund owner share- holding company (see Figure 4 for its structure). In 1995, the electricity production from SE Inc. was 22.9 TW·h (88.4%) and that from other producers 3.0 TW·h (11.6%). The group of other producers consists mainly of energy sources in factories (auto producers).

The distribution and sale of electricity in the volume of 89.7% were done by means of the regional energy enterprises shown in Table 10. The power grid operates within the framework of the CENTRAL regional set (Czech Republic, Hungary, Poland and Slovakia). In October 1995, a long-term trial test of joint operation with the UCPTE was started.

TABLE 10. DISTRIBUTION OF ELECTRICITY IN SLOVAK REPUBLIC

GW·h

| | |
|---|---|
| East Slovakia | 5,085 |
| Central Slovakia | 7,706 |
| West Slovakia | 6,935 |
| Direct consumers of SE | remaining part |

### 2.2. Decision-making process

The development of the power sector has been implemented based on the Energy concepts of the Slovak Republic approved by the Slovak Government. The organization responsible for the development is the utility SE Inc. together with power distribution enterprises.

## BODIES OF SE a.s.:

- General Assembly
- Supervisory Board
- Board of Directors

ORGANIZATIONAL CHART OF SE as. S. AS OF 1. 1. 1996

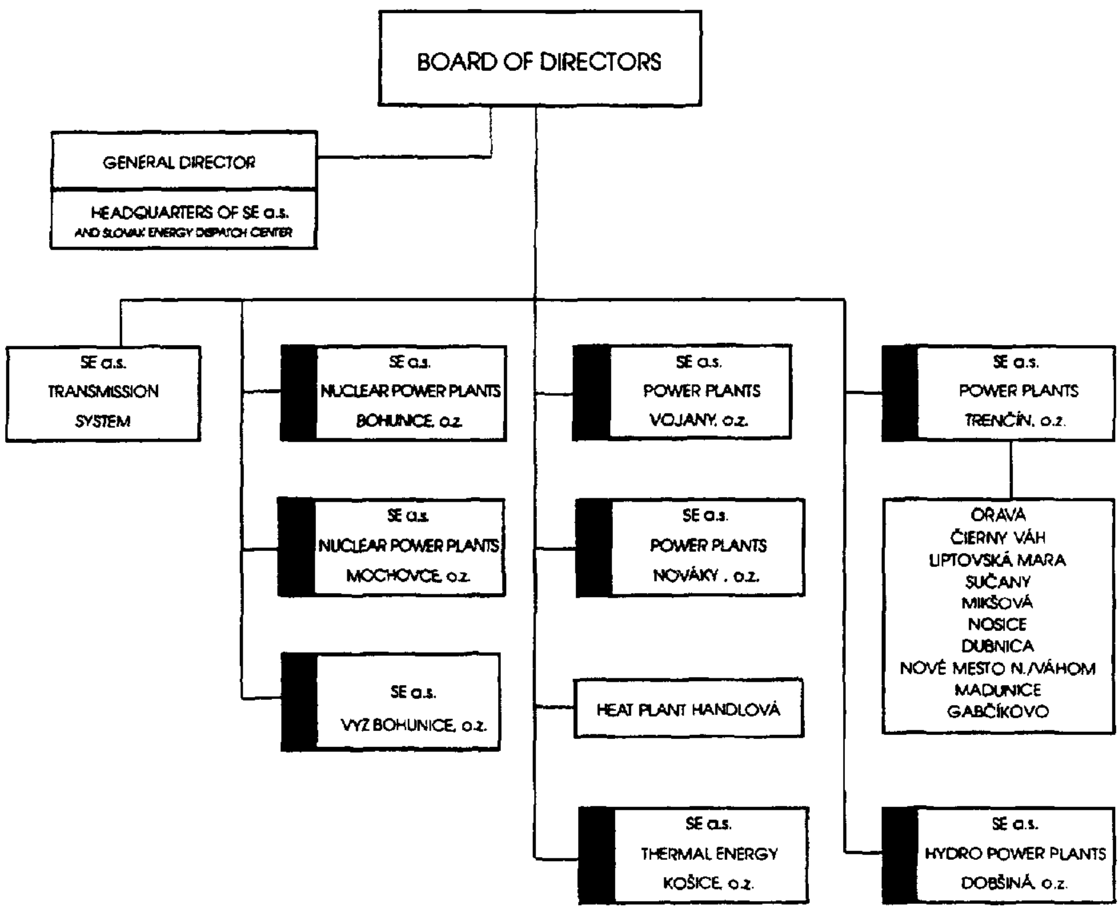


*FIG. 4. Structure of the Slovak Power Plant Utility (SE a.s.)*

### 2.3. Main Indicators

The development of the electricity production and fuel consumption is given in Table 11 and also shown in Figure 5. Table 12 shows the installed electrical capacity and Figure 6 its share by plant type. Figure 7 shows the annual load follow curve of the Slovak electricity system.

TABLE 11. DEVELOPMENT OF ENERGY PRODUCTION AND CONSUMPTION

TW·h

| | Actual value | | | Prognosis | | |
|---|---|---|---|---|---|---|
| | 1990 | 1994 | 1995 | 1996 | 2000 | 2005 |
| Nuclear power plants | 12.0 | 12.1 | 11.4 | 11.4 | 17.1 | 19.4 |
| Steam power plants | 6.6 | 5.2 | 6.3 | 6.6 | 6.6 | 7.9 |
| Hydro power plants | 2.5 | 4.5 | 5.2 | 4.6 | 3.9 | 4.0 |
| Other producers | 3.0 | 3.0 | 3.0 | 2.9 | 3.4 | 3.4 |
| Net import | 5.2 | 0.4 | 1.4 | 3.8 | 2.4 | 3.7 |
| Consumption total | 29.3 | 25.2 | 27.3 | 29.3 | 33.4 | 38.4 |
| out of which SE a.s. total | 21.1 | 21.8 | 22.9 | 22.6 | 27.6 | 31.3 |
| Production of electricity | | 24.7 | 25.9 | | | |
| Nuclear fuel consumption [PJ] | 140.4 | 141.6 | 134.5 | 134.5 | 176.2 | 207.8 |

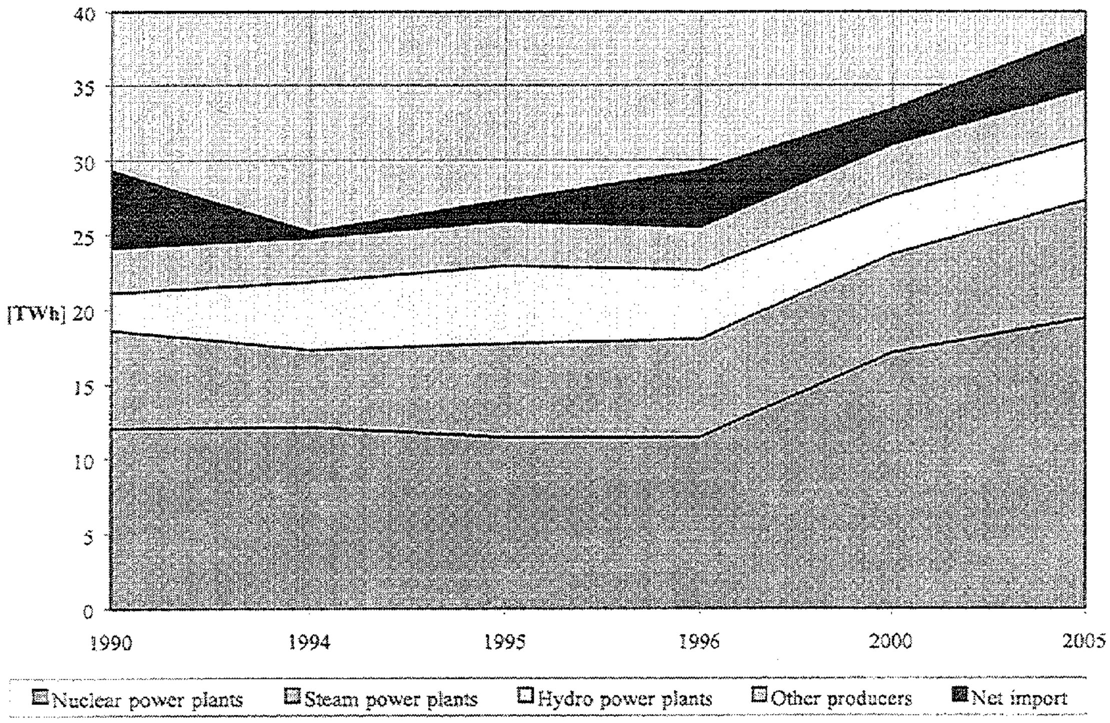


*FIG. 5. Development of Electricity Generation*

TABLE 12. INSTALLED ELECTRICAL CAPACITY

| | Unit | Slovak Republic | | Slovak Power Plants (SE) | |
|---|---|---|---|---|---|
| | | 1994 | 1995 | 1994 | 1995 |
| Installed capacity | MW | 6,925 | 7,116 | 5,938 | 6,118 |
| Nuclear power plants | MW | | 1,760 | | 1,760 |
| Thermal power plants | MW | | 2,982 | | 1,989 |
| Hydro power plants | MW | | 2,375 | | 2,369 |
| Auto producers | | | 1,013 | | |
| Peak loading | MW | 3,778 | 4,218 | | |
| Production of heat delivered | TJ | | | 10,909 | 11,092 |

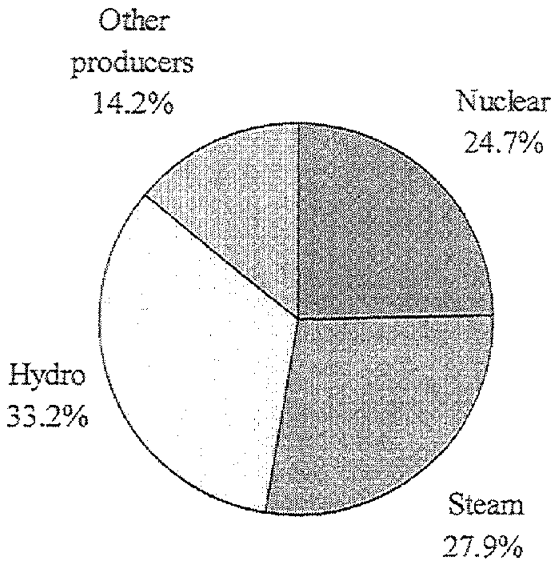


*FIG. 6. Share of Power Plant Capacity*

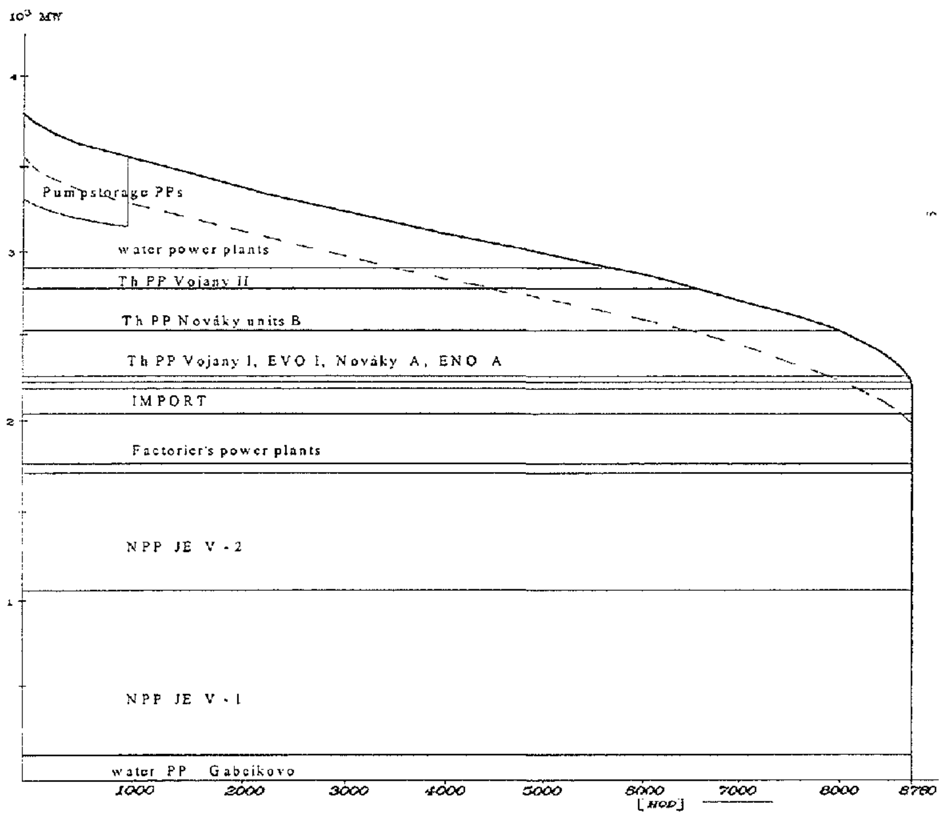


*FIG. 7. The Annual Load Follow Curve of the Slovak Electricity System*

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical development

*A-1 Bohunice:*

| | |
|---|---|
| 1956 | Intergovernmental agreement between the former USSR and CSSR on the construction of an industrial-research nuclear power plant on the territory of CSSR |
| 1957 | Establishment of an investment enterprise Nuclear Power Plant A-1 by the decision of the Governmental Committee for Nuclear Energy and of the Authority for Nuclear Power Management |
| 1958 | Beginning of A-1 construction |
| 1972 | The research and development reactor KS 150 at A-1 made critical. Gradual increase of reactor electric output up to the maximum value of 127 MW.<br>Connection of A-1 to the electric grid. |
| 1976 | First serious incident at the KS-150 reactor. |
| 1977 | The decisive severe accident during reactor refuelling |
| 1978 | Decision of CSSR government to decommission A-1. |
| 1992 | Slovak government accepted the global concepts of A-1 decommissioning |
| 1998 | Expected to bring A-1 into safe radiation conditions |

*V-1 Bohunice:*

| | |
|---|---|
| 1969 | Decision of the State Planning Commission of CSSR based on an agreement with USSR to start the construction of nuclear power plants with pressurised water reactors of WWER 440 type |
| 1970 | Decision of CSSR and USSR governments to supply two nuclear power plants each with two WWER reactors 440 MW |
| 1971 | Establishment of affiliated organization in Jaslovské Bohunice |
| 1973 | Laying of foundation stone for the construction of main production building. |
| 1978 | V-1 Unit 1 reactor made critical. |
| 1979 | Commissioning of V-1 Unit 1 into trial operation |
| 1980 | Commissioning of V-1 Unit 1 into commercial operation<br>V-1 Unit 2 reactor made critical<br>Commissioning of V-1 Unit 2 into trial operation |
| 1981 | Commissioning of V-1 Unit 2 into commercial operation |
| 1984 | Re-evaluation of V-1 safety |
| 1986 | Other safety measures to enhance nuclear safety. |
| 1990 | Execution of reviews to evaluate V-1 conditions. |
| 1991 | ÈSKAE Decision about V-1 operation based on implementation of additional safety measures |
| 1991-1995 | Implementation of Phase 1 measures to upgrade safety by backfitting V-1 units |
| 1995-1999 | Implementation of Phase 2 measures with the objective to achieve European standards and maintain V-1 in operation. |

*V-2 Bohunice:*

| | |
|---|---|
| 1976 | Agreement signed with USSR on the construction of V-2 in Jaslovské Bohunice<br>Beginning of V-2 construction |
| 1984 | V-2 Unit 1 reactor made critical<br>Commissioning of V-2 Unit 1 into trial operation |
| 1985 | Commissioning of V-2 Unit 1 into commercial operation<br>V-2 Unit 2 reactor made critical<br>Commissioning of V-2 Unit 2 into trial operation<br>Commissioning of V-2 Unit 2 into commercial operation |

*Mochovce:*

| | |
|---|---|
| 1974 | Preparatory studies, survey works, sociology survey |
| 1978 | Federal Ministry of Fuel and Power approved an investment intention to construct two twin-reactor units with the capacity of 440 MW each. |
| 1981 | Physical start of Mochovce construction |
| 1983 | Establishment of a concern enterprise Atomic Power Plants Mochovce with its headquarters in Mochovce |
| 1989 | The original deadline for Mochovce Unit 1 commissioning failed to be met due to necessary replacement of inadequate instrumentation and control system |
| 1995 | The way of funding the construction of Mochovce Units 1 and 2 was still open, construction and installation works continued in a minimum extent only.(The funding of Mochovce completion was resolved by the Government Decision No.339/96 dated May 14,1996) |

### 3.2. Current Policy Issues

The results of a survey carried out in the SR concerning the public opinion on the use of nuclear energy are shown in Figure 8. The data shown are based on the results of a standard survey by a Gallup's questionnaire method on a selected sample of 1.037 percent of population above 18 years in 1995. About 46% of the selected population indicated to be on favour of nuclear power and 44% was against.

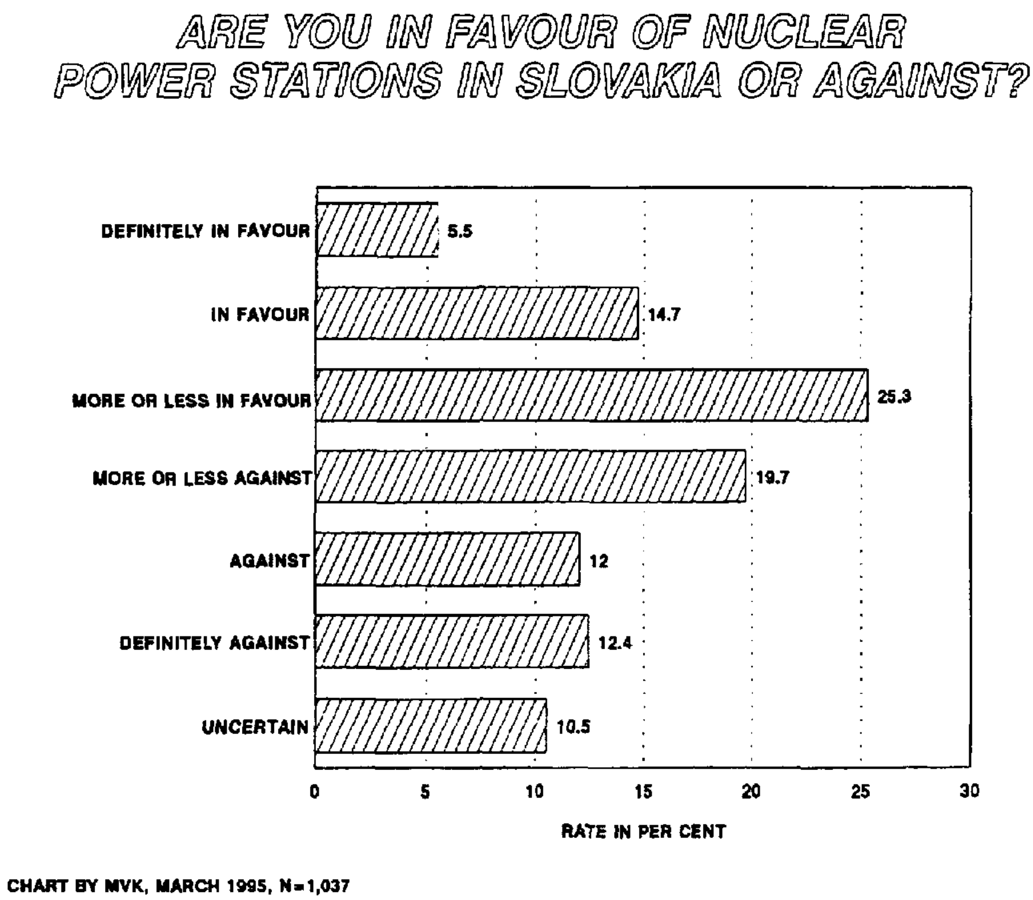


*FIG. 8. Results of a Survey on the Use of Nuclear Energy*

### 3.3. Status and trends of nuclear power

The decision about the orientation of the Slovak power industry on the utilisation of nuclear power made in seventies resulted from the status of useable reserves of primary energy resources which in no case could meet the demands on electricity. The construction of the V-1 Bohunice Plant (EBO Units 1, 2) with V-230 reactor types started in 1972 and the construction of the V-2 Bohunice Plant (EBO Units 3, 4) with V-213 reactors in 1976.

Four nuclear units are in operation in Slovakia at Bohunice, with a total capacity of 1.76 GW(e). The units produced 11.3 TW·h in 1996 and the nuclear share was about 44.5% of the electricity production of the country. The Slovak Electricity Company Slovenske Elektrarne (SE a.s.), which operates the Bohunice nuclear power plant, was transformed in 1994. Two of the Bohunice units are the older type of Soviet design WWER-440/230 pressurised water reactors. After an extensive programme for upgrading these units carried out from 1991 to 1998, which brought them up to the international safety standard level, they are expected to be operated until the turn of the century. The two other units of Bohunice are of the more recent WWER-440/230 design which incorporate most of the safety features of non-Soviet-type reactors. However, a programme of further safety enhancement of these plants has been undertaken in co-operation with western European companies following the recommendations of the Slovak safety authority and the IAEA, see later in this Section..

Based on studies of further development of nuclear power in the former CSFR and following a lengthy decision making process, the construction of another nuclear power plant with four units WWER 440 with V-213 type reactors at the Mochovce site (EMO Units 1 to 4) started in April 1981. With regard to conceptually unclarified questions of automatic control of production processes and nuclear safety, the completion of the Unit 1, originally planned for 1985, has been gradually postponed and the process of its completion has not been currently completed.

Based on a decision of the Slovak government, in a first phase Mochovce-1 and -2 will be completed in 1998 and 1999, respectively. For the completion of Mochovce-1,2, contracts were signed with the following organizations: Atomenergoexport, Electricité de France, Energoprojekt Prague Inc., EUCOM (Siemens AG, Framatome SA), Hydrostav Bratislava Inc., ŠKODA Prague Inc., VÚJE Trnava Inc., and Zarubezhatomenergostroj. The Slovak government took over guarantees for the bank loans for the Mochovce-1,2 completion.

Table 13 some basic operating data and Table 14 shows the status of the nuclear power plants in Slovak Republic. The costs of one MW·h delivered from EBO 1, 2 and EBO 3, 4 are calculated at the plant output, including a 10 per cent contribution to the State fund for decommissioning of nuclear power installations.

TABLE 13. BASIC DATA OF OPERATING NUCLEAR POWER PLANTS

| | Production in TW·h | | Load Factor in % | | Net Efficiency in % | Own electr. cons. in % | Prod. Loss in TW·h | Heat delivered in TJ | Costs per MW·h in Sk |
|---|---|---|---|---|---|---|---|---|---|
| Unit | 1995 | Since commiss. till 31.12.95 | Annual | Cumul. | Since commissioning | | 1995 | 1995 | 1995 |
| EBO 1 | 3.00 | 47.24 | 0.770 | 0.730 | 27.66 | 7.8 | 0.9 | 200 | 454 |
| EBO 2 | 3.03 | 45.31 | 0.780 | 0.753 | 28.51 | 7.5 | 0.8 | 100 | (≅ US$15) |
| EBO 3 | 2.58 | 32.76 | 0.668 | 0.773 | 29.15 | 7.6 | 1.3 | 633 | 496 |
| EBO 4 | 2.82 | 31.35 | 0.730 | 0.802 | 29.07 | 6.9 | 1.0 | 641 | (≅ US$16.5) |
| Total | 11.43 | 156.66 | | | | | 4.0 | 1574 | |

These costs are approximately half in comparison with the costs of fossil steam power plants in SR while the costs of fossil plants represent in average more than 1000 Sk per one MW·h delivered. From the total electricity generated in SR 1995, nuclear power plants generated 44,15%.

TABLE 14. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| BOHUNICE-1 | WWER | 408 | EBO | Operational | AEE |
| BOHUNICE-2 | WWER | 408 | EBO | Operational | AEE |
| BOHUNICE-3 | WWER | 408 | EBO | Operational | SKODA |
| BOHUNICE-4 | WWER | 408 | EBO | Operational | SKODA |
| MOCHOVCE-1 | WWER | 388 | EMO | Under Construction | SKODA |
| MOCHOVCE-2 | WWER | 388 | EMO | Under Construction | SKODA |
| MOCHOVCE-3 | WWER | 388 | EMO | Under Construction | SKODA |
| MOCHOVCE-4 | WWER | 388 | EMO | Under Construction | SKODA |
| A-1 BOHUNICE | HWGCR | 110 | EBO | Shut Down | SKODA |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| BOHUNICE-1 | 01-Apr.-74 | 27-Nov.-78 | 17-Dec.-78 | 15-Jun.-81 | |
| BOHUNICE-2 | 01-Apr.-74 | 15-Mar-80 | 15-Mar-80 | 01-Jan-81 | |
| BOHUNICE-3 | 01-Dec.-76 | 08-Aug.-84 | 28-Aug.-84 | 14-Feb.-85 | |
| BOHUNICE-4 | 01-Dec.-76 | 02-Aug.-85 | 09-Aug.-85 | 18-Dec.-85 | |
| MOCHOVCE-1 | 01-Oct.-83 | | | | |
| MOCHOVCE-2 | 01-Oct.-83 | | | | |
| MOCHOVCE-3 | 01-Jan-85 | | | | |
| MOCHOVCE-4 | 01-Jan-85 | | | | |
| A-1 BOHUNICE | 01-Jan-58 | 01-Jan-72 | 01-Oct.-72 | 01-Dec.-72 | 17-May-79 |

Source: IAEA Power Reactor Information System, yearend 1996

*BACKFITTING OF EXISTING NUCLEAR POWER PLANTS*

**Reactor Type V-1 - 2x440 MW WWER V-230**
Based on recommendations from IAEA and EC experts, the so called "small backfitting" of V-1 was carried out in 1991 and 1992, with the costs of 2 million Sk, and focused mainly on:

- improving confinement integrity
- upgrading seismic resistance
- analysing reactor pressure vessel life
- backfitting fire protection systems
- annealing reactor pressure vessels
- installing another diesel generator and new distributions of essential power supply
- verifying the validity of the "leak before break" (LBB) principle at reactor coolant system

The implementation of these actions was a prerequisite for the operation of the V-1 plant till 1995. According to the ÚJD SR Decision No.1/94, the prerequisite for further operation after 1995 is to implement the so called "gradual upgrading" in 1994 to 1999 with the costs of 5.500 million Sk. The content of the gradual upgrading is as follows:

- further improvement of confinement integrity
- modifications of core cooling in operation and during loss of coolant accidents
- modifications of emergency power supply for cooling systems, and of instrumentation and control systems
- enhancement of the level of quality assurance, safety, operating procedures, documents for personnel training, emergency planning etc.

The implementation of the gradual upgrading proceeds in line with the schedule approved by the ÚJD SR. Following its completion, the V-1 nuclear safety will achieve the level acceptable for early nuclear power plants according to IAEA reviews.

**Reactor Type V-2 - 2 x 440 MW WWER 213**
In 1995 to 2000, a similar programme will be implemented with the objective to upgrade V-2 resistance and nuclear safety with the costs of 5.350 million Sk focused mainly on:

- modification of reactor coolant system, essential power supply, instrumentation and control
- upgrading of seismic resistance
- improving of fire protection efficiency
- enhancement of the level of quality assurance, safety, operating procedures, documents for personnel training, emergency planning etc.

Following the completion of the V-1 gradual upgrading, its operation is considered till the end of its design life, i.e., till 2005. The ultimate goal for the V-2 is to establish conditions for extending its design life up to 40 years, i.e. till 2025.

### 3.4. Organizational Chart

Figure 9. shows the structure of the institutions involved with nuclear power.

## 4. NUCLEAR POWER INDUSTRY

The main organization participating in the development of the Slovak power system is the utility Slovak Power Plants (SE) Inc. together with the Power Enterprises of East, Central and West Slovakia that ensure the investment, construction and operation of power plants, transmission and distribution system. The state regulation of nuclear safety is provided by the Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR).

The Slovak Energy Inspection - Energy Agency fulfils the tasks of the state check about the entire management of energy and its effective use on Slovak territory. The complete development of Slovak nuclear power including the nuclear power industry has proceeded within the framework of the valid "Energy Concepts of Slovakia Till 2005" approved by the Slovak government in 1993.

### 4.1. Supply of NPPs

The domestic producer and supplier of selected components of pressure systems (separators, piping) for nuclear power plants is the Slovak Power Engineering Works in Tlmace, Inc. and the Piping Company, Inc. in Košice. The supplier of civil construction works is the Hydrostav Bratislava, Inc.

Main foreign suppliers are Atomenergoexport (Russia), ŠKODA and EGP (Czech Republic), which the well-known Western firms (EdF, Siemens and Framatome) will gradually join during the Mochovce completion and Bohunice upgrading.

### 4.2. Operation of NPPs

The owner of the Bohunice plant is the utility Slovak Power Plants (SE), Inc. The operators of these four units is a SE affiliation Atomic Power Plants Bohunice.

The Atomic Power Plants Bohunice (EBO) have built their own technical and professional capacities for the performance of maintenance activities. The performance of specialised activities is ordered by the EBO from the manufacturers of these components, or from specialised firms.

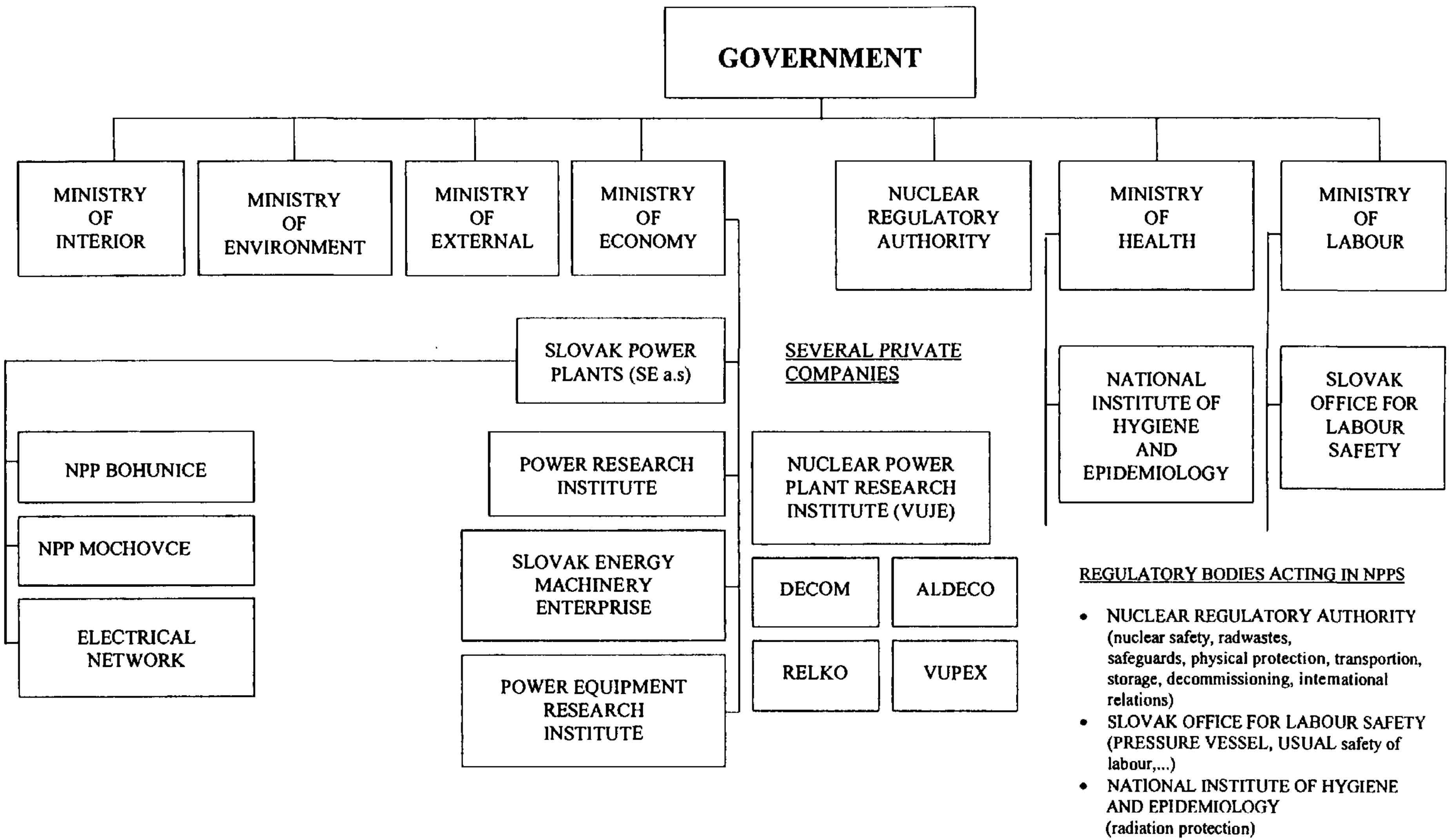


*FIG. 9. Slovak Institutions Involved In The Nuclear Field*

The training of nuclear personnel, that is of operative personnel, maintenance personnel up to decommissioning personnel, is carried out by the Training Centre in the Nuclear Power Pant Research Institute (VÚJE) Trnava, Inc. The VÚJE performs professional, practical and theoretical training of nuclear power plant personnel in six categories based on the Certificate No. 1/94 from the ÚJD SR

The Category 1 is designed for selected personnel, e.g. operators, control physicists, reactor unit supervisors. Following a successful graduation from theoretical and practical training, trainees obtain certificates. For the performance of a function, the Category 1 personnel have to obtain a ÚJD license which has to be renewed in two or three years intervals depending on the function.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management Service Supply

#### 4.3.1. Procurement of new nuclear fuel

The WWER 440 units at the nuclear power plants Bohunice and Mochovce use the same fuel. Each unit consumes annually approximately 110 fuel assemblies (about 14 tons). The manufacturer and exclusive supplier of the fuel has been the Russian Federation (RF).

In line with the concepts of the Slovak government for the future policy of the fuel cycle front end, the following principles were accepted:

- to diversify the supplies of fresh nuclear fuel, i.e., to select another manufacturer of nuclear fuel;
- not to leave the present manufacturer in RF and to buy further a portion of fresh fuel from the Russian supplier as well;
- not to accept a replacement of the Russian monopoly by another monopoly.

A fixed contract has been signed with a supplier from the RF for the period of 1994 to 1998. Starting in 1999, fresh nuclear fuel for the WWER-440/V-213 units will be provided by several suppliers. The Bohunice units have reserve fuel for half a year of operation. Fuel for Mochovce Unit 1 was delivered in 1989 and is stored on site.

#### 4.3.2. Management of spent fuel

Following 3 to 4 years of fuel stay in reactor, spent fuel is discharged from the core. It is stored in wet storage pools inside main reactor buildings during first three years (it will be six years at Mochovce units).

Following three years of storing:

- spent fuel assemblies were shipped to the former Soviet Union prior to 1987;
- spent fuel is stored in the wet pool of the intermediate spent fuel storage installation on the Bohunice site since 1987.

Approximately 3,630 Bohunice assemblies are stored in the intermediate spent fuel storage installation currently. Its capacity will be exhausted in 1999. It will be necessary to provide another storage capacity for WWER-440 spent fuel from both Bohunice and Mochovce operation since 1999. The solution is being sought:

- by increasing the storage capacity of the existing intermediate spent fuel storage installation;
- by selecting the form and supply of equipment for another long- term spent fuel storage installation.

According to the spent fuel and waste management concepts in effect:

- no reprocessing of spent fuel is envisaged;
- initial activities in site selection for an ultimate underground repository of spent fuel and high level radioactive waste are in progress.

### 4.3.3. Treatment and disposal of radwaste

The whole amount of radioactive waste from the past operation of the Bohunice units is stored temporarily on the site. The concepts of radwaste management from nuclear power installations and other organizations using sources of ionisation radiation were prepared in 1993. The following production process fixing facilities have been constructed or are being built:

- A bitumenization facility for fixing concentrates and ionexes was commissioned in 1995;
- A cementation facility of KWU for cementing concentrates was bought in 1984 to cope with situation if a potential accident event would occur;
- A vitrification facility is in the stage of non-active comprehensive testing;
- A radwaste processing centre consists of the cementation facility with a possibility to densify concentrates, a high pressure pressing and an incineration installation. The centre will be commissioned in 1997.

All low- and medium-level radwaste from Bohunice will be stored in fibre-concrete containers. To make the system of radwaste management complete, it is necessary to commission the operation of the disposal facility for low- and medium-level radwaste on the Mochovce site which is in the process of licensing.

### 4.3.4. Material and financial provision of radwaste management

A new daughter plant of the utility SE a.s. with the name of Decommissioning of Nuclear Power Installations and Management of Radioactive Waste and Spent Fuel (SE-VYZ, o.z.) has commenced its activities since January 1, 1996. The new plant is located on the site of the Bohunice nuclear power plants. Its field of activities is spread over the whole Slovakia and it will be responsible for the ultimate disposal of all kinds of radwaste and spent fuel that have been and will be produced on the Slovak territory from the operation and decommissioning of nuclear power plants, as well as for early and complete preparation of designs and facilities and for executing the above mentioned activities. Besides that, the new plant will provide the disposal of institutional radwaste from other organizations. The plant activities will be financed from the budget of the utility SE a.s. and from the State Fund for Decommissioning of Nuclear Power Installations and Management of Spent Fuel and Radwaste. This fund was established in 1995. The money is accumulated from contributions amounting to 10 percent from the selling price of electricity supplied from nuclear power plants. The payment of this contribution is the responsibility of the nuclear power plant owner. From this fund, it is possible to take finances for the preparation and decommissioning of nuclear power installations, and for the management of spent fuel and radwaste related to nuclear power installation decommissioning, provided that an approval of the Board of the State Fund for Decommissioning is given.

According to the projected electricity supply from nuclear power plants in SR, the contributions in the State Fund for Decommissioning of Nuclear Power Installations and Management of Spent Fuel and Radwaste should provide approximately 30.8 billion Sk by 2010 including the interest rate of 6 percent. This amount should be sufficient according to calculations performed for the construction of a long-term spent fuel storage installation with the costs of approximately 4.2 billion Sk and for the decommissioning of the V-1 plant following the completion of its economical life in the amount of about 10.0 billion Sk, and for other investment actions in this field. The creation of the State Fund for Decommissioning of Nuclear Power Installations and Management of Spent Fuel and Radwaste should go in advance prior to its use, and the decommissioning of nuclear power installations and management of radwaste should be assured by finances without any other requests on the state budget of SR or other sources of SE a.s.

### 4.4. Nuclear Research and Development

The goal of the nuclear research and development complex is to establish a research and development basis for state authorities, manufacturers and suppliers of process equipment for nuclear power installations and for nuclear power plant operators. As regards its structure, it includes basic research concentrated in the Slovak Academy of Sciences and at universities in a lesser extent, and applied research in a larger extent which provides the object of activities of independent research institutes (share-holding companies and companies with limited responsibilities) and sections of industrial organizations (Table 15).

TABLE 15. SLOVAK TECHNICAL SUPPORT ORGANIZATIONS WORKING IN THE NUCLEAR FIELD

| Institution Name | Headquarters | Number of employees | | | | Area of activity |
|---|---|---|---|---|---|---|
| | | 1992 | 1993 | 1994 | 1995 | |
| Nuclear Power Plants Research Institute (VÚJE) | Trnava | 543 | 462 | 434 | 420 | Nuclear Safety, in-service inspection, plant commissioning and operation, personnel training, radiation safety |
| Research Institute of Welding (VUZ) | Bratislava | 545 | 392 | 368 | 347 | Technology of welding, welding equipment and materials, preparation of personnel, in-service inspections-only partly for NPPs |
| Research Institute of Cables and Isolants (VUKI) | Bratislava | 235 | 202 | 202 | 188 | Cables with reduced flammability radiation resistant cables, testing of cables, residual life time of cables |
| Power Equipment research Institute (VÚEZ) | Levice | 118 | 109 | 106 | 106 | Tests of containment's, sealing, condensation systems, safety system design, filtration and ventilation |
| Power research institute (EGU) | Bratislava | 86 | 76 | 35 | 35 | Integrity and lifetime of RPV, tubes, antiseismic upgrading, thermal loading, economical aspects |
| Institute of Clinical and Preventive Medicine-Dept. of Hygiene of radiation | Bratislava | 28 | 30 | 30 | 30 | Personal dosimetry, radiation monitoring, protective barriers |
| CSA and EBO | Trnava | 25 | 30 | 32 | 27 | 3-D model database of nuclear facilities, structural analysis |
| National Institute of Hygiene and Epidemiology (NUHE) Dept. for radiation protection | Bratislava | 25 | 24 | 23 | 24 | Expertizing for radiation protection, state supervision in the field |
| DECOM | Trnava | 8 | 12 | 15 | 15 | Preliminary projects for decommissioning, radwaste management decontamination |
| VUPEX | Bratislava | 23 | 9 | 8 | 6 | Technical-economical studies |
| RELKO | Bratislava | - | 6 | 6 | 6 | Reliability analysis, PSA studies, impact of external events |
| ALDECO | Trnava | 12 | 14 | 14 | 17 | Decontamination technology and equipment |
| RADSAF | Bratislava | - | 3 | 3 | - | Consultancy in radiation protection |
| MERIT | Trnava | 2 | 4 | 6 | 6 | Radiation protection, dosimetry, monitoring, calculations of radiation fields |
| Institute of radioecology | Košice | not found | 20 | 15 | 15 | Radiological impact on environment, releases, decontamination |
| TOTAL | | 1650 | 1393 | 1297 | 1242 | |

With regard to financial aspects, the applied research is ensured by:

- projects of state orders;
- scientific and technical projects;
- orders from manufacture and supplier organizations, as well as from the operators of nuclear power installations.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

In the field of international co-operation, the most significant are the co-operation with the International Atomic Energy Agency (IAEA) in Vienna, the co-operation with the European Union within the PHARE programme, and last but not least also bilateral co-operations with foreign institutions and organizations. Slovakia co-operates by means of IAEA with foreign subjects on:

- the solution of research projects financed from a fund for technical co-operation;
- the national projects within the framework of co-ordinated research with financial support from the IAEA;
- the organization of international courses and seminars

The international co-operation with the EU goes within the framework of research and development programmes of the European Community focused mainly on PHARE programmes. The PHARE programmes in the field of nuclear safety in relation to the EU are co-ordinated by the Slovak Ministry of Economy.

The Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR) is a participant in discussions on regional and national programmes in the field of nuclear safety. The national projects in this field are solved since 1993 as regional ones in order to use the funds more effectively.

The basis for bilateral co-operations are intergovernmental agreements out of which some were transformed from the point of view of Slovakia as an independent state. Bilateral co-operation is widely developed which is evidenced by:

- the establishment of the REKON consortium (VÚJE Inc. and SIEMENS) for the V-1 gradual safety upgrading;
- the co-operation with the BABCOCK firm in the design and implementation of control systems for thermal power plants;
- the solution of research, development and technical problems together with:
    - KfK and NUKEM from Germany
    - EdF, Framatome, IPSE and CORYS from France
    - KEMA from the Netherlands
    - AEA Technology, Sheerbonnet and NNC from the United Kingdom
    - Westinghouse, SAIC, ANL Argonne Virginia Tech from the United States
    - ŠKODA, EGP, ÚJV Řež Inc. From the Czech Republic
    - Atomenergoexport and Zarubezhatomenergostroj from Russia.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority (ÚJD SR) and the Licensing Process

The ÚJD SR was established on January 1, 1993 as an independent central body of the Slovak state authorities with direct access both to the government and National Council of the Slovak Republic for the domain of nuclear regulations over nuclear safety (Figure 10).

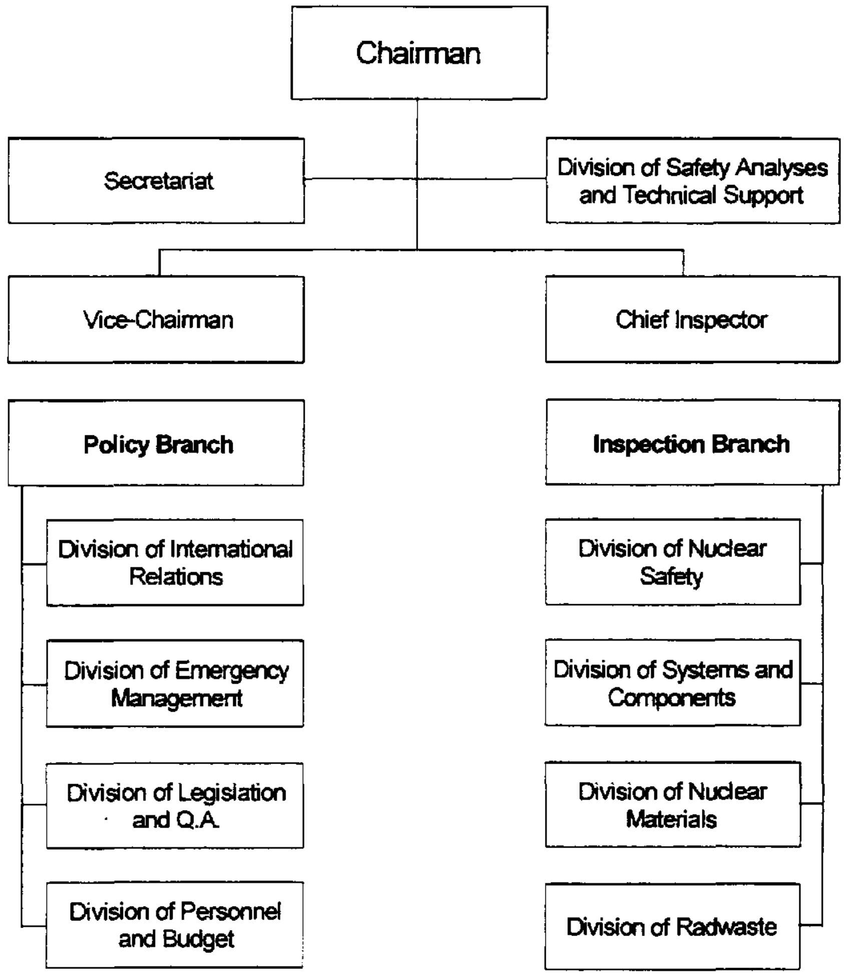


*FIG. 10. Organizational Structure of the Nuclear Regulatory Authority ÚJD SR*

The ÚJD SR Chairman is appointed by the government and co-operates with other central bodies of the state authorities in performing his activities, and he submits regularly to the Slovak government reports about the safety of nuclear installations in Slovakia and about his activities.

The ÚJD SR executes the state regulation over:

i) nuclear safety of nuclear installations including the regulation over the management of nuclear waste, spent nuclear fuel and other phases of nuclear fuel cycle;
ii) nuclear materials including their control and recording;
iii) quality of selected equipment and instrumentation.

The ÚJD SR ensures:

i) review of intentions how to use nuclear energy;
ii) evaluation and inspection of emergency plans;
iii) fulfilment of the commitments of the Slovak Republic resulting from international agreements in the field of nuclear safety and nuclear material safeguards.

The execution of nuclear regulation is supported by laws, especially in the law No. 28/1984 and in several regulations that give to the authority high powers including the acceptance of such measures as requirements on safety improvement, as well as orders for power reduction or reactor shut-down if required by safety reasons.

According to the law No. 28/1984, the ÚJD SR performs:

i) routine inspections by site inspectors;
ii) special inspections by nuclear safety inspectors;
iii) team inspections.

The routine inspections are executed according to standard procedures developed for the particular inspections. The special and team inspections are executed according to programmes developed for the particular inspection. These programmes are sent in advance to the organization in which the inspection is to take place. The inspectors write down protocols about the inspections performed.

The inspections in 1995 were performed in line with the Order of the ÚJD SR Chairman No.2/1995, with an inspection plan and programme of quality assurance and inspection activities as Appendix. Totally 382 inspections were performed, 148 protocols written down, 48 biweekly reports of site inspectors and 24 monthly reports of site inspectors.

The authority has been established in line with international recommendations as was confirmed by a number of expert missions of the International Atomic Energy Agency and the European Commission. Work contacts with partner regulatory bodies in all European countries with nuclear power developed, but also in the U.S.A and Japan, contribute significantly to improving the work quality of the ÚJD SR.

### 5.2. Main National Laws and Regulations

- The law of the National Council of the Slovak Republic No. 2/1992 amends the law of the Slovak National Council No. 347/ 1990 on the organization of ministries and other bodies of state authorities in the Slovak Republic.

- The law No. 28 from 1984 on the state supervision over nuclear safety of nuclear installations.

- The CSKAE Decree No. 28/1987 on the recording and control of nuclear materials.

- The CSKAE Decree No. 67/1987 on the assurance of nuclear safety during nuclear waste management.

- The CSKAE Decree No. 100/1989 on the physical protection of nuclear installations and nuclear materials.

- The Decree No. 191/1989 which establishes the way, terms and conditions for the evaluation of special professional abilities of selected personnel from nuclear installations.

- The CSKAE Decree No. 436/1990 on the quality assurance of selected equipment with regard to nuclear safety of nuclear installations.

- The CSKAE Decision No. 2/1978 on the assurance of nuclear safety in designing, approving and performing constructions with nuclear power installation.

- The CSKAE Decision No. 4/1979 on the general criteria for the assurance of nuclear safety in siting constructions with nuclear power installations.

- The CSKAE Decision No. 6/1980 on the assurance of nuclear safety in commissioning and operation of nuclear power installations.

- The CSKAE Decision No. 8/1981 on the testing of facilities for transport and disposal of radioactive materials.

- The CSKAE Decision No. 9/1985 on the assurance of nuclear safety of research nuclear installations.

A draft bill on the peaceful utilisation of nuclear energy was developed and after elaborating comments form the Slovak government it was again prepared for approval. The acceptance of the bill by the National Council of the Slovak Republic is expected by the end of 1996.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related safeguards agreement INFCIRC/173/Add 2 | Entry into force by Czechoslovakia: | 28 December 1972 |
| | Succession: | 1 January 1993 |
| • Improved procedures for designation of safeguards inspectors | Accepted | |
| • Revised supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 4 October 1995 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Succession: | 1 January 1993 |
| • Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Sea Bed and the Ocean Floor and in the Subsoils their off. | | |
| • Agreement on privileges and immunities | Succession: | 27 September 1993 |
| • Convention on physical protection of nuclear material | Entry into force: | 1 January 1993 |
| • Convention on early notification of a nuclear accident | Entry into force: | 1 January 1993 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 1 January 1993 |
| • Convention on civil liability for nuclear damage | Entry into force: | 7 June 1995 |
| • Joint protocol | Entry into force: | 7 June 1995 |
| • Convention on nuclear safety | Ratification: | 7 March 1995 |

| | |
|---|---|
| • ZANGGER Committee | Czechoslovakia was Member |
| • Nuclear Export Guidelines | Adopted by Czechoslovakia |
| • Acceptance of NUSS Codes | Summary of reply received from Czechoslovakia: Codes are appropriate for formulating and implementing national requirements. They are used for that purpose.<br>Letter of: 2 November 1988 |
| • Nuclear Suppliers Group | Member |

*BILATERAL AGREEMENTS*

- Agreement between the Government of the Czech and Slovak Federal Republic and the Government of Hungary on Information Exchange and Co-operation in the Field of Nuclear Safety and Radiation Protection.
- Agreement between the Government of the Czech and Slovak Federal Republic and the Federal Government of Germany on Regulatory Questions of Common Interest Regarding Nuclear Safety on Radiation Protection.
- Agreement between the Government of the Czech and Slovak Federal Republic and the Government of Austria on Regulatory Questions of Common Interest Regarding nuclear Safety and Radiation Protection.
- Agreement between the Government of the Czech and Slovak Federal Republic and the Government of the United States of America on Co-operation in Peaceful Uses of Nuclear Energy.
- Agreement between the Government of the Czechoslovak Socialist Republic and the Government of India on Co-operation in the Field of Peaceful Uses of Nuclear Energy.
- Agreement between the Government of the Czechoslovak Socialist Republic and the Union of Soviet Republics on Extensions of Co-operation in Peaceful Uses of Nuclear Energy.
- Agreement between the Government of the Czechoslovak Socialist Republic and the Government of the Federal Socialist Republic of Yugoslavia on Co-operation in Peaceful Uses of Nuclear Energy.
- Agreement between the Government of the Slovak Republic, the Government of Ukraine and the Government of the Russian Federation on Co-operation in the Field of Transportation of Nuclear Fuel Between the Slovak Republic and the Russian Federation Across the Territory of Ukraine (1993).

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## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Nuclear Regulatory Authority | |
| Bajkalska 27 | |
| 820 07 Bratislava | Tel: 42-7-522 15 31 |
| Slovak Republic | Fax: 42-7-29 36 03 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Slovak Power Plants Inc. | |
| Hranièná 12 | Tel.: 421-7-521 75 85 |
| 827 36 Bratislava | Fax: 421-7-521 75 33 |
| | |
| Affiliations: | |
| - NPP Bohunice | Tel.: 421 805 213 01 |
| 91931 Jaroslavske Bohunice | Fax: 421 805 244 67 |
| | |
| - Decommissioning of nuclear power | |
| installations and management of | Tel.: 421 805 912 16 |
| radwaste and spent fuel | Fax: 421 805 244 67 |
| - NPP Mochovce | Tel.: 421 813 391 164 |
| 93533 Mochovce | Fax: 421 813 391 120 |
| | |
| Slocak Power Inspectorate | |
| Power Agency | Tel.: 421 7 522 20 12 |
| Bajkalska 27 | 421 7 339 33 03 |
| 827 99 Bratislava | Fax: 421 7 293 95 1 |
| | |
| Occupational safety office | |
| of the Slovak Republic | |
| Špitálska 8 | Tel.: 421-7-326 42 3 |
| 816 43 Bratislava | Fax: 421-7-361 42 1 |

*RESEARCH AND DEVELOPMENT ORGANIZATIONS:*

| | |
|---|---|
| Nuclear Power Plants Research Institute (VÚJE) | |
| Okružná 5 | Tel: 421-805 605 356 |
| 918 64 Trnava | Fax: 421-805-502 574 |
| | |
| Research Institute of Welding (VUZ) | |
| Raèianska 71 | Tel.: 421-7-253 500 |
| 832 59 Bratislava | Fax: 421-7-252 003 |
| | |
| Research Institute of Cables and Isolants (VUKI) | |
| Továrenská 16 | Tel.: 421-7-326 586 |
| 815 71 Bratislava | Fax: 421-7-526 7066 |

Power Equipment Research Institute (VÚEZ)
P.O. Box 153
Michala Sv. 4 Tel.: 421-813-312 055
934 01 Levice Fax: 421-813-313 663

Power Research Institute (EGU)
Bajkalská 27 Tel.: 421-7-522 1267
827 21Bratislava Fax: 421-7-522 1560

Institute of Clinical and Preventive Medicine-
Dept. of Hygiene of Radiation
Limbová 14 Tel.: 421-7-373 560
833 01 Bratislava Fax: 421-7-373 906

CSA and EBO
Bottu 2 Tel.: 421-805-521 052
917 01 Trnava Fax: 421-805-521 049

National Institute of Hygiene and Epidemology.
(NUHE) Dept. for Radiation Protection
Trnavská cesta 52 Tel.: 421-7-621 01
826 45 Bratislava Fax: 421-7-211 449

DECOM
Bottu 2 Tel.: 421-805-521 074
917 01 Trnava Fax: 421-805-521 077

VUPEX
Bajkalská 27 Tel.: 421-7-522 5893
827 52 Bratislava Fax: 421-7-522 5893

RELKO
P.O.Box 95,
Racianska 75 Tel.: 421-7-253 000
Bratislava Fax: 421-7-253 301

ALDECO
Jiráskova 243 Tel.: 421-805-213 01
917 01 Trnava Fax: 421-805-914 30

MERIT
Hajdoczyho 10
P.O.Box 10 Tel.: 421-805-410 37
917 00 Trnava Fax: 421-805-263 62

Institute of Radioecology
P.O.Box A-41,
Garbiarska 2 Tel.: 421-95-68 03 183
040 61 Košice Fax: 421-95-62 23 769

*SCHOOLS:*

Slovak Technical University
Bratislava

Faculty of Electric-Technology & Information
Ilkovièova 3
Bratislava Tel.: 421-7-791 111

Faculty of Chemical Technology
Radlinského 9
19 Bratislava Tel.: 421.7-326 021

Comenius University
Faculty of Mathematics and Physics
Mlynska dolma
81000 Bratislava Tel.: 421-7 724 000

Comenius University
Faculty of Natural Sciences
81000 Bratislava Tel.: 421-7-796 111
Bratislava

*OTHER ORGANIZATIONS:*

Slovak Academy of Sciences
Štefánikova 49 Tel.: 421-7-392 751
Bratislava Fax: 421-7-394 105

Hospital - Oncology Institute
of St. Elizabeth
Heydukova 10 Tel.: 421-7-384 9111
81000 Bratislava Fax: 421-7-323 711

# SLOVENIA

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# SLOVENIA

## 1. GENERAL INFORMATION

### 1. General Overview

The Republic of Slovenia lies on the southern side of the Alps, neighbouring to Italy, Austria, Hungary and Croatia. It covers an area of 20.251 square kilometres. The country is devised into three climate regions, one influenced by the Alps mountain chain, a part with continental climate and a part significantly influenced by the Adriatic Sea. In 1993, Slovenia had a population of approximately 2 million inhabitants (Table 1). Slovenia used to be part of the former Yugoslavia and became a sovereign country in 1991.

TABLE 1. POPULATION INFORMATION

| | 1980 | 1985 | 1989 | 1990 | 1992 | 1993 | Average growth rate (80-92) |
|---|---|---|---|---|---|---|---|
| Population (millions) | 1.9 | 2.0 | 2.0 | 2.0 | 2.1 | 2.1 | 8.26 |
| Population density (inhabitants /km$^2$) | 94 | 97 | 99 | 99 | 101 | 102 | |

### 1.2. Economic Indicators

The economic development of the country after the Second World War was significantly influenced by the centralised planning economy. After a relatively high economic growth in 60s and 70s, the country was confronted with an economic decline, starting in late 70s. Economic recession was accompanied with a rather high inflation rate which escalated at the end of 80s into a hyperinflation. After the independence, Slovenia lost the whole market of the rest of Yugoslavia, which contributed almost 35% to the total Slovenian export. The country undertook great efforts to overcome the economic decline. Its exports had to be reoriented to other markets, mostly western ones, which were much more demanding than the former Yugoslav ones. Production has been reorganised in many sectors to match the new standards and market requirements. Unemployment became a severe problem overnight, reaching a level of almost 15%. Nevertheless, the undertaken measures and efforts resulted in a stabilisation of Gross Domestic Product (GDP) in 1993. In 1994, an economic swing upwards was registered. GDP grew 4.5% and the industrial production had an increase of 8%. According to the IAEA Energy and Economic Data Base, Slovenia had in 1993 a GDP per capita of US$ 6,450. The GDP structure by sector in 1992 was: agriculture 5%, industry 40% and service sector 55% (Table 2).

As seen from the above shown indicators, Slovenia is facing many challenges as it develops towards a market economy. Following the split from the former Yugoslavia, new infrastructure, including additional connections to neighbouring countries, may also be required. Slovenian economy is heavily export oriented and as such very sensitive to any regional or world recession.

### 1.3. Energy Situation

Slovenia has rather limited energy reserves. The proven and recoverable reserves of low quality brown coal and lignite amount to 190 million tons. Oil reserves are very scarce, 850,000 tons with annual exploitation of 2,500 tons. The estimated hydro reserves of Slovenia are up to 9 TW·h per year, out which 3.5 TW·h are already exploited. Oil and gas are imported entirely. The country is connected to two gas pipelines from Algeria and Russia respectively. In 1992 the energy dependency of the country was 69%.

The severe economic recession and political turbulence which affected the country has also been reflected in the energy sector. Relatively high energy growth rate stabilised in the 80s. The final energy consumption grew during the early 80s with an average yearly growth rate of 2.1% and reached the value 185 PJ in 1987. During the period 1987-1992 the primary energy consumption decreased by 18%. Table 3 shows the historical energy statistics.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1993 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 7 | 10,146 | 17,304 | 12,493 | | 1.6 |
| GDP (millions of constant 1990 US$) | 9,854 | 17,859 | 17,304 | 14,783 | 15,526 | -1.4 |
| GDP per capita (current US$/capita) | | | | 6,490 | | |
| GDP by sector : | | | | | | |
| Agriculture 5% | | | | | | |
| Industry 40% | | | | | | |
| Services 55% | | | | | | |

Source: IAEA Energy and Economic Data Base

A significant share of Slovenian industrial production is very energy intensive such as steel production, aluminium, chemicals, paper industry and building material manufacturing. In 1987, energy demand of the industry sector accounted for 50% of the total final energy demand, a much higher share than seen in most West European economies. The high energy consumption in industry is also reflected in high energy use per unit of Gross Domestic Product, compared to most West European countries. Energy use per capita is lower than the average for EU countries. The analysis of specific final energy consumption for Slovenia and the European Union shows that the ratio of final energy consumption to GDP in Slovenia is unfavourable compared to the European Union. In 1992, this ratio was 556 toe/mio ECU for Slovenia versus 184 toe/mio ECU for the EU. Table 4 shows the comparison between Slovenia and the EU concerning primary energy consumption and energy intensity.

TABLE 3. PRIMARY ENERGY SUPPLY

Petajoule

| | 1980 | 1985 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|
| Indigenous Production | | | | | | |
| Coal | 64 | 68 | 59 | 55 | 60 | 57 |
| Crude Oil & NGL | 0 | 0 | 0 | 0 | 0 | 0 |
| Natural Gas | 0 | 0 | 1 | 1 | 1 | 1 |
| Hydro Power | 13 | 12 | 12 | 14 | 13 | 14 |
| Other Commercial | 0 | 0 | 0 | 0 | 0 | 0 |
| Non Commercial | 10 | 11 | 11 | 11 | 10 | 11 |
| Nuclear Power(1) | 0 | 23 | 26 | 0 | 0 | 0 |
| Total Production | 87 | 115 | 109 | 81 | 84 | 82 |
| Imports(+) | | | | | | |
| Coal, Coal Products | 13 | 18 | 5 | 6 | 5 | 7 |
| Crude Oil | 22 | 19 | 23 | 23 | 21 | 23 |
| Refined Petroleum Products | 61 | 52 | 60 | 63 | 52 | 54 |
| Natural Gas | 18 | 29 | 30 | 29 | 24 | 28 |
| Nuclear Fuel(2) | 0 | 0 | 30 | 29 | 24 | 28 |
| Electricity | 4 | 4 | 6 | 4 | 1 | 2 |
| Total Imports | 119 | 123 | 125 | 176 | 154 | 167 |
| Exports(-) | | | | | | |
| Coal, Coal Products | 1 | 1 | 1 | 1 | 1 | 2 |
| Crude Oil | 0 | 0 | 0 | 0 | 0 | 0 |
| Refined Petroleum Products | 1 | 1 | 1 | 6 | 1 | 7 |
| Natural Gas | 0 | 0 | 0 | 0 | 0 | 0 |
| Electricity | 0 | 3 | 2 | 11 | 8 | 7 |
| Total Exports | 2 | 6 | 3 | 18 | 9 | 15 |
| Total Primary Energy Supply | 203 | 232 | 230 | 241 | 228 | 233 |

TABLE 4. COMPARISON OF SOME INDICATORS WITH EU

| Indicator | Region | Unit | 1985 | 1990 | 1992 |
|---|---|---|---|---|---|
| Energy Intensity | Slovenia | toe/mio ECU | 720 | 770 | 811 |
| Energy Intensity | EU | toe/mio ECU | 308 | 286 | 203 |
| Primary energy consumption per capita | Slovenia | toe/cap | 3.09 | 3.07 | 2.73 |
| Primary energy consumption per capita | EU | toe/cap | 3.2 | 3.4 | 3.5 |

### 1.4. Energy Policy

In 1994, the Slovenian Government adopted a long-term energy strategy for the country over a period 1992-2010. Considering the optimistic economic scenario, the final energy consumption will grow 1.2% annually in the period 1992-2000, and will slow down to 0.43% annually over the period 2000-2010. According to the optimistic scenario, energy intensity will decrease to 360 toe/mio ECU by 2010. In order to achieve the foreseen targets the following measures will be required:

i) refurbishment and upgrading of the existing generating capacities,
ii) to make all the necessary incentives for the efficient use of energy,
iii) energy prices should gradually reach the European level through a new tariff system,
iv) market liberation for primary energy sources as well as for the power sector in compliance with provisions of European Energy Charter and the respective protocols.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

In the past the electric power sector was entirely State owned as well as transmission and distribution of power. Slovenian Electric Utility (ELES) is responsible for the transmission, wholesale purchase and sales of electricity. Electric power is generated in seven dislocate centres, whereas the distribution retail sales are performed by five distribution companies. ELES is also monitoring the imports and exports of electric power in Slovenia. All companies involved in the power sector operate as independent entities. At this moment in time, institutional and ownership structure is changing, i.e., the power sector will be privatised, whereas the State will keep a fixed share.

### 2.2. Decision Making Process

The ministry of Economic Activities is responsible for the development of the power sector of the country in close contact with The Ministry of Finance. The objective of Slovenia's electricity policy is to supply reliable and cost effective power. The Slovenian Government has set up a severe programme for energy conservation and efficient use of energy in order to reduce the growing energy needs. According to EU experience it is possible to improve energy efficiency (useful energy/final energy) by 2% per annum when applying appropriate energy efficiency programmes. The following measures will be implemented to achieve a more efficient power system:

- implementation of integral energy planning, global cost minimisation and least-cost planning;
- establishing national energy efficiency agencies to pave and promote the efficient use of energy;
- applying new regulations in power sector as well as in construction sector reducing further losses in industry, service and household sectors;
- local energy concepts;
- energy auditing.

Energy prices are controlled by the Slovenian Government. As a result of former economic policy in Slovenia, some energy prices, in particular the electricity price, are currently still lower than the equivalent prices in Western European countries. Current policy aims to allow energy prices to increase and reflect all costs and meet competitive level. To avoid undue economic and social hardship, the increase of energy prices will be introduced over a period of years. A goal is set to achieve the level of electricity prices prior to taxation, that will be comparable to the EU countries and will cover internal and external costs. This goal will apply to all consumer groups of electric power. It is expected that the real electric power prices will gradually grow by 7% per annum in the period of the next five years.

### 2.3. Main Indicators

In 1993 the Slovenian power system produced 10,608 GW·h. The total available electricity was 11.69 TW·h. The generation breakdown by type of production was: 27% by hydro, 38% by thermal and 35% by nuclear. Table 5 shows the electricity production data and installed capacities and Table 6 the related energy ratios for 1992 and 1993. Total installed capacity at the end of 1993 was 2,480 MW(e). The country is undertaking significant efforts to refurbish and upgrade the existing capacities. The largest chain of hydro power plants on the Drava river is undergoing major refurbishment and upgrading, financed by an EBRD loan. Slovenia is a member of the European power network UCPTE and is fulfilling all the respective requirements. A major priority for the country is to construct additional 150 MW(e) reserve capacity, which were lost due to the war in former Yugoslavia.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITIES

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Electricity production (TW·h) | | | |
| - Total[1] | 12.09 | 11.69 | 12.63 |
| - Thermal | 4.90 | 4.92 | 4.84 |
| - Hydro | 3.41 | 3.02 | 3.40 |
| - Nuclear | 3.77 | 3.75 | 4.39 |
| Capacity of electrical plants (GW(e)) | | | |
| - Total | 2.53 | 2.48 | 2.52 |
| - Thermal | 1.14 | 1.09 | 1.14 |
| - Hydro | 0.76 | 0.76 | 0.76 |
| - Nuclear | 0.63 | 0.63 | 0.63 |

[1] *Electricity losses are not deducted.*

Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1992 | 1993 | 1994 |
|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 101 | 107 | 98 |
| Electricity per capita (kW·h/capita) | 4,935 | 4,957 | 5,169 |
| Electricity production/Energy production (%) | 96 | 99 | 100 |
| Nuclear/Total electricity (%) | 33 | 34 | 37 |
| Ratio of external dependency (%)[1] | 50 | 53 | 50 |
| Load factor of electricity plants | | | |
| - Total (%) | 55 | 54 | 57 |
| - Thermal | 49 | 51 | 49 |
| - Hydro | 52 | 46 | 51 |
| - Nuclear | 68 | 68 | 79 |

[1] *Total net import / Total energy consumption.*

Source: IAEA Energy and Economic Data Base

Thermal generation has the largest share in electricity generation. This has caused severe impacts on the environment, especially what concerns sulphur emissions. A large desulphurization device is under construction on the largest thermal block in TPP Sostanj. With the new device, the $SO_2$ emission will be essentially reduced.

It is also foreseen to improve and enlarge the transmission and distribution network in the country. Within the long-term plan until 2010, 163 km of 110 kV lines are expected to come in line, 5100 km of 20 kV lines and 1100 km of 400 V lines are anticipated to come into operation with respective control centres.

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

Slovenia has one nuclear power plant in operation since 1983, the NPP Krsko. The NPP Krsko is a pressurised water reactor of 632 MW(e), delivered by Westinghouse, and is jointly owned with the Republic of Croatia. The operational and safety record of Krsko NPP is good and complies with all international standards and requirements. The steam generator side of the plant was designed for 15 year lifetime. The safety status of the plant has been supervised by IAEA safeguards and OSART missions to the country. Apart from power generation, Slovenia has a research reactor with an extensive research activity.

### 3.2. Current Policy Issues

The life-time of steam generators is slowly phasing out (15 years of anticipated operation) and the Slovenian Government endorsed the replacement. The replacement of the steam generators will also upgrade the generating capacity by 6.6% (42.5 MW(e)) and also extend the lifetime of the NPP. In 1992, the former Ministry of Energy submitted a study on a possible early shut down of NPP Krsko. The analysis was a multi-aspect one, concerning legal, political, social, economic, safety, technical, ecological and power system issues. The results clearly showed, that an early shut down is not justified by none of the mentioned criteria, as long as the plant is achieving high safety and operational standards.

### 3.3. Status and Trends of Nuclear Power

In 1996 the NPP Krsko produced 4.36 TW·h or almost 38% of total electricity generation of the country. The load factor was 69%. Domestic and international institutions, including IAEA, were involved in safety missions to the NPP and they all rated the level of safety as good and the level is still improving. The designed life time is 40 years. Table 7 shows its current status.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| KRSKO | PWR | 632 | NEK | Operational | WEST |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| KRSKO | 30-Mar-75 | 11-Sep-81 | 02-Oct-81 | 01-Jan-83 | |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organizational Chart

Not provided for this report.

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of NPPs

Not provided for this report.

### 4.2. Operation of NPPs

Not provided for this report.

### 4.3. Fuel Cycle and Waste Management Service Supply

*Spent Fuel*

Spent fuel elements are stored at the power plant in the spent fuel pool which has enough space for 17 refuellings and the entire reactor core (121 fuel elements) as a permanent available reserve if, for any reason, it was necessary to empty the reactor core. The capacity of the spent fuel pool is therefore sufficient for the storage of used fuel elements until the year 2000. The plant operator is making great efforts to increase the duration of the fuel cycle and to achieve better efficiency by improving the nuclear core design. This would make it possible to use the existing spent fuel pool even beyond the year 2000.

*Radioactive Waste*

All radioactive waste is packed at the site of the power plant in 200 litre drums: low radioactive compressible waste without additional protection, other more active waste with additional protection which consists of a concrete cylindrical liner inside drums. It is located in the on-site LILW interim storage. During the twelve years of power plant operation 1,875 $m^3$ of LIL waste has accumulated. The average specific activity in barrels (drums) is 30 $Gbq/m^3$.

In 1993 the Slovenian Nuclear Safety Administration (SNSA) issued a licence to the operator for supercompaction of the barrels containing evaporator bottoms. These activities were carried out by using a mobile Westinghouse supercompactor unit, in 1994. The lifetime of the existing LILW interim storage on the NPP site will thus be significantly extended without any additional environmental impact above limits specified by the regulations.

*Radioactive Emissions to the Environment*

The limiting values of radioactive emissions into environment are stipulated by the licence to start operations of the Krsko NPP issued on February 6, 1984, by the Republican Energy Inspection Authority. The emissions of radioactive effluent into the Sava river are at the level of only a few percent of limiting values for all radionuclides, except for tritium for which the annual emitted activity was approximately 70%. The same applies for air emissions for the Krsko NPP. The limiting values for tritium are considerably lower than those stipulated or enforced in licences issued for nuclear power plants in other European countries.

The respective administrative authorities are informed on regular basis about emissions by regular and special reports by the NPP. Regular reports are made on a weekly, monthly and yearly basis. Special reports are mostly relevant to planned emissions from the containment before the venting. The Krsko NPP daily informs respective administration bodies in regular operation reports about the type and activity of emissions of radioactive waste into Sava river.

*Doses received by NPP Staff*

The average exposure of the staff in the power plant is low and does not exceed 1/20 of the prescribed limit value for professional staff. The received values are higher during refuelling and maintenance operation than during normal operation. The dose limits for nuclear power plant and contractor workers complied with, and were even bellow the latest ICRP recommendations.

*Radioactivity in the Human Environment in Slovenia*

The programme for measuring and monitoring radioactivity in the human environment in Slovenia is determined by the regulation on the locations, methods and time limits for the examination of contamination with radioactive substances ( Official Gazette of the SFRY, No. 40/86), and on the basis of expert opinions adopted after the Chernobyl accident and included in the regulation on the locations and time intervals for systematic examinations of the content of radionuclides in the human environment. The programme is executed by the Work Safety Institute and the Jozef Stefan Institute.

The programme encompasses the following activities:

i) monitoring with immediate control of the degree of radioactive contamination, such as for example, daily measurements of radioactivity of samples (air, precipitations) and continuos measuring of the external gamma radiation dose rate;

ii) measurements at 50 locations in Slovenia of daily and monthly doses received from the external gamma radiation;

iii) control of radioactivity in food from animal and plant sources - seasonal measurements as the basis for the calculation of doses received through ingestion.

The first two segments of the programme are essential for the early detection of the environmental contamination, and the third one serves to monitor long-term trends in environment contamination from artificial sources.

### 4.4. Research and Development Activities

*TRIGA Research Reactor*

Jozef Stefan Institute's TRIGA Mark II research reactor at Podgorica near Ljubljana, with a power of 250 KW has been operating for more than 20 years. The reactor produces radioactive isotopes, mostly short-lived, used in medicine, science and industry. Additional works related to neutrons and gama research, activation analyses, irradiation of materials for manufacturing of semiconductors have been carried out. The reactor also serves for training purposes.

In accordance with regulations all the necessary service for protection against irradiation, storage of radioactive waste, and records and storage of nuclear fuel are organised in the reactor centre. Head operator of the reactor, five operators and service for protection against ionising radiation are in charge of the reactor operation.

*Personnel Training*

Regulations require a highly trained personnel for peaceful use of nuclear energy. Not only is the level of education stipulated by regulations but also programmes of initial and permanent training, as well as the system of checking of the skills of personnel for specific jobs and tasks. This is stipulated by Reactor Regulations (as of September 1981) for Krsko Senior Reactor Operators and Shift Engineer Managers and department for protection against irradiation.

The Krsko NPP has its own training department which takes care of annual training programmes. As there is no simulator of nuclear power plant in Slovenia, the Krsko NPP training department organises obligatory annual courses on a simulator abroad, mostly in the United States. All personnel that require the permit of operator or senior reactor operator took part in refreshment courses in 1992 on a simulator of NPP GINNA, Rochester, N.Y., USA. The same staff also participated in permanent training in spring and autumn according to the program which contains besides regular refreshment courses also additional studying on the basis of experience from nuclear power plants in other countries, and specialised topics like nuclear safety. Expenses for personnel training amount to approximately 2.5% of the plant's total working expenses.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Slovenia was admitted to full membership of the IAEA in 1992. Co-operation with the IAEA covers a wide range of activities, of which the most important are:

- Preparation of International Conventions;
- IAEA missions to Slovenia;
- Technical co-operation including attendance of Slovenian experts on Agency's sponsored seminars and training courses, scholarship, scientific visits, research contracts;
- Co-operation with the EU Commission's PHARE programme on nuclear safety;
- Bilateral co-operation with national administrative agencies for nuclear and radiological protection and the use of nuclear energy.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Process

*Safety Authority and the Licensing Process*

The Slovenian Nuclear Safety Administration (SNSA) is responsible for nuclear safety, trade of nuclear and radioactive materials, safeguarding nuclear materials and conducting regulatory process related to liability for nuclear damage, qualification and training of operators at nuclear facilities, quality assurance and inspection of nuclear facilities.

The SNSA is a part of the Ministry for Environment and Regional Planning. In accordance with the recommendations of the International Atomic Energy Agency, the SNSA is not supposed to promote nuclear power, therefore it is independent from the Ministry of Energy, which is in charge of power utilities.

The major nuclear facility supervised by the SNSA is the NPP Krsko. Besides the NPP, the TRIGA Mark II research reactor of 250 KW thermal power operates within the Reactor Centre of the Jozef Stefan Institute. There is an interim storage of low and medium radioactive waste at the Reactor Centre site. Also the closed uranium mine Zirovski Vrh was supervised by the SNSA.

*Activity of the Slovenian Nuclear Safety Administration*

The activities of the SNSA cover four main areas:

- systematic issues and international relations,
- nuclear safety,
- nuclear materials,
- inspection.

At the legislation level, the SNSA continuously works on the preparation of a new Slovenian law on nuclear and radiological safety and a new Slovenian law on liability for nuclear damage. A standing committee set up by IAEA is preparing draft changes to the Vienna convention.

The SNSA sector for inspection of nuclear facilities supervises in accordance with its competence the management of nuclear facilities. It abides by the effective legislation, standards, technical specifications and other regulations relating to the enforcement of all nuclear safety measures regarding the siting, design and construction, the installation of systems and components, functional and drive tests, trial run, operation, verification of the work quality and built-in material, emergency planning and preparedness, verification of personnel qualification, responsible for the plant operation, maintenance, audits, overhauls and safety equipment modifications, the accounting of nuclear materials and the responsibility of nuclear damage.

### 5.2. Main National Laws and Regulations

In the process of establishing sovereign and independent state the Constitutional Law on the Enforcement of the Basic Constitutional Charter on the Autonomy and Independence of the Republic of Slovenia was passed, which provides that all those laws which in the past had been passed by the former Yugoslav (federal) authorities, and which do not conflict with the Slovenian legal system, remain in force also in the Republic of Slovenia until adequate laws are passed by the Slovenian Parliament.

Among other acts and laws which were adopted in the Slovenian legal system is also the one related to nuclear safety in the ex-Yugoslav Act on Protection Against Ionising Radiation and Special Safety Measures in the Use of Nuclear Energy, (referred to hereafter as 1984 Act) and 15 regulations based upon this law.

The legal basis for regulating framework in the field of nuclear safety and inspection control (function) on nuclear installation are given by:

- Act on Organisation and Field of Activity of the Administration,
- Act on Government of the Republic of Slovenia,
- Act on Energy Economy,
- Act on Protection Against Ionising Radiation and Special Safety Measures in the Use of the Nuclear Energy (1984 Act),
- Constitutional law on the Enforcement of the Basic Constitutional Charter on the Autonomy and the Independence of the Republic of Slovenia,
- Regulations based on 1984 Act.

Since the 1984 Act was adopted, several very important regulations for carrying out nuclear safety provisions of this act have been prepared and adopted. Most of them concern radiation protection:

- monitoring of radioactivity in the environment,
- monitoring of radioactivity around nuclear facilities,
- storage and disposal of radioactive waste,
- trading and utilisation of radioactive materials,
- qualification of persons who work with ionising radiation sources,
- dose limits for the members of the public and for occupational exposure,
- application of sources of ionising radiation for medicine,
- limiting activities for trade of foodstuff,
- limiting activities for radioactive contamination and decontamination,
- records and accounting of sources, doses to population and workers,
- conditions for siting, construction, commissioning,

- trial operation of nuclear facilities, format and scope of safety reports, qualifications and tests required for operators.

### 5.3. International, Multilateral and Bilateral Agreements

The Republic of Slovenia accepted succession of the following treaties to which the former Socialist Republic of Yugoslavia was a party:

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related agreement INFCIRC/204* | *Safeguards are still based on safeguards agreement with Yugoslavia. Entry into force: | 28 December 1973 |
| • Safeguards agreement | signed on: | September 1995 |
| • Improved procedures for designation of safeguards inspectors | Simplified designation procedure has been accepted | |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 4 October 1995 |
| • Statute of the International Atomic Energy Agency | | |

*OTHER RELEVANT INTERNATIONAL TREATIES.*

| | | |
|---|---|---|
| • NPT | Succession: | 7 April 1992 |
| • EURATOM | Non-Member | |
| • Agreement on privileges and immunities | Entry into force: | 21 September 1992 |
| • Convention on physical protection of nuclear material | Entry into force: | 25 June 1991 |
| • Convention on early notification of a nuclear accident | Entry into force: | 25 June 1991 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 25 June 1991 |
| • Vienna convention on civil liability for nuclear damage | Member | |
| • Joint protocol | Entry into force: | 27 April 1995 |
| • Convention on nuclear safety | Signature: | 20 September 1994 |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines | Not adopted | |

- Acceptance of NUSS Codes — No reply
- Partial Test-Ban Treaty — Non-Party
- Treaty banning nuclear weapons tests in the atmosphere, in the outer space and under water,
- The IAEA Incident Reporting System (IAEA-IRS)
- Treaty on the prohibition of the emplacement of the nuclear weapons and other weapons of mass destruction on the sea-bed and ocean floor and its subsoil thereof

## REFERENCES

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[2] Operation of Nuclear Facilities in Slovenia, Annual Report 1993, Slovenian Nuclear Safety Administration, Ljubljana, (1994).

[3] Energy Data Profile by World Energy Council, Slovenian National Committee, Ljubljana, (April 1993).

## ANNEX I. DIRECTORY OF THE MAIN ORGANISATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Slovenian Nuclear Safety Administration | |
| Ministry of Environment and Physical Planning | Tel.: +386-61-172 1100 |
| Vojkova 59 | Fax: +386-61-172 1199 |
| SI- 1000 Ljubljana, Slovenia | Tlx: 39437 URSJV SI |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Milan Vidmar | |
| Institute for Power Economy and Electrical Industry | |
| 61000 Ljubljana, Hajdrihova 2, | Tel.: +386 61 1250 333 |
| SLOVENIA | Fax: +386 61 1250 341 |
| | |
| Jozef Stefan Institute | |
| 61000 Ljubljana, Jamova 39, | Tel.: +386 61 159 199 |
| SLOVENIA | Fax: +386 61 161 029 |
| | |
| Slovenia Nuclear Safety Administration | |
| 61113 Ljubljana, Vojkova 59, | Tel.: +386 61 172 11 00 |
| SLOVENIA | Fax: +386 61 172 11 99 |
| | |
| NPP Krsko | |
| 68270 Krsko, Vrbina 12, | Tel.: +386 608 21 621 |
| SLOVENIA | Fax: +386 608 21 528 |
| | |
| Slovenian Electric Utilities - ELES | |
| 61000 Ljubljana, Hajdrihova 2, | Tel.: +386 61 216 405 |
| SLOVENIA | Fax: +386 61 219 389 |

# SOUTH AFRICA

## SOUTH AFRICA

# 1. GENERAL INFORMATION

## 1.1. General Overview

South Africa is situated at the southernmost part of Africa and lies between 23 degrees and 35 degrees South Latitude, resulting in a country with a climate ranging from temperate to semi-tropical. With a land area of 122 Million hectares and a population of 40 million (1993) it has a low population density of 327 persons per thousand hectares. The population is increasing at a rate of 2.3% per annum though with a decreasing rate (Table 1).

It is a country with a dual socio-economic composition - a large industrial base with a good infra-structure (the best in Africa) , but with a large third world component. For instance South Africa is a large electricity producer but two-thirds of its population does not have access to electricity.

The country has recently gone through a major political change during which the policy of apartheid was replaced by a democratic form of government.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 17.4 | 22.5 | 29.2 | 37.1 | 39.7 | 40.6 | 2.4 |
| Population density (inhabitants/km²) | 14.2 | 18.4 | 23.9 | 30.4 | 32.5 | 33.2 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 2.2 |
| Area (1000 km²) | 1221.0 |
| Urban population in 1993 as percent of total | 50.0 |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic Indicators

The country is classed as a developing country with a GNP per capita of US$ 2822 per capita in 1993 (Table 2). The economic growth rate during the worst years of the apartheid era was running at 3.3% per annum (GNP) and 1.3% per annum (Gross Domestic Product (GDP)) (1980 to 1991).For a developing country in Africa it is highly industrialized with industry contributing 39.3% to total Gross Domestic Product (GDP).

## 1.3. Energy Situation

The country has very large coal deposits, small hydro potential and very small deposits of gas. South Africa has large uranium deposits associated with its gold-bearing ores (Table 3).

The country's coal deposits are large and consist of thick shallow seams. This makes coal very cheap and results in 91% of primary energy being based on coal.

There are no commercial oil deposits and all petroleum must be imported. During the period when world sanctions were applied because of the country's' apartheid policies the Government undertook the construction of a vast oil-from-coal facility (Sasol) and a smaller oil-from-gas facility (Mossgas). At peak production these two facilities produced 30% and 10% respectively of local oil products demand. With the end of sanctions these plant are not required as a strategic components but continue to be operated since the capital cost is considered as sunk and operating costs are low.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 17,469 | 77,542 | 102,167 | 111,916 | 121,875 | 3.3 |
| GDP (millions of constant 1990 US$) | 63,285 | 88,156 | 102,167 | 100,627 | 102,967 | 1.1 |
| GDP per capita (current US$/capita) | 778 | 2,658 | 2,756 | 2,822 | 3,005 | 0.9 |

| GDP by sector : | |
|---|---|
| Agriculture | 5% |
| Industry | 39% |
| Services | 56% |

Source: IAEA Energy and Economic Data Base

Because of its low cost coal is exported to various countries. However because of its high ash content coal for export has to be beneficiated.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro (2) | Total |
| Total amount in place | 1787.26 | | 1.84 | 86.66 | | 1875.75 |

*(1) This total represents essentially recoverable reserves.*

*(2) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1992) by a factor of 10.*

Source: IAEA Energy and Economic Data Base

The energy balance of commercial energy for 1993 is given in Table 4; the 1993 final energy consumption in Table 5; and the historical energy situation in Table 6.

TABLE 4. 1993 ENERGY BALANCE

Mtoe

| Primary Supply | Oil | Gas | Coal | Electricity |
|---|---|---|---|---|
| Production | | | 133.1 | 1.8 |
| Imports | 10.7 | | | |
| Exports | 1.1 | | 31.0 | 0.2 |

TABLE 5. 1993 FINAL CONSUMPTION

| | Mtoe | % age |
|---|---|---|
| Oil | 15.3 | 33 |
| Oil -synthetic | 5.1 | 11 |
| Coal | 13.7 | 30 |
| Electricity | 11.7 | 26 |
| Total | 45.8 | 100 |

TABLE 6. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[(1)] | 0.97 | 1.44 | 2.91 | 4.13 | 4.25 | 4.21 | 5.63 | 2.67 |
| - Solids[(2)] | 0.99 | 1.60 | 3.12 | 4.04 | 4.17 | 4.11 | 5.90 | 1.99 |
| - Liquids | | | | | | | 13.47 | |
| - Gases | | | | | | | | |
| - Primary electricity[(3)] | | | 0.01 | 0.09 | 0.08 | 0.10 | 24.33 | 18.03 |
| Energy production | | | | | | | | |
| - Total | 0.99 | 1.60 | 3.02 | 4.13 | 4.25 | 4.21 | 5.73 | 2.39 |
| - Solids | 0.99 | 1.60 | 3.01 | 4.04 | 4.17 | 4.11 | 5.71 | 2.24 |
| - Liquids | | | | | | | | |
| - Gases | | | | | | | | |
| - Primary electricity[(3)]) | | | 0.01 | 0.09 | 0.08 | 0.10 | 24.33 | 18.03 |
| Net import (import - export) | | | | | | | | |
| - Total | | | | | | | | |
| - Solids | | | | | | | | |
| - Liquids | | | | | | | | |
| - Gases | | | | | | | | |

[(1)] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[(2)] *Solid fuels include coal, lignite and commercial wood.*
[(3)] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

In the past energy was considered a strategic commodity and therefore policy was aimed at becoming independent of imported energy forms. This led to the construction of the Sasol oil-from-coal and the Mossgas oil-from-gas plants. Neither if these was economic in terms of accounting cost.

Currently, policy is being formulated by Government through a process of consultation with all stake-holders. The result is likely to be the continuation of electricity supply through a Government controlled body - the parastatal Eskom - in order to ensure that the process of electrification of all the country's population is achieved.

There is no policy on coal which was deregulated some ten years ago. The pricing policy - which is strictly Government controlled - is currently being debated.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the electricity sector.

Generation and transmission of electricity is in the hands of the Government controlled parastatal Eskom, some municipalities and some private producers. However 90% of electricity sold in the country is generated by Eskom. Distribution was in the hands partially of Eskom but also in the hands a few municipalities and some 300 small distributors. Many of these small distributors were inefficient and this fragmentation resulted in poor financial viability and poor technical service. The problems with the distribution sector resulted in the formation of a National Electricity Regulator who has been given the task of proposing a method of tidying up the distribution sector.

Eskom has embarked on a very large programme of electrifying those areas that are not connected to the grid. In addition Eskom embarked on a programme of electrifying many schools and clinics with photovoltaic installations. The financing of this remote area power supply programme has been taken over by the Government which has formed a company, Renewable Energy Forum for South Africa (REFSA), to obtain funding and to drive the programme.

Municipalities supply their own consumers with electricity generated by themselves or with electricity bought from Eskom or by a combination of these two. Municipal electricity tariffs have been structured to support other local rates services and this policy is currently being discussed.

The licensing of generation and distribution is in the hands of a National Electricity Regulator. Eskom is one of the largest electricity utilities in the world with an installed capacity of 36 000 MW and annual sent-out production of 160 300 GW·h. The generation mix of sales in 1995 is given in Table 7.

TABLE 7. 1995 GENERATION MIX

| | Production % | Installed % |
|---|---|---|
| Coal-fired | 92.4 | 88.7 |
| Hydro-electric | 0.6 | 1.6 |
| Pumped storage | 0.9 | 3.7 |
| Gas-turbine | 0 | 0.9 |
| Nuclear | 6.1 | 5.1 |

## 2.2. Decision Making Process

The country has a surplus of generating capacity because of the downturn in the economy in the mid 1980's. Thus no further capacity is required before the middle of the next decade. Planning has started however on the possible next station. In the past Eskom has carried out its own planning process without it being overtly transparent. The decision on the next station is complicated by the entry into the energy supply arena of gas from Mozambique and from Namibia.

## 2.3. Main indicators

Table 8 shows the historical electricity production and the installed capacity and Table 9 the main energy and electricity related ratios.

TABLE 8. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 24.37 | 50.79 | 89.64 | 165.39 | 174.58 | 182.36 | 6.73 | 5.20 |
| - Thermal | 24.35 | 50.77 | 88.63 | 156.32 | 166.72 | 172.05 | 6.67 | 4.85 |
| - Hydro | 0.01 | 0.03 | 1.01 | 0.62 | 0.62 | 0.62 | 24.33 | -3.44 |
| - Nuclear | | | | 8.45 | 7.24 | 9.69 | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 5.14 | 10.51 | 18.38 | 26.39 | 26.39 | 26.39 | 6.58 | 2.62 |
| - Thermal | 5.13 | 10.50 | 17.84 | 24.00 | 24.00 | 24.00 | 6.43 | 2.14 |
| - Hydro | 0.01 | 0.01 | 0.55 | 0.55 | 0.55 | 0.55 | 21.57 | 0.04 |
| - Nuclear | | | | 1.84 | 1.84 | 1.84 | | |

[1] *Electricity losses are not deducted.*

Source: IAEA Energy and Economic Database

TABLE 9. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 56 | 64 | 100 | 111 | 107 | 104 |
| Electricity per capita (kW·h/capita) | 1,401 | 2,115 | 3,070 | 4,100 | 4,099 | 4,176 |
| Electricity production/Energy production (%) | 24 | 29 | 29 | 35 | 37 | 39 |
| Nuclear/Total electricity (%) | | | | 6 | 4 | 6 |
| Ratio of external dependency (%)[(1)] | | | | | | |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 54 | 55 | 56 | 72 | 76 | 79 |
| - Thermal | 54 | 55 | 57 | 74 | 79 | 82 |
| - Hydro | 13 | 20 | 21 | 13 | 13 | 13 |
| - Nuclear | | | | 52 | 45 | 60 |

[(1)] *Net import / Total energy consumption.*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

South Africa has large reserves of coal and most of its electricity has been traditionally generated from coal. However the coal fields are situated on the Highveld some 1500 kilometers from some of the further load centers such as Cape Town. Investigating the potential for alternative generation capacity for such areas in the early 1970's, it was determined that nuclear capacity of around 2000 MW would be cheaper than building a coal-fired plant in the Cape and railing coal from the Highveld area, or to transmit the power to the Cape via 400 kV transmission lines.

It was decided in the mid-1980's to build the Koeberg Nuclear Power Plant on the coast at Duinefontein, 35 kilometers north of Cape Town. The plant was commissioned in 1984.

The plant consists of two Pressurized Water Reactors and was built by Framatome. Fissile fuel was obtained from overseas but at the high of the sanctions period there were fears that nuclear fuel could be embargoed and the Atomic Energy Board was asked by the Government to design, build and operate an enrichment plant to provide power plant enriched fuel. Later this was expanded to manufacture the fuel locally.

### 3.2. Current Policy Issues

The change of Government to a democratic form in 1992 resulted in a critical review of all the establishments of the previous Government, and in particular those energy enterprise which are seen as being the result of strategic anti-sanctions decisions are being investigated.

The nuclear scene is being seen as having been instigated for military purposes and especially for the production of enriched fuel to produce an atomic bomb. Thus Koeberg Power Station is being seen as a component of the bomb-uranium programme. A vociferous lobby has resulted that is calling for the immediate closure of Koeberg, citing cost and unsafe operating conditions as reasons.

A decision has been postponed until the production of a Energy White Paper from which recommendations are likely to come to appoint a Committee to investigate the economic viability and safety of the continued operation of the plant.

### 3.3. Status and Trends of Nuclear Power

ESKOM, the electricity utility, owns and operates South Africa's only nuclear plant, the twin reactor Koeberg Power Station near Cape Town, at the South-West tip of the country (Table 10). Koeberg operating parameters are shown in Table 11.

TABLE 10. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| KOEBERG-1 | PWR | 921 | ESKOM | Operational | FRAM |
| KOEBERG-2 | PWR | 921 | ESKOM | Operational | FRAM |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| KOEBERG-1 | 01-Jul.-76 | 14-Mar-84 | 04-Apr.-84 | 21-Jul.-84 | |
| KOEBERG-2 | 01-Jul.-76 | 07-Jul.-85 | 25-Jul.-85 | 09-Nov.-85 | |

[Source] IAEA Power Reactor Information System, yearend 1996

TABLE 11. KOEBERG OPERATING PARAMETERS

| | |
|---|---|
| Type | Pressurized Water Reactors |
| Number of reactors | 2 |
| Rated station output | 1840 MW |
| Nuclear Island Contractor | Framatome |
| Cooling | Sea Water |

### 3.4. Organization

The nuclear power station is owned and operated by the parastatal ESKOM. Procurement of fuel was, until recently, through the Government's Atomic Energy Corporation (previously the Atomic Energy Board) which was responsible for the negotiations for fuel purchase and its importation. Under the sanctions strategic scenario the Atomic Energy Corporation became the total fuel supplier from enrichment to fuel fabrication. Recently this has changed and the procurement of fuel will be the responsibility of ESKOM.

ESKOM was responsible to an Electricity Board who had the authority to license the supply, transmission and distribution of electricity. Recently a National Electricity Regulator has been appointed to oversee this function.

Legislation on Nuclear Safety has created the Council for Nuclear Safety (CNS)who have full control over safety aspects of all stages of the nuclear chain. The CNS issue licenses, from the safety point of view, for the complete chain of nuclear activity, including the mining of uranium ore. The CNS is responsible to the Minister of Mineral and Energy Affairs.

## 4. Nuclear Power Industry

### 4.1. Supply of NPP

South Africa has one nuclear power station - Koeberg - situated near Cape Town.

Client: ESKOM

Contractors:

- Nuclear Island: Framatome
- Conventional Island: Alsthom Atlantique
- Civil Works: Spie Batignolles
- Coordination: Framateg

### 4.2. Operation of NPP

Koeberg Power Station is operated by ESKOM the state parastatal electricity utility.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management

ESKOM is responsible for fuel procurement. At present spent fuel is stored in wet storage inside the power station. Low level waste from the Power Station is stored in steel or concrete cask at Vaalputs, some 150 km north of Cape Town, in an open trench site. Transport to the site is by the operator, ESKOM, who transport cask on a road low-loader. The present reassessment of nuclear power by the Government includes consideration of waste disposal in the longer term. The safety of all waste disposal is monitored by the Council for Nuclear Safety.

### 4.4. Research and Development Activities

Research and Development in the nuclear field has been the province of the Atomic Energy Council, who have carried out research into the application of radioactive techniques in industry, the treatment of foodstuffs using radioactive sources, etc. They have also carried out all the necessary research and development in to uranium enrichment.

Because of the heavy cost commitment of the Atomic Energy Council Government has decided to close down all nuclear research activities except for those in support of other programmes. The Atomic Energy Council is now diversifying into industrial applications of their expertise. They will continue to operate the Safari Research Reactor for Research applications and are carrying on with research into advance uranium enrichment technology.

### 4.5. International Cooperation in the Field of Nuclear Power Development and Implementation

Information not provided for this report.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and the Licensing Procedure

Information not provided for this report.

### 5.2. Main National Laws and Regulations

Legislation on nuclear energy dates back to 1948 when the predecessor of the present Atomic Energy Corporation of South Africa (AEC), namely the Atomic Energy Board, was created by the Atomic Energy Act.

This Act was amended over the years to keep pace with developments in nuclear energy. A major addition in this field came about in 1963 when the Nuclear Installations Act came into force. This made provision for the licensing of Nuclear Installations by the Atomic Energy Board. The Uranium Enrichment Corporation was created in 1970 by the Uranium Enrichment Act. This allowed the enrichment of uranium by a State Corporation separate from the Atomic Energy Board and subject to licensing by the latter.

A major change took place in 1982 when the AEC was created and made responsible for all nuclear matters, including uranium enrichment. This came about through the Nuclear Energy Act of 1982. This Act was amended several times in subsequent years. A major amendment created the autonomous Council for Nuclear Safety (CNS), responsible for nuclear licensing and separate from the AEC, in 1988 (Nuclear Energy Amendment Act, Act 56 of 1988).

The old Nuclear Energy Act was replaced by a new Act in 1993 (Nuclear Energy Act 131 of 1993). This maintained the autonomous character of the CNS but made provision for the implementation of the Safeguards Agreement with the IAEA pursuant to the requirements of the Nuclear Non-Proliferation Treaty to which South Africa acceded in June 1991. This Act is still in force and also regulates, through appropriate Regulations, the import, export, use and possession of nuclear equipment and materials defined by the Nuclear Exporters Committee (Zangger Committee) and Nuclear Suppliers Group (NSG).

The import, export, use and possession of nuclear-related dual-use items, as defined by the NSG, are regulated by the Non-Proliferation of Weapons of Mass Destruction Act, Act 87 of 1993. This Act also implements the Chemical Weapons Convention, Biological Weapons Convention and the Missile Technology Control Regime.

*FINANCING FOR DECOMMISSIONING AND WASTE DISPOSAL*

In general, the financing for decommissioning and waste disposal follows the rule "polluter pays" although this has led, in some cases, to uncertainty of who the "polluter" is. The Government has initiated a process to establish a National Radioactive Waste Policy that will probably also address the accountability for the financing of waste disposal.

Decommissioning and waste disposal is currently taking place in the following areas:

i) ongoing radioactive waste from hospitals, general industry and from the Atomic Energy Corporation's own activities is disposed of at Thabana, a low and medium active waste disposal site operated by the Atomic Energy Corporation (AEC) on its Pelindaba site. The financing for this operation is dealt with through the AEC's annual State allocation for operating activities;

ii) low and medium active waste from Koeberg is disposed of in shallow land-fill trenches at Vaalputs, the National Radio-active Waste Disposal facility operated by the AEC and situated about 600 km north of Cape Town. Although the State financed the initial development costs of the site, ESKOM pays for the operational costs;

iii) decommissioning and waste disposal of the AEC's two enrichment plants (the Y and Z plants) are undertaken by the AEC itself and the financing is carried by the State through the AEC's annual State allocation for operational funds;

iv) decommissioning of disused mine equipment (primarily in the gold, copper, phosphate and beach sands operations) are currently undertaken. The mining companies finance the decommissioning costs themselves and subcontract the operations out to specialized agencies such as the AEC or one or two private sector groups. The financing of the final disposal costs of the highly contaminated alpha-bearing waste has not been settled yet as the mining industry has expressed its reluctance to bear such very long term liabilities. This matter will certainly be addressed in the National Radioactive Waste Policy.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related agreement INFCIRC/394 | Entry into force: | 16 September 1991 |
| • Improved procedures for designation of safeguards inspectors | Accepted on | 9 July 1995 |

| | | |
|---|---|---|
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | - |
| • AFRA | Entry into force: | 18 May 1992 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 10 July 1991 |
| • Agreement on privileges and immunities | Entry into force: | Non-Party |
| • Convention on physical protection of nuclear material | Signature: | 18 May 1981 |
| • Convention on early notification of a nuclear accident | Entry into force: | 10 September 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 10 September 1987 |
| • Conventions on civil liability for nuclear damage and joint protocol | | Non-Party |
| • Convention on nuclear safety | Signature: | 20 September 1994 |
| • ZANGGER Committee | | Member |
| • Nuclear Export Guidelines | Not adopted | (observer status in NSG) |
| • Acceptance of NUSS Codes | | No reply |
| • Partial Test-Ban Treaty | Entry into force: | 10 October 1963 |
| • Nuclear Suppliers Group | | Member |
| • African Nuclear-Weapon-Free Zone Treaty. | | |

*BILATERAL AGREEMENTS*

- Agreement between the Government of South Africa and the Government of the USA on Nuclear Co-operation.
- Agreement between the Government of South Africa and the Government of the France on Co-operation on Molecular Laser Isotope Enrichment.

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Atomic Energy Corporation | |
| of South Africa Ltd. | Tel.: +27-12-3164911 |
| Box 582 | Fax: +27-12-3164111;316-5111 |
| Pretoria 0001 | Telex: 322948 SA;322448 SA |
| South Africa | Cable: ISOTOPE PRETORIA |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Council on Nuclear Safety (CNS) | |
| Box 7105 | |
| Hennopsmeer 0046 | Tel.: +27-12 663-5500 |
| South Africa | Fax: +27-12 663-5513 |

| | |
|---|---|
| Nuclear Fuels Corporation | |
| of South Africa Pty.Ltd.(NUFCOR) | |
| Box 61453 | |
| Marshalltown 2107 | |
| South Africa | Tel.: +27-11-8321411 |
| Johannesburg 2001 | Fax: +27-11-8382776 |

*UNDP RESIDENT REPRESENTATIVE*

| | |
|---|---|
| The Resident Representative of the | |
| UNDP in South Africa | |
| Box 6541 | |
| Pretoria 3001 | |
| South Africa | |
| Van der Walt Street | Tel.: +27-12-3204350 |
| Pretoria 0001 | Fax: +27-12-3204353/54 |

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# 1. GENERAL INFORMATION

## 1.1. General Overview

Spain is a constitutional democracy. The Head of State is the King. Executive power is vested in the president of the government. The constitution was adopted in 1987. Spain is situated in south-western Europe, occupying the grater part of the Iberian Peninsula, the Balearic and Canary Islands and a small part of northern Africa (Ceuta and Melilla), and bounded on the north by the Bay of Biscay, France and Andorra; on the east by the Mediterranean Sea; on the south by the Mediterranean Sea and the Atlantic Ocean; and on the west by Portugal and the Atlantic Ocean. The area of Spain is 504,800 $km^2$.

The climate of Spain is marked by extremes of temperature and, generally, insufficient rainfall. The variegated physical features of the country ensure pronounced climatic differences. The climate is most equable along the Cantabric and Atlantic coasts, which are generally damp and mild. The central plateau is dry and hot. Most of Spain receives less than 610 mm of precipitation per year, the northern mountains get considerable more moisture. By contrast, the southern Mediterranean coast has a subtropical climate. Malaga, in the extreme south, has an average winter temperature of 14°C. Average precipitation in Spain is 627 mm..

The historical population data are given in Table 1. The population in Spain estimated for 1994 is 39,143,000, the overall density was about 77 persons per $km^2$. Spain is increasingly urbanising with more than three-fourths of the population in towns and cities. The population growth rate is close to zero, so the population is stabilising.

Spain has traditionally been an agricultural country and is still one of the largest producers of farm commodities in Western Europe, but since the mid-1950s, industrial growth has been rapid. A series of development plans, initiated in 1964, helped the economy to expand, but in the later 1970s an economic slowdown came by rising oil costs and increased imports. In January 1986, Spain became a full member of the European Community.

Spain actually has nine operating nuclear units which represents 7,400 MW gross electric power and produces about 35% of the electricity generation. The reactors are of both types BWR and PWR from different suppliers namely Westinghouse, General Electric and Siemens. The energy policy is outlined in the present National Energy Plan 1991-2000 which does not consider the construction of new nuclear plants. Actually, the main issues in the nuclear field are the exploitation of the nuclear plants and studies on alternatives for high level radioactive wastes disposal.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 30.5 | 33.8 | 37.5 | 39.3 | 39.5 | 39.6 | 0.4 |
| Population density (inhabitants/$km^2$) | 60.3 | 66.9 | 74.4 | 77.8 | 78.3 | 78.4 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.1 |
| Area (1000 $km^2$) | 504.8 |
| Urban population in 1993 as percent of total | 76.0 |

Source: IAEA Energy and Economic Data Bank

### 1.2. Economic Indicators

The Gross Domestic Product (GDP) has been increasing since the early 90's due to an increase in the service sector. In 1991, GDP was 58,852 billion current pts. Table 2 shows the historical GDP statistics in US$.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 37,907 | 214,485 | 491,759 | 478,391 | 482,786 | 6.0 |
| GDP (millions of constant 1990 US$) | 260,429 | 365,993 | 491,759 | 500,931 | 510,840 | 2.4 |
| GDP per capita (current US$/capita) | 1,122 | 5,713 | 12,522 | 12,107 | 12,201 | 5.6 |

| GDP by sector (1992): | |
|---|---|
| Agriculture | 3.8% |
| Industry | 34.0% |
| Services | 62.2% |

Source: IAEA Energy and Economic Data Base

### 1.3. Energy Situation

Spain has some indigenous energy sources (Table 3). The main sources are coal, hydro and uranium. The primary energy consumption raised to 92,463 ktep in 1993. This figure is obtained as the result of adding every non-electric final energy consumption and the energy sector consumptions (self consumption and transformation consumptions) and the energy losses. The final energy demand in the same year was 64,496 ktep and the national primary energy production was 31,162 ktep. Table 4 shows the historical energy statistics from the IAEA Energy and Economic Data Base.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro (2) | Total |
| Total amount in place | 24.58 | 0.11 | 0.67 | 6.23 | 14.49 | 46.08 |

(1) *This total represents essentially recoverable reserves.*

(2) *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.*

Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

The income of electricity companies was regulated by the Royal Decree 1538 of 11.12.87, known as "Marco Legal Estable" (stable frame), which defines the tariff as the price in pesetas per kW·h calculated by dividing the total cost of the electricity sector (estimated by standard cost methodology) by the predicted demand of electric energy. Based on these calculations, the Ministry of Industry and the Government establish the different electricity tariffs depending on the type of application and consumer. This regulation has recently been completed by the Law 40/1994 of 30 December which outlines the National Electricity System and introduces new elements such as the open entrance into the electricity sector, considering two types of establishments, integrated or not integrated into the National System. It pursues the separation between electricity generation and electricity distribution. The new Law establishes an admonishing regime, which contemplates measures related with the nuclear activities. Finally, it also adjusts the amount of the nuclear liability compensation in case of nuclear damage, fixed by the Law 25/1964 of 29 April on Nuclear Energy.

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 0.70 | 1.73 | 3.03 | 3.72 | 3.72 | 4.01 | 7.59 | 2.01 |
| - Solids[2] | 0.35 | 0.47 | 0.56 | 0.85 | 0.80 | 0.79 | 2.38 | 2.52 |
| - Liquids | 0.20 | 1.00 | 2.07 | 1.88 | 1.88 | 2.09 | 12.31 | 0.07 |
| - Gases | | | 0.08 | 0.23 | 0.27 | 0.31 | | 10.15 |
| - Primary electricity[3] | 0.15 | 0.26 | 0.32 | 0.75 | 0.78 | 0.81 | 3.91 | 6.81 |
| Energy production | | | | | | | | |
| - Total | 0.50 | 0.65 | 0.85 | 1.40 | 1.30 | 1.29 | 2.71 | 3.04 |
| - Solids | 0.34 | 0.37 | 0.45 | 0.54 | 0.46 | 0.45 | 1.32 | 0.06 |
| - Liquids | | 0.01 | 0.07 | 0.05 | 0.05 | 0.04 | 17.47 | -3.60 |
| - Gases | | | | 0.06 | 0.03 | 0.01 | | 51.46 |
| - Primary electricity[3]) | 0.15 | 0.28 | 0.33 | 0.75 | 0.77 | 0.79 | 4.07 | 6.33 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.34 | 1.22 | 2.33 | 2.54 | 2.68 | 2.93 | 10.06 | 1.63 |
| - Solids | 0.01 | 0.08 | 0.17 | 0.29 | 0.34 | 0.31 | 16.30 | 4.50 |
| - Liquids | 0.34 | 1.14 | 2.09 | 2.08 | 2.10 | 2.31 | 9.57 | 0.74 |
| - Gases | | | 0.08 | 0.17 | 0.24 | 0.30 | | 10.00 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear − Wind.*
Source: IAEA Energy and Economic Data Base

That new Law also considers the final closing of the nuclear power plants which construction was halted under the moratorium (i.e., the plants Lemoniz I and II, Trillo II and Valdecaballeros I and II) and envisages a system to provide to the owners a compensation.

In order to establish a regulatory mechanism for specific energy activities and for long-term national planning of basic decisions that will affect the energy sector, a National Energy Plan (NEP) is prepared by the Government in a systematic manner and is presented to the Parliament. Last NEP was for the 1991-2000 period. The present NEP does not foresee the construction of new nuclear power plants.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

The electricity supply industry in Spain is highly segmented, since almost 800 companies of various sizes exist. The industry can be divided into the following groups:

i) companies with both power generation and distribution;
ii) ENDESA a state-owned company which is only a generator;
iii) companies which are only distributors (most of them are small distributors);
iv) companies which are self generators;
v) large utilities which control over 95 % of the total.

The large number of companies result from the origin of the electric services which were highly regionalized with independent private suppliers in each geographical area. However, the progressive interconnection of isolated systems, the need to co-ordinate the operation of the company's power plants, an increasingly active role of the public sector and, finally, the great mobility with regard to the companies ownership, rendered the segmentation of the electricity supply industry more apparent than real.

Currently, the electricity sector is concentrated in two main organizations (ENDESA and IBERDROLA) and one smaller group U.E. FENOSA, which control most part of the electricity market through their subsidiaries. The concentration of the electricity supply industry began in the early 90's.

ENDESA, the National Electricity Enterprise, S.A. was established by the Spanish State in 1958 to promote electricity generation in thermal power stations by burning national coal. Progressively ENDESA extended its control over the capital stock of other companies, and has been very active in purchasing shares, both in Spain and abroad. ENDESA controls a large number of main electricity companies as ENHER (91%), GESA (55%), Electra de Viesgo (88%), ERZ (61%), UNELCO (100%), FECSA (49%) and C. SEVILLANA (40%).

IBERDROLA was established in 1991, through a merger between Iberduero and Hidroelectrica Española (which became Iberdrola I and II respectively). This group controls HIDRUYA (55%) and competes with ENDESA for the top position in the electricity sector. U.E.FENOSA is the third group in the electricity sector and is significantly smaller than the two main groups ENDESA and IBERDROLA.

Another party in the electricity sector is REE (Red Electrica de España), which is the company responsible for the management of the system transmission and economic load dispatching. Its share holders are the electricity companies, and its principal owner is the State through ENDESA which controls 57,6 % of the funds. REE is empowered by legislative regulations, to manage the unified operation of interconnected power facilities and integrated in the national system, through the high voltage network. REE was established in 1985 and is in charge of defining the optimal load-flow and planning load dispatching on an almost on-line basis.

The new law 40/1994 of 30 December, outlining the National Electricity System suspends OFICO, which was the office in charge of adjusting the imbalances to the companies as a consequence of the unified tariff system implemented nation-wide in Spain. Its competence's are transferred to a new agency created in this law, the National Electric System Commission.

**2.2. Decision Making Process**

As explained above, the National Energy Plan (NEP) is prepared by the Government in a systematic manner and is presented to the Parliament. The present NEP was prepared for the 1991-2000 period and it does not consider the construction of new nuclear power plants. The NEP can be reconsidered by the Government at any time and it represents the national strategy to be followed in the energy sector.

The main decision makers in the electricity sector are consequently the Government and the Electricity Companies, which must develop their activities under an administrative control regime for certain operations, such as the expansion of their installations and the improvement of the efficiency of the national electricity system.

The Ministry of Industry and Energy and the Nuclear Safety Council are the main government authorities. The Ministry of Industry and Energy mainly defines the global energy policy and in the nuclear field its main tasks and duties are:

- to dictate norms and rules;
- grant licenses for:
    - nuclear & radioactive installations,
    - transport of nuclear materials,
    - nuclear component fabrication,
    - nuclear materials commerce/trading,
    - authority to suspend permits,
    - power to sanction the law transgressions,
    - to impose the risk coverage by nuclear damage,
    - to define the radioactive waste policy.

The Ministry also has the role of controlling strategic institutions and companies, namely the CIEMAT, the Research Centre for Energy and Environment that shares 80 % of ENRESA and 40 % of ENUSA.

The Nuclear Safety Council is the competent Organization in matters of Nuclear Safety and Radiation Protection. The Council is formed by 5 Members which are designated by the Government through a proposal of the Minister of Industry and Energy. They must be accepted by a 3/5 majority of parliament. At present, its Secretariat has about 400 people. It has permanently two inspectors at every NPP site and its main tasks are:

- to issue the perceptive Safety Reports, previous to the authorisation by MINER;
- to carry out all kind of inspections with capability to suspend the activity in case of a risk;
- to propose to the Government norms and rules concerning nuclear safety and radiological protection;
- to propose to MINER sanctions in matters of nuclear safety and radiation protection;
- to grant licenses for operators of nuclear and radioactive installations;
- to inform the public about subjects of its competence;
- to report every six months to the Parliament about its activities.

### 2.3. Main Indicators

The electricity production from natural gas plants has increased while the oil consumption has fallen. In 1993, the primary energy consumption of the electricity sector was 34,413 , which represents 37.2 % of the total primary energy consumption in Spain. Table 5 shows the historical electricity production and installed capacities and Table 6 the energy related ratios.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITIES

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 18.61 | 56.31 | 109.20 | 151.76 | 156.53 | 161.50 | 9.25 | 2.83 |
| - Thermal | 2.99 | 27.61 | 74.49 | 73.68 | 77.15 | 79.52 | 17.44 | 0.47 |
| - Hydro | 15.62 | 27.78 | 29.53 | 26.18 | 25.78 | 29.18 | 3.23 | -0.08 |
| - Nuclear | | 0.92 | 5.19 | 51.90 | 53.60 | 52.80 | | 18.03 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 6.57 | 17.91 | 27.40 | 43.41 | 43.89 | 44.44 | 7.40 | 3.52 |
| - Thermal | 1.97 | 6.88 | 13.48 | 20.08 | 20.36 | 20.85 | 10.10 | 3.16 |
| - Hydro | 4.60 | 10.88 | 12.83 | 16.23 | 16.40 | 16.46 | 5.26 | 1.79 |
| - Nuclear | | 0.15 | 1.09 | 7.11 | 7.11 | 7.11 | | 14.32 |
| - Wind | | | | | 0.03 | 0.03 | | |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Database

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 23 | 51 | 81 | 95 | 94 | 101 |
| Electricity per capita (kW·h/capita) | 606 | 1,547 | 2,732 | 3,667 | 3,808 | 3,946 |
| Electricity production/Energy production (%) | 36 | 79 | 118 | 99 | 111 | 115 |
| Nuclear/Total electricity (%) | | 2 | 5 | 36 | 36 | 34 |
| Ratio of external dependency (%)[(1)] | 49 | 70 | 77 | 68 | 72 | 73 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 32 | 36 | 45 | 40 | 41 | 41 |
| - Thermal | 17 | 46 | 63 | 42 | 43 | 44 |
| - Hydro | 39 | 29 | 26 | 18 | 18 | 20 |
| - Nuclear | | 69 | 54 | 83 | 86 | 85 |

[(1)] *Total net import / Total energy consumption*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

Nuclear Energy in Spain was developed in the early 50's. At that time, the main organization responsible in this field was the Junta de Energia Nuclear, subordinate organization of the Ministry of Industry and Energy, in charge of personnel training, raw materials prosecution, basic scientific research and technology development. In 1964, the law 25/1964 of Nuclear Energy, was enforced, regulating this sector.

In the late 60's, started the construction of the first generation nuclear power plants Jose Cabrera, Santa MarRa de Garona and Vandellos I. These plants enabled to obtain the first experience in order to establish a nuclear programme to cover the growing electricity demand. In the early 70's the construction of the second generation NPPs as Almaraz, Lemoniz, Asco y Cofrentes started.

In 1979, ENUSA (Empresa Nacional del Uranio, S.A.), a state owned company, was established, taking charge of all the front end activities. The Law 15/1980 created the Consejo de Seguridad Nuclear (Nuclear Safety Council), the only organization competent in nuclear safety and radiological protection matters in Spain. In the early 80's, started the construction of the NPPs Valdecaballeros I and II, Vandellos II and Trillo I, NPPs, and preparatory studies for Trillo II were initiated.

In 1984, ENRESA (Empresa Nacional de Residuos Radiactivos, S.A.) was established. The State owned company responsible for the radioactive waste management and the dismantling of nuclear installations in Spain.

### 3.2. Current Policy Issues

The Spanish Energy Policy, that incorporates the Nuclear Policy, is determined in the National Energy Plan (PEN or Plan Energitico Nacional) 1991-2000, which is the latest review. The previous issue, the PEN 1983-1992 determined the moratorium (construction pause) of Lemoniz I and II, Trillo II and Valdecaballeros I and II. The current PEN does not foresees the start up of any new NPP before the year 2000. The Law 40/1994 of National Electric System Outlining (Ley de ordenacion del sistema electrico nacional), established the definitive cessation of the NPPs under moratorium.

### 3.3. Status and Trends of Nuclear Power

Table 7 shows the status of the Spanish NPPs and Figure 1 shows the location of each plant, their owners and shares, the electric power, the type of reactor and the year of connection to the grid.

The Vandellos I NPP is cancelled since 1990, while a plan for its decommissioning and shutdown has been presented to the Administration.

### 3.4. Organizational Chart

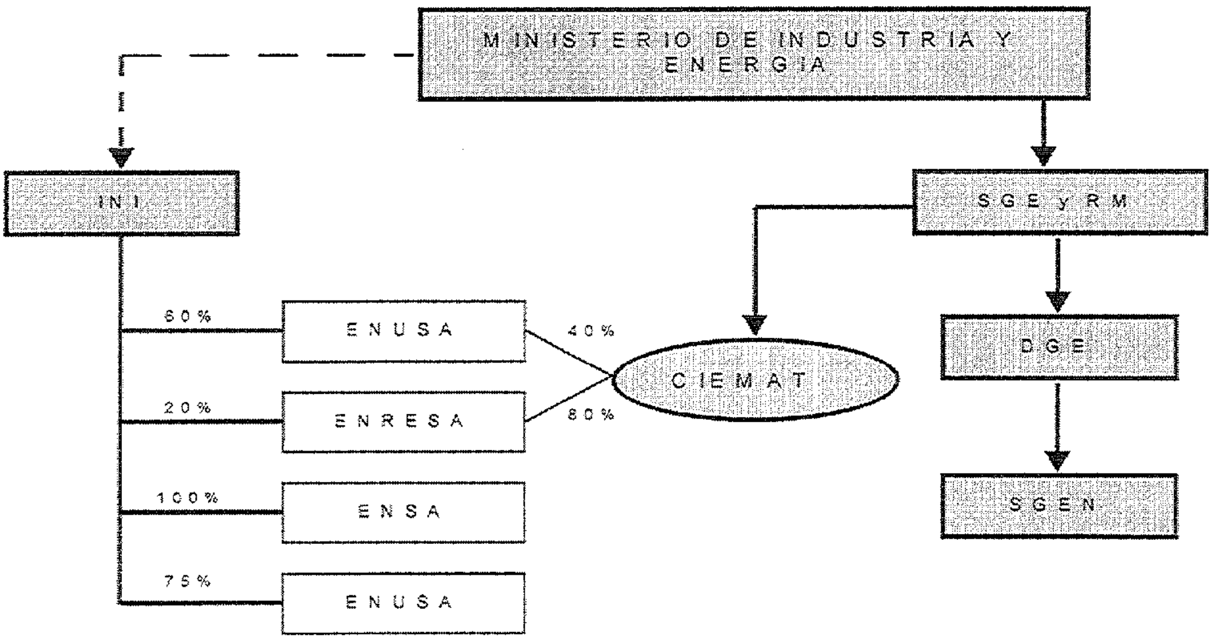
Figure 2 illustrates the licensing process for nuclear installations.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| ALMARAZ-1 | PWR | 900 | CNA | Operational | WEST |
| ALMARAZ-2 | PWR | 900 | CNA | Operational | WEST |
| ASCO-1 | PWR | 917 | ANA | Operational | WEST |
| ASCO-2 | PWR | 936 | ANA | Operational | WEST |
| COFRENTES | BWR | 955 | ID | Operational | GE |
| JOSE CABRERA-1(ZORITA) | PWR | 153 | UF | Operational | WEST |
| SANTA MARIA DE GARONA | BWR | 440 | NUCLENOR | Operational | GE |
| TRILLO-1 | PWR | 1000 | CNT | Operational | KWU |
| VANDELLOS-2 | PWR | 966 | ANV | Operational | WEST |
| VANDELLOS-1 | GCR | 480 | HIFRENSA | Shut Down | CEA |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| ALMARAZ-1 | 01-Jul.-73 | 05-Apr.-81 | 01-May-81 | 01-Sept.-83 | |
| ALMARAZ-2 | 01-Jul.-73 | 19-Sept.-83 | 08-Oct.-83 | 01-Jul.-84 | |
| ASCO-1 | 01-May-74 | 16-Jun.-83 | 13-Aug.-83 | 10-Dec.-84 | |
| ASCO-2 | 01-Mar-75 | 11-Sept.-85 | 23-Oct.-85 | 31-Mar-86 | |
| COFRENTES | 01-Sept.-75 | 23-Aug.-84 | 14-Oct.-84 | 11-Mar-85 | |
| JOSE CABRERA-1(ZORITA) | 01-Jun.-64 | 30-Jun.-68 | 14-Jul.-68 | 13-Aug.-69 | |
| SANTA MARIA DE GARONA | 01-May-66 | 05-Nov.-70 | 02-Mar-71 | 11-May-71 | |
| TRILLO-1 | 01-Sept.-79 | 14-May-88 | 23-May-88 | 06-Aug.-88 | |
| VANDELLOS-2 | 01-Jun.-81 | 14-Nov.-87 | 12-Dec.-87 | 08-Mar-88 | |
| VANDELLOS-1 | 01-Jun.-68 | 11-Feb.-72 | 06-May-72 | 01-Jul.-72 | 31-Jul.-90 |

Source: IAEA Power Reactor Information System, year end 1996




ENDESA: Produces 40% of total electricity and has 3300 MWe of nuclear power i.e. 45.3% of total installed nuclear power
ENUSA: Responsible for front end of nuclear fuel cycle: mining and milling, Quercus facility; supply of conversion and enrichment services; fuel fabrication: Uzbado facility
ENRESA: Responsible for back end of nuclear fuel cycle; decommissioning LLW & MLW storage (El Cabril facility)
ENSA: Heavy equipment (NSSS) manufacturer (Maliano facility)
SGE y RM: Secretaria General de la Energia y Recursos Minerales
DGE: Direccion General de la Energia
SGEN: Subdireccion General de la Energia Nuclear

*FIG. 1. Administrative Arrangements*

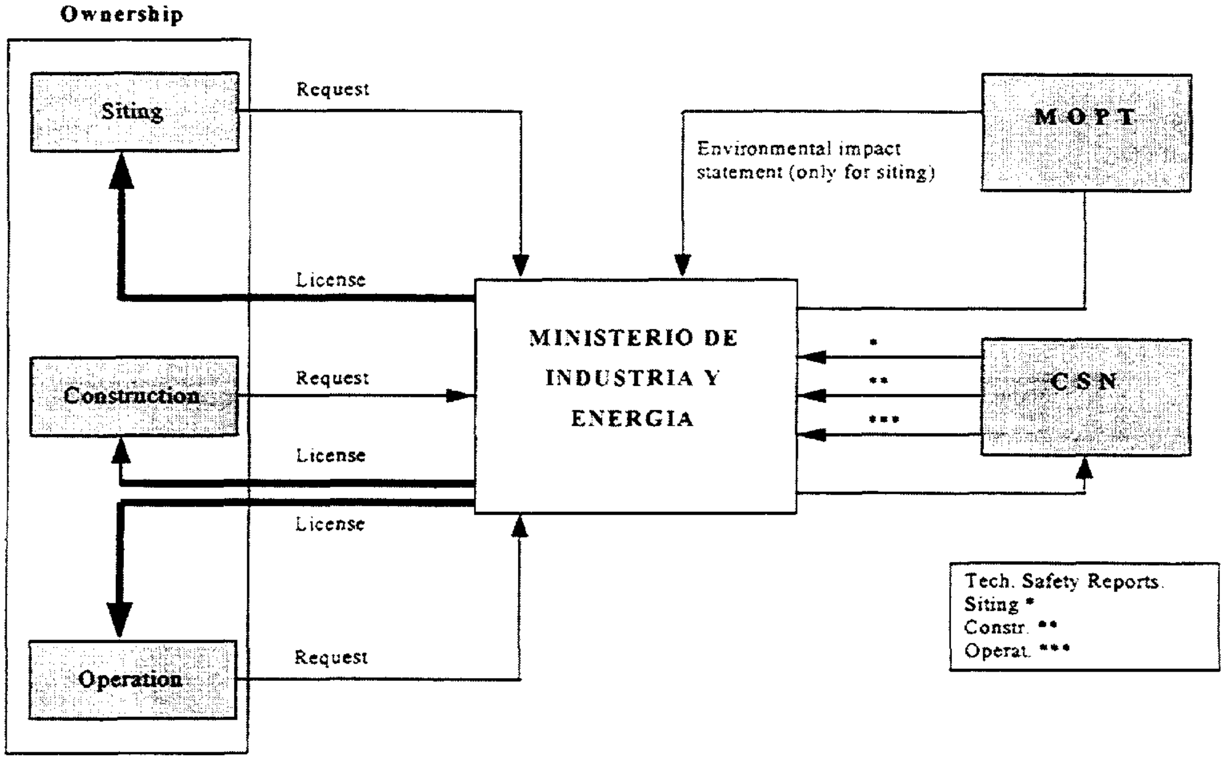



*FIG. 2. Licensing of NPP*

## 4. NUCLEAR INDUSTRY

### 4.1. Supply of NPPs

*Architect Engineers*

The Spanish Engineering Companies which play the main role in the National Nuclear Sector are Empresarios Agrupados, Initec, Inypsa and Sener.

These companies have collaborated solely or in consortium with others in launching the first generation NPPs and in successive projects, increasing progressively the nuclear installed capacity. The first NPPs were carried out as turn-key projects and only in the following projects were local engineering companies involved. The scope of each project has been different, having the engineering companies focus on different activities such as design, licensing, procurement operations and collaboration in start-up and in tests. Actually, as there are no NPPs under construction, these companies have concentrated on operational support, shutdown and decommissioning of NPPs, research and development and radioactive waste engineering activities.

*NSS Manufacturers*

The main Spanish NSS manufacturer is ENSA (Equipos Nucleares, S.A.), which designs, produces and inspects NPPs primary circuit equipment and components. Its manufacturing plant is located in Maliano (Cantabria). This company is State owned through the National Industry Institute (INI), who controls 100% of its shares.

ENSA has provide primary circuit equipments as steam generators, reactor vessels, etc. and components to the second and third generation Spanish NPPs and has export to several countries as: Germany, Argentina, United Kingdom, India, United States of America, Belgium and others.

*Other Main Components Suppliers*

Last NPPs built in Spain enclosed a large range of equipments and components of national made.

The following list of national manufacturers aims to be useful, and includes only the main companies.

| | |
|---|---|
| Turbines: | E.N.Bazan |
| Pumps: | Ingersoll-Rand, Sulzer, Neyrpic. |
| Air compressor: | ABC, Betico. |
| Valves: | Walthom Weir Pacific, Poyam. |
| Electric equipments: | Asea Brown Boveri (ABB), Merlin-Gerin, Pirelli. |
| Instrumentation & Control: | Abengoa, CAE. |
| Air conditioning: | Sulzer. |

### 4.2. Operation of NPPs

*Owners/Operators*

Table 7 included in section 3.3 shows the ownership of each NPP.

*Operation Service Suppliers*

There are several companies who offer operational services in the Nuclear sector, as TECNATOM, TECNOS, LAINSA, ENWESA and NUSIM. TECNATOM provides training services to operational personnel of NPPs. It has PWR and BWR simulators. TECNATOM has also carried out several in service inspection and maintenance activities giving support to the Spanish NPPs. TECNOS, LAINSA, ENWESA and NUSIM are focusing on maintenance and operational support to NPPs, quality assurance, radiological protection and various activities.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management Service Supply

ENUSA (Empresa Nacional del Uranio), the State owned company, is responsible for the front-end fuel cycle activities in Spain. Its main duties are:

- Prosecution, research and exploitation of radioactive mineral mines, comprising the mineral treatment to obtain concentrates.
- Conversion of uranium concentrates to uranium hexafluoride.
- Uranium enrichment.
- Nuclear fuel elements manufacturing.

These duties can be carried out by ENUSA it self or by a subcontracted company. ENUSA operates a mine and a milling plant (Quercus Plant) located in Saelices el Chico (Salamanca) and also it has a nuclear fuel manufacturing Plant located in Juzbado (Salamanca).

The uranium concentrates from ENUSA comes from its own production from Quercus Plant and from COMINAK, a company from Niger, owned by several foreign companies including ENUSA which holds 10% of its shares. The rest of its uranium concentrates demand comes from several foreign companies. There are no uranium conversion and enrichment plants in Spain. ENUSA has signed several contracts with companies abroad for uranium conversion and enrichment activities.

The Juzbado plant produces fuel elements for most PWRs and BWRs in Spain and for some reactors in Sweden, Germany and France.

ENRESA (Empresa Nacional de Residuos Radiactivos), the State owned company, was set up in 1984 and is in charge of the radioactive waste management activities and the dismantling of nuclear installations. Its duties are as follows:

- Radioactive waste treatment and conditioning.
- Searching for locations, design, construction and operation of interim and final storage centres for high, medium and low level radioactive wastes.
- Management of the different operations related to the decommissioning of nuclear and radioactive installations.
- To establish systems for collecting, transferring and transporting radioactive wastes.
- To give support to civil protection services in case of nuclear emergencies.
- Final and safe conditioning of wastes derived from the mining and milling processes.
- Assuring of the long-term management of every radioactive waste storage facility.
- To carry out the appropriate technical and economic studies, considering the deferred costs and to outline the proper economic policy.

ENRESA has a medium and low level radioactive waste storage installation located in El Cabril, Cordoba. ENRESA main tasks, that presently are carried out, are as follows:

- Shut down and decommissioning of Vandellos NPP Unit-I.
- Different activities concerning the exploration of locations for high radioactive waste storage facilities.
- Processing radioactive lighting tubes .
- Research and Development activities.
- International relation tasks.

### 4.4. Research and Development Activities

CIEMAT (Centro de Investigaciones Madioambientales y Tecnologicas), is an institution under on the Ministry of Industry and Energy. One of its duties is nuclear research. It collaborates with several institutions in Spain and abroad.

CSN (Consejo de Seguridad Nuclear). This organizationis the only competent organization in nuclear safety and radiological protection subjects. It handles several research programmes related with its competence, according with its duties, which have been defined by law. It collaborates with other private and public organizations in Spain and abroad.

UNESA (Unidad Electrica, S.A.), Association which comprises the main electric companies. Its main purpose is to co-ordinate some of the activities of the electric companies. It carries out the research and development actions foreseen in the R + D Electrotechnics plan.

Apart from the above mentioned organizations, other institutions as Universities and Enterprises are carrying out several research and development programmes in the nuclear field.

### 4.5. International Co-operation in the field of Nuclear Power Development and Implementation

Spain, as member of the European Union, carries out most of its international activities within that framework. There are several non-profit associations that can promote technology exchanges and co-operation. The main associations are as follows:

- Sociedad Nuclear Española (Spanish Nuclear Society), established in 1974, was founded by relevant persons related to the nuclear sector. It accomplishes several activities such as congresses, round tables, seminars, etc. It issues a monthly publication and it is member of the European Nuclear Society.

- Sociedad Española de Proteccion Radiologica (Spanish Society for Radiological Protection), established in 1980. It includes persons and agencies that are involved in the radiological protection field. It is a partner of the International Radiological Protection Association.
- Asociacion Española para la Calidad (Quality Assurance Association). Established in 1961 under the name "Asociacion Española para el Control de Calidad". It has a section specialising in Energy Industry.
- Forum Atomico España (Spanish Atomic Forum), founded in 1962. It is an institution whose members are industries and agencies interested in nuclear energy. It encourages information exchange activities and organises courses, mainly in nuclear safety, economics and training aspects. It is associated with analogue foreign institutions in FORATOM.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authority and Licensing Process

The nuclear installation licensing procedure in Spain is regulated by the Law 25/1964 of Nuclear Energy and by the nuclear and radioactive installations regulation that proceeded the law. To license these types of installations, the following successive authorisation is needed:

- *Siting authorisation:* it is a formal acknowledge of the purpose and the location submitted.
- *Construction authorisation:* it permits to start up the construction of the installation.
- *Operation authorisation:* two different types of licenses have been envisaged:

    i. provisional operation permission, that authorises to carry out all the pertinent nuclear tests and final verifications;
    ii. definitive operation permission which is the permanent authorisation.

These authorizations and permissions are granted by the Ministry of Industry and Energy, under previous and perceptive counsel referring to nuclear safety and radiological protection issued by the Nuclear Safety Council. This report is liable in case of authorisation denying, as same as its requirements if there exist. Before granting a construction authorisation, the project must de submitted for an environmental appraisal to the General Directorate of Environment. As a consequence of this analysis, the project can be yield to certain requirements.

To obtain theses authorizations and permissions, the documents determined in the current regulations must be provided and the suitable tests, analyses and validations must be performed.

Before the final granting of theses authorizations, the favourable advice from some organizations linked with the administration is also needed, apart of the preceding requirements.

Before granting the siting authorisation, a 30 days period is established for public information of the project. Before granting the construction authorisation, the environmental appraisal is also submitted for a 30 day period for public information. During theses periods anyone can present his allegations.

### 5.2. Main Laws and Regulations

The Law 25/1964 of Nuclear Energy (Ley 25/1964 sobre Energia Nuclear de 29 de abril) and Law 25/1968 amending the 9 and 16 articles, symbolises the first step in Spanish nuclear regulation. This law has been developed by the royal decree 2869/1972 for Nuclear and Radioactive installations regulation and by the royal decree 53/1992 which formulates the regulation of Sanitary Protection against ionised radiations.

The nuclear fuel cycle is mainly regulated by the following royal decrees: R.D. 3322/1971 creating ENUSA; R.D. 29671/1979 regulates the nuclear fuel cycle activities, modified by various decrees in 1983, 84, 85 and 88; and finally the R.D. 1522/1984 creating ENRESA.

The Law 15/1980 founds the Consejo de Seguridad Nuclear (Nuclear Safety Council) and the Royal Decree 1157/1982 approves the statute of this organization. The Law 40/1994 of National Electric System Outlining (Ley de ordenacion del sistema electrico nacional) amends certain points of both above referred laws and order various themes related with the Nuclear sector. Finally, in 1995 a decree of physical protection against nuclear materials has been approved.

Regarding the financing of radioactive waste management costs, a system of payment on account has been established. That system settled in the Ministerial Order of 12 May 1983, arranges that ENRESA will set aside a provision to cover the total cost of the back-end of the nuclear fuel cycle. These funds are collected from the electricity generating sector as a quota applied to the electric tariff, which is revised periodically.

Considering the nuclear liability, Spain has joined the Paris and Brussels Supplementary Convention. The ratifying documents were published in the B.O.E. in 1.11.88 and 26.10.91. The new Law 40/1994 of 30 December, for the National Electricity System outlining, includes a chapter which modifies the Law 25/1964 of Nuclear Energy updating the warranties established in the case of a nuclear accident. It fixes the maximum compensation of 25,000 million pesetas to nuclear installations, while the Ministry of Industry and Energy is entitled to reduce it for certain activities such as transport of nuclear materials but not below 1,000 million pesetas. These amounts could be updated in the future by the Government.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • NPT related safeguards agreement INFCIRC/193 | Accession: | 5 April 1989 |
| • Improved procedures for designation of safeguards inspectors | Rejected but as EC member agreed to special procedure. | |
| • Project related safeguards agreement INFCIRC/99 | Entry into force: | 23 June 1967 |
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 10 June 1980 |

*OTHER RELEVANT INTERNATIONAL TREATIES*

| | | |
|---|---|---|
| • NPT | Entry into force: | 5 November 1987 |
| • EURATOM | Member | |
| • Agreement on privileges and immunities | Entry into force: | 21 May 1984 |
| • Convention on physical protection of nuclear material | Entry into force: | 6 October 1991 |
| • Convention on early notification of a nuclear accident | Entry into force: | 14 October 1989 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 14 October 1989 |

| | | |
|---|---|---|
| • Conventions on civil liability for vienna convention nuclear damage and joint protocol | Signature of<br>Signature: | 6 September 1963<br>21 September 1988 |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • ZANGGER Committee | Non-Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | Summary of reply: Codes consistent with Spanish standards. | |
| • Nuclear Suppliers Group | Member | |

*MULTILATERAL AGREEMENTS*

Regarding multilateral agreements, Spain is member of Euratom since it adherence to the European Union in 12 of June of 1985.

*BILATERAL AGREEMENTS*

Spain has several bilateral agreements in relation to the nuclear field:

- Agreement of 19 January 1972 with Chile for pacific uses of nuclear energy. (BOE 23.2.72)
- Agreement with Portugal, for nuclear energy Co-operation for pacific uses. (BOE 20.6.73)
- Agreement of 20 March 1974 with U.S.A. for Nuclear energy civil uses. (BOE 14.10.74)
- Agreement with Perd, for nuclear energy Co-operation for pacific uses. (BOE 15.10.76)
- Agreement of 10 May 1977, ratified on 22 November, with Ecuador for Atomic energy development and exploitation in pacific uses. (BOE 20.3.78)
- Agreement of 18 November 1978, with Mexico for Nuclear energy Co-operation in pacific uses. (BOE 20.3.79)
- Agreement of 30 November 1978, with Argentina for Atomic energy development and exploitation in pacific uses. (BOE 3.3.79)
- Agreement of 5 December 1978 with Federal Republic of Germany for Nuclear energy Co-operation for pacific uses. (BOE 25.1.79).
- Agreement of 2 February 1979, with Venezuela for Nuclear energy research Co-operation in pacific uses. (BOE 16.1.84)
- Agreement with Uruguay, for nuclear energy Co-operation for pacific uses. (BOE 3.8.79)
- Agreement of December 1980, with Colombia, for nuclear energy Co-operation for pacific uses. Not ratified.
- Agreement of 12 May 1983, with Brazil, for nuclear energy Co-operation for pacific uses. Not ratified.

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[2] Informe al congreso de los diputados sobre las actuaciones energiticas en 1992, Ministerio de Industria y Energia.

[3] Informe sobre la explotacion del sistema electrico nacional 1993, Ministerio de Industria y Energia.

[4] Informe sobre la explotacion del sistema electrico nacional 1992, Ministerio de Industria y Energia.

[5] Memoria Estadistica Electrica. UNESA, (1993).

[6] Nuclear Engineering International. World Nuclear Industry handbook, (1994).

[7] National Energy Plan. 1991-2000, Ministerio de Industria, Comercio y Turismo.

[8] Anuario del Instituto Nacional de Estadistica, INE, (1993).

[9] Fourth General Radioactive Waste Plan, Ministerio de Industria y Energia, (December 1994).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Ministerio de Industria y Energia<br>Paseo de la Castellana 160<br>E-28046 Madrid | Tel: 34 1 3494571<br>Fax: 34 1 4586109<br>Telex:MISC-E 42112 |
| Consejo de Seguridad Nuclear (CSN)<br>Nuclear safety and radiological protection<br>Coeusto Dorado 11<br>E-28040 Madrid | Tel: 34 1 3460336<br>Fax: 34 1 3460575<br>Telex: 45869 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| CIEMAT<br>Research and development centre<br>Avenida de la Complutense, 22,<br>Madrid | Tel.: +34-1-3466000<br>Fax: +34-1-3466005 |
| UNESA<br>Representing the electricity sector<br>Francisco Gervas 3<br>28020 Madrid | Tel.: +34-1-5704400<br>Fax: +34-1-5704972 |
| TECNATOM, S.A.<br>Service inspection and maintenance<br>Km.19 C.N. I Madrid-Irdn<br>28709 SAN SEBASTIAN DE LOS REYES (Madrid) | Tel.: +34-1-6516700<br>Fax: +34-1-6541531 |
| EMPRESARIOS AGRUPADOS A.I.E.<br>Architect-Engineering<br>Magallanes, 3<br>28015 Madrid | Tel.: +34-1-4456000<br>Fax: +34-1-4450113 |
| ENRESA<br>Back-end of the fuel cycle<br>Emilio Vargas, 7<br>28043 Madrid | Tel.: +34-1-5195255<br>Fax: +34-1-4135439 |
| ENUSA<br>Front-end of the fuel cycle<br>Santiago Rusinol, 12, Madrid | Tel.: +34-1-3474200<br>Fax: +34-1-3474215 |

# SWEDEN

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SWEDEN

# 1. GENERAL INFORMATION

## 1.1. General Overview

Sweden is a long narrow country in the northern part of Europe and borders Norway in the west, Finland in the north east and the Baltic Sea in the South and east.. The total length from north to south is 1,600 kilometres and the land area is 411,000 square kilometres. The size of the area is the third in Western Europe after France and Spain. The area is almost twice as big as that of Great Britain. The north-west part of Sweden consist of mountains with a slope towards the east. There are many rivers in the north and lakes are scattered all over the country. Sweden's coast line is more than 2,000 kilometres long.

The northern boundary is about 250 kilometres north of the polar circle, but because of the Gulf Stream coming from west, the climate is not of a polar type. The average temperature over the year varies between -1.5 °C in the north to 7.8 °C in the south .

The historical population data in Table 1 show a very slow increase of the population. In 1995, Sweden had 8.8 million inhabitants. The population density is 21.4 persons per square kilometres, however, the northern part of Sweden is sparsely populated with only 20% of the inhabitants living in the northern half of the country.

There are no other domestic energy sources except hydro and bioenergy (used mainly in the pulp and paper industry) exploited. There are, however large amounts of low grade uranium - 10,000 metric tonnes of uranium in ores containing between 500 and 2,000 grams uranium per tonne and 300,000 metric tonnes of uranium in still lower grades. There is no economic incitement to exploit such low grade uranium ores and no uranium mines are in use. Fuel for the nuclear power plants is imported.

The large production of hydro power is located in the north, but the electricity is transported to the south by several large 400 kV lines. All the nuclear power plants are in the southern part of Sweden. Because of the abundance of rivers and lakes, all thermal power plants (nuclear or fossil) are cooled by water and cooling towers at power plants can not be found in Sweden.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 7.5 | 8.0 | 8.3 | 8.6 | 8.7 | 8.7 | 0.4 |
| Population density (inhabitants/km²) | 16.6 | 17.9 | 18.5 | 19.0 | 19.3 | 19.4 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.5 |
| Area (1000 km²) | 450.0 |
| Urban population in 1993 as percent of total | 83.0 |

Source: IAEA Energy and Economic Data Base

## 1.2. Economic indicators

Table 2 shows the historical Gross Domestic Product (GDP) data.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 33,671 | 125,545 | 229,748 | 186,227 | 196,121 | 3.2 |
| GDP (millions of constant 1990 US$) | 155,981 | 189,312 | 229,748 | 216,634 | 221,336 | 1.1 |
| GDP per capita (current US$/capita) | 4,186 | 15,108 | 26,843 | 21,420 | 22,445 | 2.9 |

| GDP by sector : | |
|---|---|
| Agriculture | 3% |
| Industry | 34% |
| Services | 63% |

Source: IAEA Energy and Economic Data Base

### 1.3. Energy situation

Table 3 shows the Swedish energy resources and Table 4 the historical energy data.

TABLE 3. ENERGY RESOURCES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium (1) | Hydro (2) | Total |
| Total amount in place | 0.02 | | | 0.70 | 12.53 | 13.26 |

*(1) This total represents essentially recoverable reserves.*
*(2) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1992) by a factor of 10.*
Source: IAEA Energy and Economic Data Base

### 1.4. Energy policy

Since the 1970s, there has been a general policy to increase the energy efficiency and to decrease the use of oil. Since the end of the 1980s there is also a general policy not to increase the releases of carbon dioxide and in a longer perspective to decrease the use of fossil fuel. The use of more domestic energy sources as bioenergy and wind is preferred of environmental reasons. The total energy consumption has been rather stable around 375 TW·h per year in spite of an increase in industrial production with 20%, an increase of heated areas with 30% and an increase of personal transports with 30% (although goods transports has decreased with 15%).

The energy conservation programme has been rather successful especially in the domestic area. But the cheapest methods for energy conservation have resulted in less ventilation of the houses with worse indoor environment as a secondary effect. The radon content in Swedish dwellings has probably doubled because of the energy conservation measures. Since 1970 the importance of oil in the total energy balance has decreased from 78% to 45% and the consumption of electricity has doubled from about 70 TW·h to 140 TW·h per year. The use of bioenergy and wind for power production is still negligible but the pulp and paper industry uses about 60 TW·h bioenergy (most of it as heat) produced from lingnine, a component of the wood. It is possible to increase the hydro power capacity on an economical scale with about 15 TW·h per year, but the policy (since 1970) is to save the remaining rivers from exploitation of environmental reasons.

In 1980 Parliament decided after a referendum to phase out nuclear power by year 2010. No nuclear power plant has yet been closed but since 1994 there has been a vivid political debate about the future of nuclear power. In 1997 a new decision about the nuclear power policy is expected in Parliament.

In principle the energy market is free but in practice it is regulated as in all countries by means of environmental rules, environmental taxes and energy taxes. The partial monopoly situation in the power market has been changed.

TABLE 4. BASIC ENERGY SITUATION

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 0.94 | 1.87 | 1.91 | 2.15 | 2.14 | 2.14 | 3.63 | 0.83 |
| - Solids[2] | 0.11 | 0.22 | 0.14 | 0.22 | 0.24 | 0.24 | 1.05 | 3.87 |
| - Liquids | 0.53 | 1.21 | 0.94 | 0.58 | 0.58 | 0.62 | 2.91 | -2.90 |
| - Gases | | | | 0.02 | 0.03 | 0.03 | | |
| - Primary electricity[3] | 0.29 | 0.44 | 0.83 | 1.32 | 1.29 | 1.25 | 5.34 | 3.00 |
| Energy production | | | | | | | | |
| - Total | 0.31 | 0.54 | 0.89 | 1.45 | 1.43 | 1.38 | 5.42 | 3.17 |
| - Solids | 0.01 | 0.14 | 0.07 | 0.12 | 0.13 | 0.13 | 12.28 | 4.74 |
| - Liquids | | | | | | | -6.79 | -10.86 |
| - Gases | | | | | | | | |
| - Primary electricity[3]) | 0.30 | 0.40 | 0.82 | 1.33 | 1.29 | 1.25 | 5.18 | 3.03 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.65 | 1.36 | 1.16 | 0.74 | 0.76 | 0.85 | 2.90 | -2.22 |
| - Solids | 0.10 | 0.07 | 0.07 | 0.10 | 0.09 | 0.10 | -1.74 | 2.93 |
| - Liquids | 0.55 | 1.28 | 1.09 | 0.62 | 0.64 | 0.71 | 3.43 | -2.99 |
| - Gases | | | | 0.02 | 0.03 | 0.03 | | |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[2] *Solid fuels include coal, lignite and commercial wood.*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the electricity sector

Electricity production started early in Sweden. The first generating plants based on hydro power were established in the 1880s. They were small and intended to supply power to industries and communities in the close vicinity. Hundreds of small hydroelectric power stations were constructed. As the technique of transferring power over longer distances developed, it became possible to exploit the larger rivers for distribution of power to the south of the country.

The power consumption is about 140 TW·h per year, or about 16,000 kW·h per person. The consumption level has been rather stable since the beginning of the 1990s and it is expected to grow slowly (less than 1% per year) up to year 2005. A normal year more than 50% of the power is produced by nuclear and almost 50% by hydro. Only about 5% of the power is produced by fossil, mainly in plants for combined production of electricity and hot water for district heating.

Many of the companies, which today are responsible for the power supply, were formed at this time. The Government became engaged in the production and distribution of power at this stage. In 1906 Parliament granted funds for the first state owned hydro power project and in 1909 the State Power Board (now Vattenfall AB) was formed. Since that time, the production of power has been divided practically equal between, on the one hand, the Government through the State Power Board and, on the other hand, power companies owned by industries, municipalities and other non-governmental bodies.

Because of the long distance between the large rivers in the north and the population centres in the south, efficient high voltage lines were earlier needed in Sweden than in other countries. The world's first 400 kV line was built in Sweden. The 1000 kilometres long line was put into operation in 1952. Almost all 220 kV and 400 kV trunk lines are since 1990 owned by the state through Svenska Kraftnät (Swedish National Grid). Before 1990 the national grid was owned by Vattenfall AB.

Today about 95% of the electricity supply is covered by 9 utilities. Because of historical reasons, the country is divided in regions with normally just one utility serving that region. The state owned Vattenfall AB is the largest one with about half of the production, while the remaining utilities are companies owned by shareholders or by municipalities. The second largest utility is Sydkraft AB with most of the shares owned by municipalities in south of Sweden. The Sydkraft shares can be bought on the stock exchange. Another power company with shares on the stock exchange is Gullspång, which is of about the same size as Stockholm Energi, wholly owned by the City of Stockholm.

There is no monopoly in Sweden when it comes to production of electricity. It has been, and is possible in principle, for anybody to decide to build a power production facility. Since long ago there is a competition between the utilities for the delivery of electricity to large high voltage consumers (industries, cities, etc.).

Between the main power utilities there exists since a long time ago a close co-operation, in jointly owned hydro power plants and in the regulation of the rivers, as well as in jointly owned nuclear power plants and in the joint utilisation of the national grid.. There is also an effective system for exchanging temporary power, in order to optimise in every moment the utilisation of the total production system.

The co-operation between the utilities have, since several decades, been enlarged to embrace also the neighbouring countries, thanks to the strong interconnection high voltage lines which now exists between the Nordic countries. This gives possibility for an optimisation of the entire Nordic power system.

Almost all large producers, except some industries producing their own power, are distributors on the low voltage grids. But most of the distribution to about 5.6 million detail consumers is handled by independent distribution companies, in most cases without or with small production resources. There are now almost 300 distributing companies. Most of them are owned by municipalities but the ownership is changing rapidly and the amount of distribution companies is decreasing. When it comes to the distribution of power there is a system of concessions and a monopoly situation within each region. In a bill to Parliament a new system has been proposed, which will allow a larger degree of competition with the monopoly situation changed to a more open competitive market. In the new system the holder of a regional or local network concession have to allow, on reasonable terms, current to be fed into and taken out of his network, regardless of who the power producer is.

There has been a discussion of arranging a national power exchange. One disadvantage is that Vattenfall AB would be dominating on such a market place. Therefore the plans are now focusing on arranging a Nordic power exchange with as a start (during 1996) utilities in Norway and Sweden being partners. After a year, the Finnish utilities have planned to join and later on perhaps also Denmark.

## 2.2. Decision making process

The total installed capacity for power production is 34,000 MW and the power production is about 140,000 GW·h per year. A normal year more than 50% of the power is produced by nuclear and almost 50% by hydro. Only about 5% of the power is produced by fossil, mainly in plants for combined production of electricity and hot water for district heating.

Half of the electricity is produced by Vattenfall AB, a state owned company and the other half by more than 30 non - state owned utilities. Only six of these have an installed power production capacity over 500 MW. The nine largest utilities, including Vattenfall, produce 95% of the power. The Swedish Power Association with almost all power producers as members has published the a list of power production resources within the member companies, see Table 5.

TABLE 5. INSTALLED POWER PRODUCTION RESOURCES (MW) IN 1994 FOR MEMBERS OF THE SWEDISH POWER ASSOCIATION

| | Hydro power | Nuclear power | Other thermal power | Total |
|---|---|---|---|---|
| Vattenfall AB | 8,891 | 5,846 | 2,592 | 17,333 |
| Sydkraft AB | 2,356 | 2,502 | 1,775 | 6,633 |
| Stockholm Energi AB* | 894 | 607 | 875 | 2,377 |
| Gullspångs Kraft AB | 1,111 | 581 | 312 | 2,003 |
| Stora Kraft AB | 956 | 277 | 286 | 1,519 |
| Skellefteå Kraft* | 498 | 48 | 3 | 550 |
| AB Skandinaviska Elverk | 307 | 111 | 123 | 540 |
| Graninge | 502 | | 17 | 519 |
| MoDo Kraft | 252 | | | 252 |
| Västerås Kraft&Energi AB* | 45 | | 190 | 235 |
| Jämtkraft AB* | 197 | | | 197 |
| Tekniska Verken i Linköping AB* | 16 | | 149 | 166 |
| Karlstads kommun, Energiverken* | 24 | 74 | 64 | 162 |
| Umeå Energi AB* | 150 | | | 150 |
| Norrköping Energi AB* | 12 | | 106 | 118 |
| Other member companies | 67 | | 134 | 202 |
| Total | 16,279 | 10,045 | 6,626 | 32,955 |

* Owned to 100% by a municipality

Vattenfall AB was turned into a limited liability company in 1991, but is still fully owned by the State. Power is transmitted on the national grid, which operates at the voltage levels of 400 kV and 220 kV. The national grid is operated by a state owned monopoly organization, Svenska Kraftnät.

The networks using lower voltages, which transmit and distribute the power from the national grid to the customer, are owned by regional (40 - 130 kV) and local ( 40 kV) power companies. Power is produced in free competition, the regional distribution to large customers is almost a free market, but the detail distribution to about 5,000,000 customers is controlled by local monopolies based on line or area concessions. There is no central planning of the power production system or of the future development of the regional and local electric lines.

According to the new act proposed to be valid from January 1, 1996, there will in the future be no area concessions and therefore no local monopolies. The regional and local lines will be owned by companies with a line concession and with an obligation to transport power to its customers from any power producers selected in a free competition by the customer.

A new official regulator, the electricity market division of the Swedish National Board for Industrial and Technical Development (NUTEK) has started to work. It shall grant net concessions and supervise the net operators with regard to price, conditions and quality of service.

### 2.3. Main Indicators

Table 6 shows the historical electricity production data and the installed capacities and Table 7 the energy related ratios.

TABLE 6. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 34.74 | 60.65 | 96.32 | 146.45 | 144.31 | 142.89 | 5.23 | 2.86 |
| - Thermal | 3.65 | 19.05 | 10.96 | 8.11 | 9.98 | 13.25 | 5.65 | 1.36 |
| - Hydro | 31.09 | 41.54 | 58.87 | 73.03 | 75.38 | 59.37 | 3.24 | 0.06 |
| - Nuclear | | 0.06 | 26.49 | 65.30 | 58.90 | 70.20 | | 7.21 |
| - Geothermal | | | | | | | | |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | | 15.31 | 27.42 | 34.19 | 37.18 | 35.89 | | 1.94 |
| - Thermal | | 4.44 | 7.95 | 7.85 | 8.72 | 8.64 | | 0.60 |
| - Hydro | | 10.86 | 14.86 | 16.33 | 18.43 | 17.23 | | 1.06 |
| - Nuclear | | 0.01 | 4.61 | 10.00 | 10.00 | 10.00 | | 5.69 |
| - Geothermal | | | | | | | | |
| - Wind | | | | 0.01 | 0.03 | 0.02 | | |

[1] *Electricity losses are not deducted*
Source: IAEA Energy and Economic Data Base

TABLE 7. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 125 | 232 | 230 | 251 | 246 | 245 |
| Electricity per capita (kW·h/capita) | 4,542 | 7,849 | 11,328 | 16,432 | 16,130 | 15,907 |
| Electricity production/Energy production (%) | 108 | 105 | 101 | 95 | 95 | 97 |
| Nuclear/Total electricity (%) | | | 28 | 46 | 42 | 51 |
| Ratio of external dependency (%)[1] | 70 | 73 | 61 | 35 | 36 | 39 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | | 45 | 40 | 49 | 44 | 45 |
| - Thermal | | 49 | 16 | 12 | 13 | 18 |
| - Hydro | | 44 | 45 | 51 | 47 | 39 |
| - Nuclear | | 64 | 66 | 75 | 67 | 80 |

[1] *Total net import / Total energy consumption.*
Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical development

The first interest in "atomic energy" from the Government was shown in 1947, when AB Atomenergi was constituted as a research organization. Up to 1955, the programme was orientated towards basic research and concentrated on a small natural uranium/heavy water reactor.

In 1956, an official ad hoc commission proposed a forceful R&D programme with the purpose to introduce a national programme for reactors based on natural uranium and heavy water for production of heat and electricity. AB Atomenergi was proposed to be responsible for the programme. It was known that Sweden had large resources of low grade uranium ore and the idea was to establish an energy policy almost completely independent of other countries.

In 1958, AB Atomenergi moved most of its activities to a newly established national laboratory, Studsvik. A material testing reactor R2 started operation in 1960 and is still in operation (now 50 MW thermal).

Vattenfall, at that time closely connected to the Government, and AB Atomenergi, also State owned, decided in 1957 to build a small reactor for production of heat and electricity. The name was Ågesta and it started in 1964 to produce 65 MW(th). 55 MW was used for heating a suburban of Stockholm and 10 MW for electricity production. The reactor was shutoff in 1974.

Construction of a heavy water power reactor, Marviken and based on slightly enriched uranium with a possibility to change to natural uranium, with an electric output of 140 MW commenced in 1963. The project was stopped in 1970 only a few months before the fuel loading and the reactor has never been used for power production. The project was performed in co-operation between AB Atomenergi and Vattenfall, which were jointly responsible for this project, although AB Atomenergi played the leading role.

Eight non-state owned utilities with Sydkraft in the lead founded in 1955 Atomkraftkonsortiet, AKK (the Atomic Power Consortium) with the purpose to follow the international development of nuclear power. AKK had early direct contacts with utilities and vendors in the US. In 1959 AKK asked for a Governmental approval for a 60 MW BWR project, based on a concept from General Electric, but the project was never realised.

In 1964, AKK received a bid from ASEA for a project based on a BWR concept of Swedish design. The 460 MW turbine was designed by Stal Laval, a turbine manufacturing company closely related to ASEA. The high pressure system was a double rotating turbine with radial flow of the steam. This type of turbine was not possible to develop to the larger sizes which later on were needed. For deliveries to later nuclear projects, Stal Laval started a co-operation with Brown Bovery Company (BBC) in Switzerland.

AKK was transformed into OKG AB in 1965 with seven owners. OKG ordered in 1966 Oskarshamn 1 from ASEA. Oskarshamn 1 was the first LWR reactor in the world being designed without licence from US vendors. It started commercial operation in 1972.

In 1968, part of AB Atomenergi (mainly the fuel manufacturing) was transferred to ASEA, and a contract between the State and ASEA was signed. The contract also resulted in AB Atomenergi closing its reactor design office. AB Atomenergi has after that developed as a R&D company first with emphasise on nuclear energy, but later also other types of energy sources were included.

The company ASEA Atom was founded with the ownership equally divided between ASEA and the State. The contract about ASEA Atom was in function until 1979, when the ASEA Group became the single owner of ASEA Atom (now with the name ABB Atom).

In 1968, Vattenfall ordered Ringhals 1, a 750 MW BWR from ASEA, and Ringhals 2, a 800 MW PWR from Westinghouse. The outspoken reason for two orders signed with two different vendors, one Swedish and one foreign, was that Vattenfall wanted to establish a real competitive market in Sweden for the future development of nuclear power. Later Vattenfall ordered two more Westinghouse PWRs to be built at Ringhals.

In 1969 OKG ordered Oskarshamn 2 and Sydkraft ordered Barsebäck 1 with an option for Barsebäck 2. Thus four nuclear power units were ordered from ASEA Atom before the company's first unit had started to operate.

The explanation for this enormous expansion of nuclear power was that during several years there was a yearly increase in the power consumption of 7%. Further development of hydro power was not allowed because of environmental reasons. Neither the State nor the utilities wanted oil fired units to be built because of the increased dependance on oil imports.

During the first half of the 1970s Vattenfall started in co-operation with some non-state owned utilities to build the Forsmark nuclear power plant, where now 3 BWRs are in operation.

The Nuclear Power Inspectorate was functioning in a small scale from the beginning of the 1960s. Also the National Radiological Institute was operating in a small scale with Professor Rolf Sievert as an enthusiastic leader. Both the authorities became more professional at the end of the 1960s, just before the start of the large LWR-programme.

Just before the general election in 1976 nuclear power became a main political issue with the Centre Party being critical to the nuclear waste issue. The leader of the Centre Party became Prime Minister with the Government consisting of a non-socialistic coalition.

The new Government arranged a huge investigation of the risks and economies of nuclear power compared to other energy sources in an official ad hoc Energy Commission. In 1977 a unique act about the nuclear waste was accepted by Parliament. According to the new waste act, called the "Stipulation Act", the utilities would not be allowed to load fuel into a new reactor (and several were in the pipe line) before it had been shown that it was possible to arrange a final storage of the waste "in an absolutely safe way". Before Parliament accepted the act a remark was added in the minutes saying that the word "absolutely" should not be interpreted in a "draconian" way.

The result of this political development was that the utilities started Svensk Kärnbränslehantering AB (SKB, the Swedish Nuclear Fuel and Waste Management Company) to develop a comprehensive concept for final storage of high radioactive waste and to make a thorough safety evaluation of the whole concept.

One concept (KBS-1) for the final disposal of reprocessed waste was presented in 1978, followed by another concept (KBS-2) for direct disposal of spent fuel A further development of this concept (KBS-3) was presented a few years later. Late 1978 the KBS-1 and KBS-2 concepts were accepted by the Government as safe enough (but at that time the Centre Party had left the Government because of the nuclear controversy). Several reactors were allowed to start loading of fuel with reference to this principle decision by the Government, but then came the TMI accident.

A week after the TMI accident all the political parties agreed to arrange a referendum about the future of nuclear power. A special law was established forbidding the start of all new reactors until after the referendum. The referendum was arranged in March 1980 and some months later Parliament decided in accordance with the result of the referendum to allow the start of all the reactors which were ready or under construction. It was also decided that nuclear power would be phased out by 2010, if new energy sources were available at that time and could be introduced in such a way that it would not effect the social welfare programme and the employment in the heavy industry. The two last reactors in the programme of twelve started commercial operation in 1985.

A Central Interim Storage Facility for Spent Nuclear Fuel, CLAB, has been in use since 1986 and a Final Repository for Reactor Waste, SFR, has been in operation since 1988. SFR is being used for medium- and low-activity waste. Both these storage facilities can house with minor extensions all the spent fuel and reactor waste produced in Swedish reactors up to the year 2010 and beyond. CLAB is situated in the neighbourhood of the Oskarshamn nuclear power plant and SFR is close to Forsmark.

The Äspö Rock Laboratory for waste disposal experiments in the bedrock at 500 metres depth was completed in 1995 and is situated close to the Oskarshamn nuclear power plant.

The Chernobyl accident resulted in a new political debate about the Swedish nuclear power programme. Parliament decided in 1988 that the phase out of nuclear power would start in the period 1995 to 1996, with two units to be closed. After a few years, the industry and the labour unions started an intensive debate, because it was shown in official reports that the total cost of an early phasing out (after 25 years operation instead of 40 years, which is the assumed technical life time of the Swedish reactors) would cost the society more than SEK 200 billion. The price of electricity for the electricity intensive industry (paper and steel) would double with the result that between 50,000 to 100,000 persons would loose their jobs. The result was that Parliament in 1991 decided not to start the phase out by 1995. The principle decision about the phasing out by 2010 was not changed and is still valid.

The legislation in the nuclear field started with a general "Atomic Energy Act" in 1956, followed by a general Radiation Protection Act in 1958. In 1960, an act about emergency planning in case of a nuclear accident was introduced and in 1968 the Third Party Liability Act was established. In 1977 the "Stipulation Act" became effective and in 1980 Parliament passed an act on public control of the safety work at the nuclear power stations. Finally in 1981, an act on the financing of future costs for spent nuclear fuel was passed.

In 1984, the whole system of acts on nuclear power was revised. Only small changes were made in the Radiation Protection Act. The Atomic Energy Act, the Stipulation Act, the act on public control and part of the financing act were combined in one new Act on Nuclear Activities.

The Stipulation Act was superseded by some paragraphs in the new act requiring each owner of a nuclear facility to ensure a comprehensive research and development programme with the aim to conduct the handling and final disposal in a safe manner of all nuclear waste arising in the operation of the facility. The research and development should also cover future decommissioning and dismantling of the facilities.

The nuclear utilities are obliged to present a comprehensive R&D programme for all the future waste problems every third year. The nuclear utilities have handed over all the responsibility for the nuclear waste R&D to SKB.

According to the Financing Act from 1981 the nuclear utilities have to pay a fee per produced KW·h to a state fund. The fund shall cover all future costs for handling and final storage of all waste and for decommissioning of all the facilities. The average fee during the last five years has been 0.02 SEK per KW·h nuclear power.

### 3.2. Current policy issues

According to the existing Nuclear Act, no planning or construction of new nuclear power plants is allowed in Sweden. The decision in Parliament from 1980 to phase out the nuclear programme by 2010 is still valid.

The original concessions to construct and operate the twelve nuclear units were all given by the Government without any time limit. The Nuclear Act stipulates that a nuclear power unit shall be closed when and if the safety standard is evaluated not to be high enough or if the waste development programme is judged not to be appropriate. The evaluation must be made by the safety authorities and a decision by the Government to close a unit only of political reasons is not valid according to the Nuclear Act. Before the decision in Parliament in 1980 to phase out nuclear power can be fulfilled a change in the Nuclear Act is necessary.

In 1994 - 95, a new political debate about the future of nuclear power started and late 1994 a new ad hoc energy commission was asked to investigate the subject. A report will be published in December 1995 and a "final" decision about the future energy policy is expected in Parliament during 1996.

A mixed ownership of nuclear power has been accepted from the construction of the first nuclear units. Today Vattenfall, a company which is owned by the state to 100%, owns about half of the nuclear capacity. The other half of the nuclear installations are owned by privately or municipality owned utilities. Some of these are registered on the Stockholm Exchange and some of the shares are owned by foreign utilities.

Since 1988, all the nuclear power units have filtered vented containments. The efficiency of the filters has to be so high that a there would be no need for permanent evacuation in the neighbourhood of a reactor even in the case of a severe core accident.

In 1992, SKB presented a comprehensive programme for final disposal of spent nuclear fuel. The report describes a method and a preferred alternative for encapsulation and final disposal in a deep repository. Experts at universities and specialist companies as well as the regulatory authorities SKI and SSI thoroughly scrutinised and analysed the plans presented in the report. The plans were then accepted by the Government in December 1993 as a basis for SKB's future work in the field.

The deep repository is intended to be built on a site where the prospects for safety are very good. Many sites in Sweden are deemed to be capable of conforming to high standards. For this reason, the interest displayed by a municipality to host a deep repository, as well as the municipality's industrial infrastructure, also play an important role for the choice of site.

During 1994, SKB conducted feasibility studies as an initial step in the siting of the deep repository. Two studies, both at municipalities in the far north of Sweden, have been completed. The result is that both sites probably fulfil the technical criteria for building a deep repository.

However, in order to obtain a broader body of data, SKB will conduct feasibility studies at other sites as well; 5-10 sites are judged to provide an adequate selection range.

After evaluation of the feasibility studies and completion of supplementary studies, site investigations with surface and borehole studies are planned to be conducted on two sites.

If the results are good, SKB intends to proceed on one of the sites with detailed characterisation in tunnels to obtain the necessary supporting material for an application for a licence to build the deep repository several years into the next century.

To start with, the deep repository will only be put into operation for deposition of a small quantity of spent fuel. Approximately 5-10% of the fuel will be deposited in this initial phase, starting in 2008 at the earliest. After an evaluation and a renewed licensing round, the repository will be expanded to full scale.

All the costs for managing and disposing of Sweden's nuclear waste shall be paid by the owners of the nuclear power plants. This also applies to the costs of decommissioning the nuclear power plants and disposing of the decommissioning waste.

To ensure that adequate funds will be available in the future, a special charge is levied on nuclear power production. It is paid to the Nuclear Power Inspectorate, SKI, and is deposited in interest-bearing accounts in the Bank of Sweden.

### 3.3. Status and Trends of Nuclear Power

Sweden has twelve nuclear units representing a total capacity of 10 GW(e). In 1996, the electricity generated by the nuclear power plants amounted to 71 TW·h and supplied some 52% of the total electricity production of the country. Table 8 shows the status of the Swedish Nuclear Power Plants.

Oskarshamn-1 underwent an in-depth inspection, resulting in a comprehensive replacement of pipes in the primary system. A permit for operation was issued by the Swedish Nuclear Power Inspectorate in December 1995 and start-up is planned in January 1996. Steam generators of the reactor Ringhals-3 were replaced within the time and budget planned and the reactor is operating at the nominal maximum power level.

TABLE 8. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| BARSEBECK-1 | BWR | 600 | BKA | Operational | ASEA |
| BARSEBECK-2 | BWR | 600 | BKA | Operational | ASEA |
| FORSMARK-1 | BWR | 968 | FKA | Operational | ASEA |
| FORSMARK-2 | BWR | 969 | FKA | Operational | ASEA |
| FORSMARK-3 | BWR | 1158 | FKA | Operational | ASEA |
| OSKARSHAMN-1 | BWR | 445 | OKG | Operational | ASEA |
| OSKARSHAMN-2 | BWR | 605 | OKG | Operational | ASEA |
| OSKARSHAMN-3 | BWR | 1160 | OKG | Operational | ASEA |
| RINGHALS-1 | BWR | 830 | VAB | Operational | ASEA |
| RINGHALS-2 | PWR | 875 | VAB | Operational | WEST |
| RINGHALS-3 | PWR | 915 | VAB | Operational | WEST |
| RINGHALS-4 | PWR | 915 | VAB | Operational | WEST |
| AGESTA | PHWR | 10 | VAB | Shut Down | ASEA |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| BARSEBECK-1 | 01-Feb.-71 | 18-Jan-75 | 15-May-75 | 01-Jul.-75 | |
| BARSEBECK-2 | 01-Jan-73 | 20-Feb.-77 | 21-Mar-77 | 01-Jul.-77 | |
| FORSMARK-1 | 01-Jun.-73 | 23-Apr.-80 | 06-Jun.-80 | 10-Dec.-80 | |
| FORSMARK-2 | 01-Jan-75 | 16-Nov.-80 | 26-Jan-81 | 07-Jul.-81 | |
| FORSMARK-3 | 01-Jan-79 | 28-Oct.-84 | 05-Mar-85 | 18-Aug.-85 | |
| OSKARSHAMN-1 | 01-Aug.-66 | 12-Dec.-70 | 19-Aug.-71 | 06-Feb.-72 | |
| OSKARSHAMN-2 | 01-Sept.-69 | 06-Mar-74 | 02-Oct.-74 | 01-Jan-75 | |
| OSKARSHAMN-3 | 01-May-80 | 29-Dec.-84 | 03-Mar-85 | 15-Aug.-85 | |
| RINGHALS-1 | 01-Feb.-69 | 20-Aug.-73 | 14-Oct.-74 | 01-Jan-76 | |
| RINGHALS-2 | 01-Oct.-70 | 19-Jun.-74 | 17-Aug.-74 | 01-May-75 | |
| RINGHALS-3 | 01-Sept.-72 | 29-Jul.-80 | 07-Sept.-80 | 09-Sept.-81 | |
| RINGHALS-4 | 01-Nov.-73 | 19-May-82 | 23-Jun.-82 | 21-Nov.-83 | |
| AGESTA | 01-Dec.-57 | 17-Jul.-63 | 01-May-64 | 01-May-64 | 02-Jun.-74 |

Source: IAEA Power Reactor Information System, yearend 1996

### 3.4. Organizational Charts

The structure of the nuclear-electric sector in Sweden is shown in Figure 1.

Vattenfall AB is a limited company owned to 100% by the state. The Government can influence the operation of the company through the board of directors, which is elected by the Government. Matters concerning Vattenfall AB are handled by the Ministry of Industry and Commerce.

Sydkraft and all other utilities (see Table 1 for more details), Vattenfall excluded, are owned by municipalities, large industries, institutional investors or other types of shareholders. Sydkraft and some other utilities are registered on the Stockholm Exchange.

Svensk Kärnbränslehantering AB, SKB, (Swedish Nuclear Fuel and Waste Management Company) and Kärnkraftsäkerhet och Utbildning AB, KSU, (Nuclear Training and Safety Centre) are jointly owned by the utilities and/or the nuclear power operator companies.

The Nordic Safety Council is an informal organization between Swedish and Finnish nuclear power operators and ABB Atom for principal and long term safety issues.

Statens Kärnkraftinspektion, SKI (Swedish Nuclear Power Inspectorate) and Statens Strålskyddsinstitut, SSI (Swedish National Institute of Radiation Protection) are responsible for the implementation of the Act on Nuclear Activities and the Radiation Protection Act respectively. Both the authorities report to the Ministry for Environment. Thus there is no co-ordination of all nuclear activities at the ministry level. Only the Government as a whole or Parliament takes the responsibility for such a co-ordination.

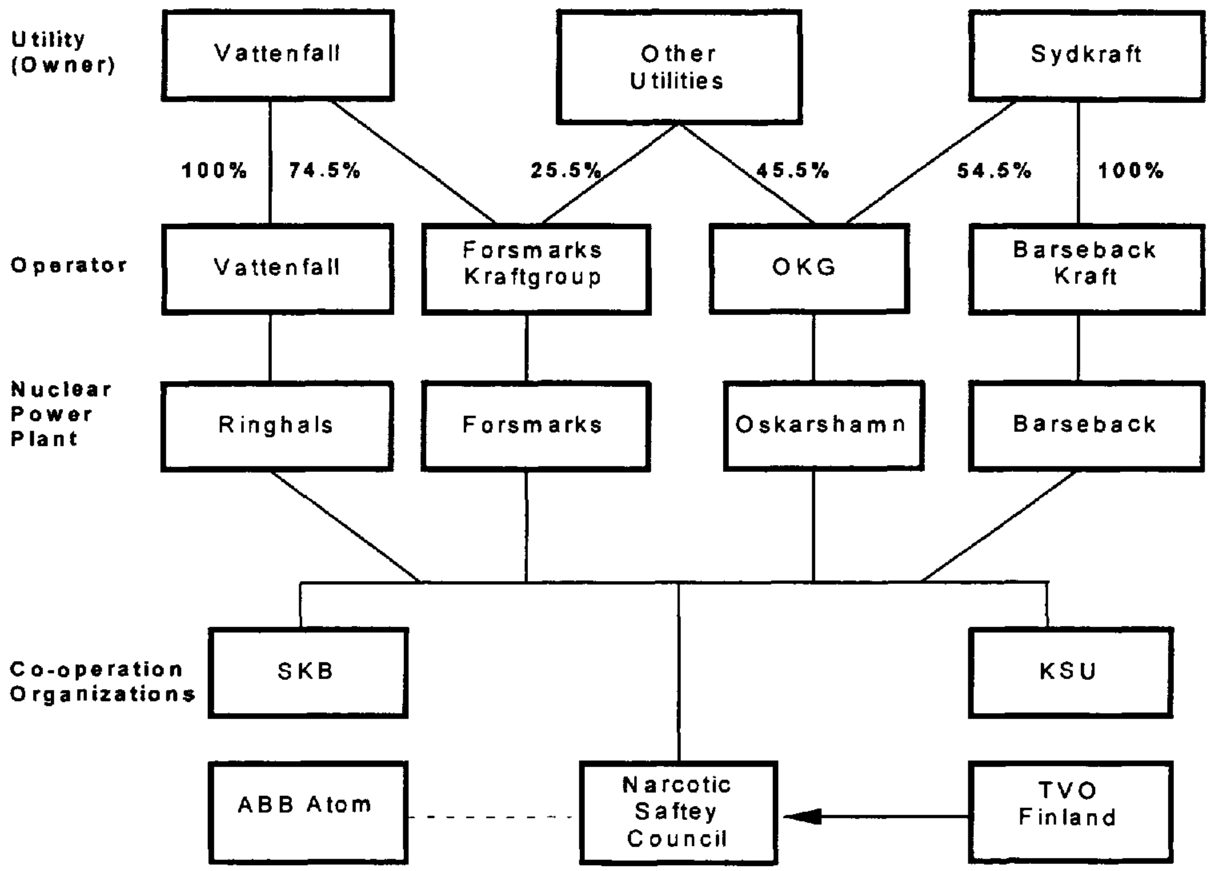


*FIG. 1. Structure of the nuclear-electric sector in Sweden*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of NPPs

ABB Atom (former ASEA Atom) has designed and delivered nine BWRs in Sweden and two in Finland. All the reactors were designed without any license from the US. ABB Atom used to have an indoor capability including architect engineering but during the 1980s the utilities in Scandinavia took the main responsibility for co-ordination of the nuclear power projects.

The reactor fuel, the control rods and the control rod drives have been manufactured by ABB Atom. The control rooms and most of the electric components have been manufactured by sister organizations to ABB Atom within ABB (earlier ASEA). The turbines and all types of heat exchangers have been manufactured by ABB (former ASEA Stal in Sweden and Brown Boveri Company in Switzerland).

The latest reactor design of ABB Atom is BWR 90, an advanced BWR plant design built on the operation experiences of Forsmark 3 and Oskarshamn 3. The net electric output is 1200 or 1375 MW.

VBB-VIAK (former VBB) has been responsible for the building design and building construction co-ordination on behalf of some of the utilities or ABB Atom.

Two Swedish building and civil engineering companies have been involved in the construction of the nuclear power plants in Sweden and Finland: NCC and SKANSKA.

Sandvik is a Swedish manufacturer of fuel canning tubes and steam generator tubes.

### 4.2. Operation of NPPs

The operators and some of the owners of Swedish nuclear power plants are shown in Figure 1. Some additional information about the power utilities is given in Table 5. It should be mentioned that all the operators are relatively independent of their mother organizations when it comes to technical capability.

Maintenance services are supplied by ABB Atom, ABB TRC, ABB Stal, Studsvik AB and several other Swedish companies. Major maintenance service companies in Germany, France and UK are often engaged at the Swedish nuclear power plants.

Kärnkraftsäkerhet och Utbildning AB, KSU (Nuclear Training and Safety Centre) has seven full scale nuclear power plant simulators in operation and is responsible for the training of the nuclear power operators. KSU also provides nuclear power plant technicians with complementary education on a university level in nuclear power related topics. KSU participates in the work on nuclear safety performed within the Swedish utilities and co-ordinate these efforts. KSU also provides information regarding operating experience in the Swedish plants internationally. KSU is owned jointly by the Swedish utilities (Vattenfall 50%, OKG 25% and Barsebäck Kraft 25%).

### 4.3. Fuel cycle

Swedish utilities import all their need of uranium and enrichment services. ABB Atom manufactures reactor fuel both for BWRs and PWRs. Half of the deliveries are to utilities abroad. The Swedish utilities buy part of their fuel elements from abroad. The spent fuel from all the Swedish nuclear power plants is transported by boat to the central interim storage CLAB. The facility started operation in 1985 and is situated close to the Oskarshamn nuclear power plant.

Some low level waste is finally deposed of at local dumps and some of it is incinerated at Studsvik. All other waste from reactor operation is transported to SFR, the final repository for radioactive operational waste, in operation since 1988. SFR is located close to the Forsmark nuclear power plant. Most of the waste from decommissioning of the reactors will be disposed at SFR.

Svensk Kärnbränslehantering AB, SKB (Swedish Nuclear Fuel and Waste management Company) has built and owns the CLAB, SFR and the Äspö Hard Rock Laboratory. SKB is acting on behalf of the nuclear utilities in conducting the extensive research and development and demonstration work with regard to the remaining facilities for final disposal of long-lived spent nuclear fuel. SKB is also responsible for co-ordination and investigations regarding the costs for nuclear waste and future decommissioning. SFR and CLAB are operated by Forsmark Kraftgrupp and OKG respectively on behalf on SKB. SKB is jointly owned by the Swedish utilities (Vattenfall 36%, Forsmark Kraftgrupp 30%, OKG 22% and Barsebäck Kraft 12%).

### 4.4. Research and Development

AB Atomenergi started in the late 1950s the national nuclear power laboratory at Studsvik. Later it was transformed to a general energy laboratory but now most of the activities at the site are managed by Studsvik AB, still heavily involved in the nuclear area. One of the main tools is the materials test reactor R2 (50 MW) with extensive material laboratory facilities. Studsvik AB is today a commercial organization not owned by the state any more. Studsvik AB offers components, services and consulting. Today there is no central planning of the research and development activities in the nuclear field in Sweden.

Most of the reactor safety research and development is directed by the nuclear power operators and by SKI and SSI. It is performed at universities - also abroad -, Studsvik, at the Vattenfall central laboratory and at other research institutes.

SKB has been directing a large research programme for developing safe waste disposal methods. The research has been conducted in collaboration with universities, institutes of technology, research institutions in Sweden and abroad.

### 4.5. International Co-operation

Most of the Swedish contacts with IAEA and OECD/NEA are through official channels managed in the nuclear field by SKI and SSI.

KSU analyses and evaluates operating experience gained at other nuclear power world-wide which can benefit the operation of the Swedish plants. KSU is the main communication channel between the Swedish utilities and the nuclear safety organizations WANO and INPO.

SKB has a broad network of international contacts. Formal co-operation agreements exist with the following organizations:

| | |
|---|---|
| CEC/EURATOM | EU |
| TVO/IVO | Finland |
| CEA/ANDRA | France |
| JNFL | Japan |
| AECL | Canada |
| Nagra | Switzerland |
| USDOE | USA |

The following organizations have signed agreements of participation in the Äspö Hard Rock Laboratory project: Atomic Energy of Canada Limited (AECL); Power Reactor & Nuclear Fuel Development Corporation (PNC) of Japan; Central Research Institute of Electric Power Industry (CRIEPI) of Japan; ANDRA of France; TVO of Finland;, NIREX of UK; USDOE and Nagra of Switzerland.

## 5. REGULATORY FRAMEWORK

### 5.1. Safety Authorities and the Licensing Process

*Statens Kärnkraftinspektion, SKI (Nuclear Power Inspectorate)*

SKI is responsible for the implementation of the Act on Nuclear Activities in Sweden. SKI reports to the Minister of Environment. It is a main principle for SKI that the organizations with licences to operate nuclear facilities have the full and undivided responsibility for the safety. SKI's role is to supervise how the licensees live up to their responsibilities. This is being done by SKI by creating an own and well founded picture of the safety conditions at the plants and of the quality of the safety programmes developed by the licensees.

SKI has the ambition to:

- press on the safety programmes of the licensees when operation experiences, results from R&D and technical development indicate that it is motivated to further develop the safety standards;
- work for a comprehensive waste R&D programme to be maintained by the nuclear industry and see to it that money is paid to the funds to cover the future costs for waste disposal and decommissioning;
- work so that the competence in the safety programmes can be maintained and developed within SKI and in the nuclear industry;
- issue and stipulate conditions and regulations for nuclear power activities as long as it is judged to be necessary for the safety and because of international commitments by Sweden; and
- actively inform about circumstances and occurrences of interest from the safety point of view.

SKI was reorganised in the beginning of 1993. Under the Director General there are now three offices, i.e., on Reactor safety, on Nuclear Materials Control and on Nuclear waste safety. There are about 100 persons employed by SKI. The total budget is about 100 MSEK. Beside that amount, SKI also has a budget of 50 MSEK for a safety programme in the former Soviet Union. Funding for SKI's regulatory activities as well as for the safety research initiated and administrated by SKI is covered by the statutory fees payable by licensees and applicants for licences. The number of persons engaged by SKI per operating reactor is 8, which is less than half the number normally used in countries like USA, France and Germany.

*Statens Strålskyddsinstitut, SSI (the Swedish National Institute of Radiation Protection)*

SSI is responsible for the implementation of the Radiation Protection Act and has some responsibilities with reference to the Act on Nuclear Activities. SSI reports to the Minister of Environment. SSI is responsible for all sorts of radiation protection, both non ionising and ionising radiation. Thus SSI also has to deal with medical radiation and radon applications.

The main tasks for SSI are the following:

i. to prevent acute deaths and other serious acute injuries caused by radiation;
ii. to prevent accidents caused by the use of accelerators and other types of strong radiation sources;
iii. to prevent and decrease harmful late defects of radiation on large groups of the population. The maximum dose to individuals belonging to the general public from a given regulated radiation source, for example caused by releases from nuclear power plants, should be limited to less than 0,1 mSv per year;
iv. to further prevent the harmful late defects of radiation for specially exposed individuals. The average radiation dose to persons working in a radiation environment should be limited to less than 5 mSv per year;
v. to contribute to increased knowledge about the harmful effects from radiation and about the occurrence of radiation in the total environment.

In total there are 130 persons employed by SSI but only about 30 of these are directly engaged in radiation protection at nuclear power plants and preparedness for nuclear power accidents. The total budget is 90 MSEK, of which 45 MSEK are used within the nuclear power sector. As for SKI all the costs in the nuclear power sector are paid for by the nuclear power plants and other sites.

*Statens Råd för Kärnavfallsfrågor, KASAM (National Council for Nuclear Waste)*

KASAM is a committee connected to the Ministry of Environment. KASAM is the advisory committee to the Government on waste issues.

According to its instructions, KASAM shall:

i) every third year present a report to the Government with a statement of its independent opinion on the state of knowledge within the nuclear waste area;
ii) present its independent opinion on the programme for research and development concerning the final disposal of spent nuclear fuel, which is issued every third year by the nuclear power industry;
iii) act as an advisory committee - on request - to the authorities working in the nuclear waste area (SKI and SSI), in matters with connection to nuclear waste and decommissioning of nuclear power plants.

The council is also working through seminars to open up a dialogue between different fractions having a serious interest in questions concerning nuclear waste.

In principle there still is a procedure for licensing new nuclear power plants, but according to the Act on Nuclear Activities "A license to construct a nuclear power plant must not be granted" (Section 5 of the Act). Thus the Act on Nuclear Activities can only be applied to nuclear power plants already in operation. The Act is a nuclear safety law and it gives SKI a well defined mandate (in fact an obligation) to stop nuclear power operation as soon as the plant or the operation of the plant is judged not to be safe enough. But it is also clearly stated that the main responsibility for the safety at nuclear installations should be taken by the operator. It is possible for SKI to make critical reviews of the safety standards in all aspects, for example the actual safety standard of the equipment's (components and systems), of education of the staff, of safety procedures, of the quality of the management, etc.

There are no considerations whatsoever to the economy of the utility (or the country) or the need for power supply in the act. The Act on Nuclear Activities gives SKI great power. But there are no possibilities for the public or groups with special interest to intervene when an operation license has been granted.

### 5.2. Main National Laws and Regulations

1. Act on Nuclear Activities (1984, latest amendment by June 1992.
   Ministry: Environment
   Authority: SKI

2. Radiation Protection Act (1988)
   Ministry: Environment
   Authority: SSI

3. Act on Financing of Future Expenses for Spent Fuel (1981, latest amendment 1986).
   Ministries: Finance and Environment
   Authority: SKI

4. Nuclear Liability Act (1968, latest amendment 1995)
   Ministry: Justice
   Authority: The Private Insurance Supervisory Service.

The costs of managing and disposing of the spent nuclear fuel shall be paid by owners of the nuclear power plants. The costs are financed by today's electricity production and must not burden future generations. This also applies to the costs of decommissioning and disposing of the decommissioning waste. To ensure that adequate funds will be available in the future, a special charge is levied on nuclear power production. It is paid to SKI and is deposited in interest-bearing accounts in the Bank of Sweden. The charge is fixed annually by the Government and is based on a cost calculation submitted by SKB to SKI. All costs for all necessary systems and facilities are included, i.e., transportation system, CLAB, SFR, encapsulation plant and deep repository for spent fuel and other long-lived waste. The calculations also includes costs for research, development, demonstration and information about the waste issue.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • EURATOM/IAEA NPT related safeguards agreement INFCIRC/193 | Entry into force: | 1 June 1995 |
| • Improved procedures for designation of safeguards inspectors | Following EU policy. | |

*OTHER RELEVANT INTERNATIONAL TREATIES ETC.*

| | | |
|---|---|---|
| • NPT<br>EURATOM Member | Entry into force: | 9 January 1970 |
| • Agreement on privileges and immunities | Entry into force: | 8 September 1961 |
| • Convention on physical protection of nuclear material | Entry into force: | 8 February 1987 |
| • Convention on early notification of a nuclear accident | Entry into force: | 30 March 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 25 July 1992 |
| • Conventions on civil liability for nuclear damage and joint protocol | Ratification of Paris Convention:<br>Entry into force of Joint Protocol: | 27 January 1992<br>27 April 1992 |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | Summary: Codes well suited for national safety rules. Compatible with Swedish law and other rules. | 12 June 1990 |
| • Nuclear Suppliers Group | Member | |
| • EURATOM treaty | Member | |

*MULTILATERAL AGREEMENTS*

- Exchange of ministerial notes between Sweden, Denmark, Finland and Norway about guiding principles for contacts about nuclear safety concerning nuclear plants at the borders between Denmark, Finland, Norway and Sweden. (SÖ 1977:48)

*BILATERAL AGREEMENTS*

- Treaty with Switzerland about co-operation in the field of the peaceful use of atomic energy. (SÖ 1969:1)

- Treaty with Finland about co-operation in the field of the peaceful use of atomic energy. (SÖ 1970:8)

- Agreement with the Soviet Union (now with Russia) about co-operation in the field of the peaceful use of atomic energy. (SÖ 1970:9)

- Agreement with Canada concerning the use of fissile material, equipment, plants and information transferred between Sweden and Canada. (SÖ 1981:89-90)

- Agreement with Australia about condition for and control of transfers between Australia and Sweden in the filed of nuclear power. (SÖ 1982:86-87)

- Exchange of notes with Finland in the field of nuclear power (SÖ 1983:1)

- Agreement with the United States of America about the peaceful use of nuclear power. (SÖ 1984:66)

- Treaty with Denmark about exchange of information about the Barsebäck Nuclear Power Plant. (SÖ 1986:15)

- Treaty with Denmark about exchange of information and notice about Swedish and Danish nuclear facilities etc. (SÖ 1987:12)

- Treaty with Finland about exchange of information and notice about Swedish and Finnish nuclear facilities etc. (SÖ 1987:16)

- Treaty with Norway about exchange of information and notice about Swedish and Norwegian nuclear facilities etc. (SÖ 1987:26)

- Treaty with the Soviet Union (now with Russia) about notice in the case of a nuclear power accident and about exchange of information about nuclear facilities. (SÖ 1988:5)

- Treaty with Germany about notice in the case of a nuclear power accident and about exchange of information about nuclear power facilities. (SÖ 1990:??)

## ANNEX I. DIRECTORY OF MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Ministry of the Environment<br>S-103-33 Stockholm<br>Sweden | Tel.: +46 8 4051000<br>Fax: +46 8 241629<br>Telex: 15499 MINENS |
| Swedish Nuclear Power Inspectorate<br>Statens Kärnkraftinspektion (SKI)<br>S-106 58 Stockholm<br>Sweden | Tel.: +46 8 698 8400<br>Fax: +46 8 6619086<br>Telex: 11961 SWEDATOM S<br>Cable: SWEDATOM |
| Swedish Radiation Protection Institute<br>Statens Strålskyddsinstitut (SSI)<br>S-171 16 Stockholm<br>Sweden | Tel.: +46-8 7297100<br>Fax: +46- 8 7297108<br>Telex: 11771 SAFERAD S |
| KASAM<br>Vitriskestigen 5<br>S-611 63 Nyköping<br>Sweden | Tel.: +46-1565 21 54 40<br>Fax: +46-155 21 06 32 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Board of the Swedish Nuclear<br>Waste Fund<br>c/o Kammarkollegiet, Box 2218<br>S-103 15 Stockholm<br>Sweden | Tel.: +46-8 700 0800<br>Fax: +46- 8 203881 |
| Swedish National Council for<br>Nuclear Waste<br>c/o Ministry of the Environment<br>S-103 33 Stockholm<br>Sweden | Tel.: +46-8 7634289<br>Fax: +46- 8 103807 |

*POWER UTILITIES*

| | |
|---|---|
| Vattenfall AB<br>S-162 87 Stockholm<br>Sweden | Tel.: +46-8 739 50 00<br>Fax: +46-8 37 01 70 |
| Sydkraft AB<br>S-205 09 MALMÖ,<br>Sweden | Tel.: +46-40 25 50 00<br>Fax: +46-40 97 60 69 |

Stockholm Energi AB
S-115 77 Stockholm — Tel.: +46-8 671 70 00
Sweden — Fax: +46-8 671 70 60

Gullspång Kraft AB
Box 1643 — Tel.: +46-19 21 81 00
S-701 16 Örebro — Fax: +46-19 26 24 23
Sweden

*NUCLEAR POWER PRODUCTION COMPANIES AND SUBSIDIARIES*

Ringhals Vattenfall
S-430 22 Väröbacka, — Tel.: +46-340 66 70 00
Sweden — Fax: +46-340 66 51 84

Barsebäck Kraft AB
Box 524
S-246 25 Löddeköpinge, — Tel.: +46-46 72 40 00
Sweden — Fax: +46-4677 57 93

OKG AB — Tel.: +46-491 860 00
S-573 83 Oskarshamn — Fax: +46-491 869 20
Sweden

Forsmark Kraftgrupp AB — Tel.: +46-173 810 00
S-742 03 Östhammar — Fax: +46-173 551 16
Sweden

Svensk Kärnbränslehantering AB (SKB)
Box 5864
S-102 40 Stockholm — Tel.: +46-8 665 28 00
Sweden — Fax: +46-8 661 57 19

Kärnkraftsäkerhet och Utbildning AB (KSU)
Box 1039 — Tel.: + 46 155 26 35 00
S-611 29 Nyköping — Fax: +46-155 26 30 74
Sweden

*SUPPLIERS OF NPPS, COMPONENTS AND SERVICES*

ABB Atom AB
S-721 63 Västerås, — Tel.: +46-34 70 00
Sweden — Fax: +46-21 18 71

ABB Tekniska Röntgencentralen AB
Box 121 — Tel.: +46-8 732 80 20
S-183 22 Täby — Fax +46-8 732 76 41
Sweden

ABB Stal AB
S-612 72 Finspång
Sweden
Tel.: +46-122 81 000
Fax: +46-122 816 96

Sandvik AB
S- 811 81 Sandviken
Sweden
Tel.: +46-26 26 00 00
Fax: +46-26 26 13 50

Studsvik AB
S-611 82 Nyköping
Sweden
Tel.: +46-155 22 10 00
Fax: +46-155 26 30 00

# SWITZERLAND

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# 1. GENERAL INFORMATION

## 1.1. General Overview

Switzerland is one of the most mountainous countries in Europe, with most of its area covered by the Alps and the Jura. Between these mountain systems lies the Swiss Plateau, about 400 m above sea level and about 50 km wide. The principal river system is formed by the Rhine and its tributaries: Aare, Limmat etc. Other important rivers are the Rhine, Ticino, Inn. The Swiss rivers are not navigable for any appreciable extent. The most important lakes are those of Geneva, Constance, Lugano, the Lago Maggiore, and the lakes of Neuchâtel, Luceme, Zürich, Brienz and Thun.

On the Plateau and in the lower valleys a temperate climate prevails with a mean annual temperature of about 10 $^0$C. Precipitation on the plateau is about 900 mm annually, higher regions generally receive more precipitation. Much of the precipitation occurs as snow during the winter. In the Alps are large glaciers and the peaks of most mountains are snow covered throughout the year. Predominant winds come from the north-east (cold) or from the west and in certain regions from the south (warm and dry).

The population of Switzerland, roughly 7 million people, is essentially concentrated in small towns of the Swiss Plateau (Table 1). The main languages are German, French, and Italian with a minority of Retho-romansch. Foreigners and their families represent some 15% of the population.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 5.4 | 6.2 | 6.3 | 6.8 | 7.1 | 7.1 | 0.9 |
| Population density (inhabitants/km²) | 129.9 | 149.8 | 153.0 | 165.5 | 170.9 | 172.7 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0. 9 |
| Area (1000 km²) | 41. 3 |
| Urban population in 1993 as percent of total | 60. 0 |

Source: IAEA Energy and Economic Data Base

Switzerland has a highly developed industrialized economy and one of the highest standards of living in the world. Manufacturing, based on private enterprise, is the dominant economic sector, followed by trade, finance and services. Agriculture accounts for less than 4% of the national output. The natural resources are essentially limited to the hydro electric potential.

Switzerland is a Confederation of States governed under a Constitution adopted in 1874 and amended several times since. The Swiss political system combines direct and indirect democracy, the electorate chooses its representatives and decides on important issues by means of referenda, initiatives or petitions. The executive power is the Federal Council, seven members elected by the Swiss Parliament, one of them being elected President for one year. The Swiss Parliament consists of two houses: The Council of States (46 members) and the National Council (200 members). All powers not delegated to the Confederation by the Constitution are reserved to the Cantons. Each of the 20 Cantons and 6 half Cantons has an elected legislative council and an executive council.

## 1. 2. Economic Indicators

The historical Gross Domestic Product (GDP) data are shown in Table 2.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 20,733 | 101,629 | 226,055 | 234,224 | 262,977 | 7.0 |
| GDP (millions of constant 1990 US$) | 162,452 | 183,882 | 226,055 | 223,366 | 226,028 | 1.5 |
| GDP per capita (current US$/capita) | 3,351 | 16,083 | 33,078 | 33,195 | 36,878 | 6.1 |
| GDP by sector in 1992: | | | | | | |
| Agriculture % | | | | | | |
| Industry % | | | | | | |
| Services % | | | | | | |

Source: IAEA Energy and Economic Data Base

## 1. 3. Energy Situation

Switzerland has no major energy resources except for hydro, which reserves amount to about 14 Exajoules according the IAEA Energy and Economic Data Base. The Swiss the energy statistics are shown in Table 3.

TABLE 3. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[(1)] | 0.40 | 0.80 | 0.92 | 1.10 | 1.12 | 1.09 | 4.31 | 1.21 |
| - Solids[(2)] | 0.08 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 | -5.56 | -1.65 |
| - Liquids | 0.15 | 0.51 | 0.51 | 0.51 | 0.51 | 0.49 | 6.21 | -0.31 |
| - Gases | | | 0.04 | 0.08 | 0.09 | 0.09 | -38.64 | 6.12 |
| - Primary electricity[(3)] | 0.17 | 0.25 | 0.35 | 0.49 | 0.50 | 0.49 | 3.70 | 2.49 |
| Energy production | | | | | | | | |
| - Total | 0.18 | 0.31 | 0.45 | 0.52 | 0.57 | 0.62 | 4.69 | 2.23 |
| - Solids | | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | | 1.51 |
| - Liquids | | | | | | | | |
| - Gases | | | | | | | | |
| - Primary electricity[(3)]) | 0.18 | 0.30 | 0.44 | 0.51 | 0.57 | 0.61 | 4.58 | 2.25 |
| Net import (import - export) | | | | | | | | |
| - Total | 0.24 | 0.58 | 0.61 | 0.64 | 0.60 | 0.62 | 4.83 | 0.11 |
| - Solids | 0.08 | 0.02 | 0.02 | 0.02 | 0.01 | | -5.82 | -10.47 |
| - Liquids | 0.16 | 0.55 | 0.55 | 0.55 | 0.50 | 0.52 | 6.28 | -0.33 |
| - Gases | | | 0.04 | 0.08 | 0.09 | 0.09 | -38.64 | 6.12 |

[(1)] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*
[(2)] *Solid fuels include coal, lignite and commercial wood.*
[(3)] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*
Source: IAEA Energy and Economic Data Base

## 1. 4. Energy Policy

After the oil crisis, the Government set up in 1974 a commission to elaborate an overall concept for a Swiss energy policy. The goals were to : establish an energy concept for Switzerland, formulate needed legislative measures on a short and mid-term basis, assess an overall energy policy for the various energy sources, assess the potential of energy savings and of alternative energies, stipulate measures for new energy research projects, strengthen the importance of an abundant, ecologically and economically optimal energy supply.

The commission handed its final report over to the government in 1978. In a nutshell, it proposed that the future energy policy of Switzerland be based upon savings, research, oil substitution and long term views. Furthermore it proposed three additional nuclear power stations to be built until the year 2000. In order to accomplish such an energy policy the commission proposed that an energy clause be added to the Swiss Constitution. This energy clause was voted on and approved in 1990.

Swiss utilities own de facto (through financial participation and commitments) the equivalent of two large nuclear plants in France (part ownership in Bugey and Fessenheim, drawing rights in Cattenom). As long as France keeps its export policy, the Swiss utilities will continue to be interested to secure power from France.

The "Energy 2000" action programme was launched in 1991. Its key objectives were to : stabilise total fuel consumption and $CO_2$ emissions by 2000 and reduce them thereafter; progressively decelerate growth of electricity consumption and stabilise demand by 2000; increase the contribution of renewables to 0,5% in electricity production and 3% in heat production by 2000; expand hydropower production by 5% and capacity of existing nuclear plants by 10% by 2000. Policy decisions taken in connection to this include a decree on air pollution prevention, which came into effect on 1st February 1992 with more stringent regulations for power and heat producers; a decree on energy efficiency, in effect from 1st March 1992; a law on water protection adopted on 17th May 1992; and the decision to authorise upgrading of generating capacity of the nuclear power plant Muhleberg by 10%.

Alongside these federal actions progress has been made in establishing a legal framework for many of the cantonal and municipal measures called for in "Energy 2000"; organizing action groups and implementing supporting measures such as information and advice, vocational training and education, pilot and demonstration plants and promotional programmes. Discussion of controversial issues has been encouraged, though real progress in achieving some degree of consensus has yet to be achieved. A divergence of views persists on some objectives and means proposed by "Energy 2000", including capacity increases at nuclear power plants, new hydropower projects.

## 2. ELECTRICITY SECTOR

### 2. 1. *Structure of the Electricity Sector*

The electricity industry consists of 1200 production and distribution utilities. Of these, 970 utilities account for 65 % of supply and are owned or controlled by local authorities. Many of these are also responsible for the provision of water services. The private sector companies account for 25 % of supply and the remaining 10 % comes from auto producers. There are six main regional suppliers and three large municipal suppliers in Basel, Bern and Zürich. Except for nuclear energy, the Federal Government's influence is relatively low on the electricity sector. Local authorities exert influence through their participation's or through cantonal legislation.

A new law on water protection has taken effect on 1st November 1992, it places minimum flow requirements on all new hydro plants and on existing plants when present concessions are to be renewed. The Government estimates that this law will eventually reduce existing plant capacity by no more than 6 % by 2070 and that cantonal regulations will double this estimated loss; new plants and the expansion of existing ones should nonetheless more than offset the total loss of capacity.

Since individual electricity undertakings apply tariffs on an independent basis, there are no binding federal regulations for the establishment of these tariffs. Even the Swiss Association of Electricity Supply Undertakings (VSE) has no authority in this area. However, the VSE tariffs committee prepares regular guidelines and recommendations for the use of member companies. These recommendations are generally incorporated into tariffs applied by electricity utilities.

Charges for construction costs are levied by electricity distributors when new electric power plants are installed or when existing plants are enlarged. In general, a distinction is drawn between system costs and connecting costs, with many electricity companies incorporating these two cost elements into a single charge. These construction charges are generally levied on a one-off basis when the customer is connected to the electricity supply system, with a variety of procedures being applied by individual companies. A small number of companies increase the energy rate (and/or the demand rate) in the area which they supply, rather than charging newly connected customers for construction costs. In some cases, prices fixed by the utilities are subject to formal approval by the local authority concerned. The recommendations published by the Federal Department of Transport, Communication and Energy in 1989 cover the principles of tariff-setting in networks.

### 2. 2. Decision Making Process

The Swiss Federal Government has adopted the action programme "Energy 2000" which concern the energy as a whole (see Section 1. 4). This action programme defines also the objectives in the electricity sector. The Federal Department of Transports, Communications and Energy is the Swiss regulatory body for this action programme, in co-operation with the authorities of the Cantons. He supports R&D programmes, elaborates recommendations and regulations, but not the policy. The policy and decision making is in the hands of the electricity generation industry within the regulatory framework.

Because electricity in Switzerland is decentralized and the electric utility industry and nonutility generators are, for the most part, privately owned, policy and decision making in the electricity generation industry is decentralized, subject to Federal and Cantonal laws and regulations. The regulatory body examines the submitted projects, eventually proposes some modifications and prepare a proposition to the cantonal or federal concerned political organization for a decision. By the way of an initiative or referendum the electorate may make the final decision.

### 2. 3. Main Indicators

Table 4 shows the historical electricity production and installed capacity statistics and Table 5 the energy related ratios.

TABLE 4. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | | | | | | | Average annual growth rate (%) | |
|---|---|---|---|---|---|---|---|---|
| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | 1960 to 1980 | 1980 to 1994 |
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 19.07 | 32.57 | 47.06 | 55.80 | 61.07 | 65.64 | 4.62 | 2.40 |
| - Thermal | 0.25 | 1.39 | 0.96 | 2.51 | 2.43 | 2.71 | 7.03 | 7.71 |
| - Hydro | 18.83 | 28.72 | 32.44 | 30.98 | 36.62 | 39.95 | 2.76 | 1.50 |
| - Nuclear | | 2.45 | 13.66 | 22.30 | 22.03 | 22.98 | | 3.78 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 5.84 | 10.54 | 13.99 | 16.30 | 16.23 | 16.40 | 4.46 | 1.14 |
| - Thermal | 0.20 | 0.57 | 0.60 | 0.97 | 0.81 | 0.87 | 5.65 | 2.65 |
| - Hydro | 5.64 | 9.62 | 11.45 | 12.35 | 12.44 | 12.55 | 3.60 | 0.66 |
| - Nuclear | | 0.35 | 1.94 | 2.99 | 2.99 | 2.99 | | 3.13 |

(1) *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 5. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 74 | 130 | 146 | 161 | 159 | 153 |
| Electricity per capita (kW·h/capita) | 3,311 | 4,494 | 5,878 | 7,604 | 7,395 | 7,293 |
| Electricity production/Energy production (%) | 101 | 102 | 100 | 100 | 100 | 100 |
| Nuclear/Total electricity (%) | | 8 | 29 | 41 | 37 | 36 |
| Ratio of external dependency (%)(1) | 60 | 72 | 66 | 58 | 53 | 57 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 37 | 35 | 38 | 39 | 43 | 46 |
| - Thermal | 14 | 28 | 18 | 30 | 34 | 36 |
| - Hydro | 38 | 34 | 32 | 29 | 34 | 36 |
| - Nuclear | | 80 | 80 | 85 | 84 | 88 |

(1) *Total net import / Total energy consumption.*
Source: IAEA Energy and Economic Database

## 3. NUCLEAR POWER SITUATION

### 3. 1. Historical Development

In November 1945, the Swiss Government established the independent Atomic Energy Committee with the mandate to advise the Government in all civilian and military matters dealing with nuclear energy. In 1946, the Swiss Government mandated the Atomic Energy Committee to investigate all aspects dealing with nuclear weapons, i. e. to prepare the necessary measures for protecting army and population against their impact and also to study what would be required to develop such weapons. On 18 March 1957, the Swiss Parliament ratified the IAEA Statute which has been brought into force on 29 July 1957. In 1969, Switzerland signed the Non-Proliferation Treaty and the Parliament ratified it on 9 March 1977.

As early as 1946, Brown Boveri & Cie (BBC), now Asea Brown Boveri AG (ABB), took the first steps to build up a team of physicists and to launch a development programme. BBC was later joined by Sulzer Brothers and Escher-Wyss. Initial studies dealt with graphite-carbon dioxide reactor concepts, but from 1952 on, development was concentrated on heavy water with the subsequent planning of the research reactor DIORIT. In 1955, more than 150 private companies joined forces and formed the company "Reactor Ltd" to build and operate the new privately-owned research center, in Wurenlingen, with two reactors on the site: SAPHIR and DIORIT. In 1960, the Swiss Government took over the research center, well known under its abbreviation EIR (Eidgenoschisches Institut fuer Reaktorforschung). In 1988, the fusion of the EIR and SIN (Schweizerisches Institut fuer Nuklearphysik) led to the creation of the "Paul Scherrer Institut".

In Switzerland, the nuclear age began on 30 April 1957, when the SAPHIR reactor went critical under the responsibility of Swiss scientists and engineers. This swimming pool reactor had been purchased in 1955 from the American Government, after being exhibited in Geneva during the First International Conference on the Peaceful Uses of Atomic Energy. SAPHIR has been definitely shut down at the end of 1993. DIORIT, the first reactor designed and constructed by Swiss scientists, reached criticality on 15 August 1960. DIORIT has been definitely shut down in 1977.

In 1962, began the construction of the experimental nuclear power reactor in Lucens, a 30 MWth, 6 MWe, heavy-water moderated, carbon dioxide cooled reactor located in an underground cavern. Criticality was reached in late 1966 and commissioning in early 1968. In spite of numerous difficulties, the supply consortium led by Sulzer Brothers had demonstrated that Swiss industry was capable of building nuclear plants. Unfortunately, on 21 January 1969, the Lucens plant was abruptly put out of service by a partial core meltdown that destroyed the integrity of the primary system and released radioactivity into the cavern.

A turnkey contract was awarded, by Nordostschweizerische Kraftwerke AG (NOK), in August 1965 to a consortium made up of Westinghouse International Atomic Power Co, Ltd and

Brown Bovery & Cie for the supply of a 350 MWe plant equipped with a pressurized water reactor and two turbo-generators (Beznau). In late 1967, NOK took the option to order a duplicate of the first unit. Beznau I reached criticality by the end of June 1969, and Beznau II in October 1972.

In 1965 too, Bernische Kraftwerke AG (BKW) chose a 306 MWe plant equipped with a boiling water reactor manufactured by General Electric (GE) and twin turbo-generators from BBC (Muhleberg). In July 1971, full power was achieved, but on 28 July a turbine fire broke up. Sixteen months later the plant was officially handed to the owner.

In 1973, a supply contract was signed by a consortium of Swiss utilities with Kraftwerk Union (Siemens) for the delivery of a 900 MWe pressurized water reactor and turbo-generator (Goesgen). Construction of the plant went very smoothly until the first connection to the grid in February and 80% power test in March 1979. However, the accident at Three Mile Island on 29 March 1979 led to an 8-month delay in commissioning.

In December 1973, a consortium of Swiss utilities and one German utility awarded a turnkey contract to General Electric Technical Services Overseas (GETSCO) and BBC for the supply of a 940 MWe nuclear power plant equipped with a boiling water reactor (Leibstadt). Construction began in 1974 and the plant was commissioned in December 1984.

The nuclear controversy began in Switzerland in 1969 with the first signs of local opposition to a nuclear plant project at Kaiseraugst, near Basel. For 20 years, the Kaiseraugst project was to remain center stage in the nuclear controversy: site permit, local referenda, legal battles, site occupation by opponents in 1975, parliamentary vote in favor of construction in 1985, and finally parliamentary decision in 1989 to kill the project definitively. The Chernobyl accident of spring 1986 had drastically affected the political climate. An other project, less advanced than Kaiseraugst, Graben has also been cancelled.

The nuclear controversy led to several anti-nuclear initiatives:

i) an attempt to forbid all nuclear plants, both new and those already in operation - rejected by 51,2 % of the voters in February 1979;
ii) aimed at forbidding future nuclear plants, leaving untouched the plants in operation, two initiatives differing only in the treatment to be applied to Leibstadt, then under construction - rejected by 4,2 and 55 % of the voters in September 1984;
iii) nuclear phase-out - rejected by 52,9 % of the voters in September 1990;
iv) 10-year moratorium - accepted by 54,6 % of the voters in September 1990.

In 1972, specific steps toward the realisation of Swiss disposal facilities were initiated through the formation of the national co-operative for the disposal of radioactive wastes (NAGRA), which brings together the operators of nuclear power plants and the Federal Government. NAGRA must ensure that in the near future (about 2000) low and medium level radioactive wastes could begin to be stored in a final repository, and that at a later stage (about 2020) a separate deep disposal site will be ready to receive the high-level radioactive wastes to be returned by the fuel reprocessing plants abroad.

Two interim storages for low and medium level radioactive waste are operative since 1993:

- "ZWIBEZ" on the site of BEZNAU
- "BZL" on the site of the Paul Scherrer Institut

A third one "ZWILAG" (interim storage for radioactive wastes from nuclear power plants), on the site of the Paul Scherrer Institut, should be operative in 2000, and a final storage for low and medium level radioactive wastes should be erected at the Wellenberg, in central Switzerland, in the coming years.

### 3. 2. Current Policy Issues

Today, there is a broad political debate about nuclear power generation in Switzerland, as in many other industrialized countries around the world. The Swiss Government and public utilities have clearly stated that nuclear energy is needed to solve energy problems in the future. The population has, however, accepted, with a small majority, a ten years moratorium which will end in the year 2000.

For now, the capacity increase of the nuclear power plant at Leibstadt (to be licensed by the beginning of 1996), the authorization for the repository for low and medium level radioactive wastes at the Wellenberg (general license to be granted before 1997) and the intermediate storage for the wastes from nuclear power plants at Wurenlingen (construction license and operating license planned for spring 1996) are the only open issues.

### 3. 3. Status and Trends of Nuclear Power

The five nuclear units in operation in Switzerland contribute more than 35% of the electricity generation in the country. In December 1994, Beznau-II, a 350 MW(e) PWR unit in operation since 1971, was issued a license for operation until the end of 2004. Similarly, the 355 MW(e) BWR unit in operation at Muehleberg was issued a ten year operation license after refurbishment and 10% capacity upgrade in 1992. In both cases, the operating utilities intend to seek for an extension of the license before it expires. The three other units in operation have unlimited operating licenses. Table 6 shows the status of the Swiss nuclear power plants.

In September 1990, Switzerland voted by referendum to impose a ten year moratorium, which prevents any plan to undertake the construction of a new nuclear unit before the turn of the century.

TABLE 6. STATUS AND TRENDS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier |
|---|---|---|---|---|---|
| BEZNAU-1 | PWR | 365 | NOK | Operational | WEST |
| BEZNAU-2 | PWR | 357 | NOK | Operational | WEST |
| GOESGEN | PWR | 970 | KKG | Operational | KWU |
| LEIBSTADT | BWR | 1030 | KKL | Operational | GETSCO |
| MUEHLEBERG | BWR | 355 | BKW | Operational | GETSCO |

| Station | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|
| BEZNAU-1 | 01-Sep-65 | 30-Jun-69 | 17-Jul-69 | 01-Sep-69 | |
| BEZNAU-2 | 01-Jan-68 | 16-Oct-71 | 23-Oct-71 | 01-Dec-71 | |
| GOESGEN | 01-Dec-73 | 20-Jan-79 | 02-Feb-79 | 01-Nov-79 | |
| LEIBSTADT | 01-Jan-74 | 09-Mar-84 | 24-May-84 | 15-Dec-84 | |
| MUEHLEBERG | 01-Mar-67 | 08-Mar-71 | 01-Jul-71 | 06-Nov-72 | |

Source: IAEA Power Reactor Information System, yearend 1996

### 3. 4. Organizational Chart

The institutional structure of the Swiss regulatory nuclear sector and the relationship among different organizations are shown in Figure 1. The Federal Department of Transports, Communications and Energy (EVED) is a regulatory body, which reports to the Federal Council. The Federal Office of Energy (BEW), also a regulatory body, reports to the Federal Department of Transports, Communications and Energy (EVED). The Swiss Nuclear Inspectorate is part of the Federal Office of Energy (BEW). The Commission for Safety of Atomic Installation Reports to the Federal Council via the Federal Office of Energy (BEW).

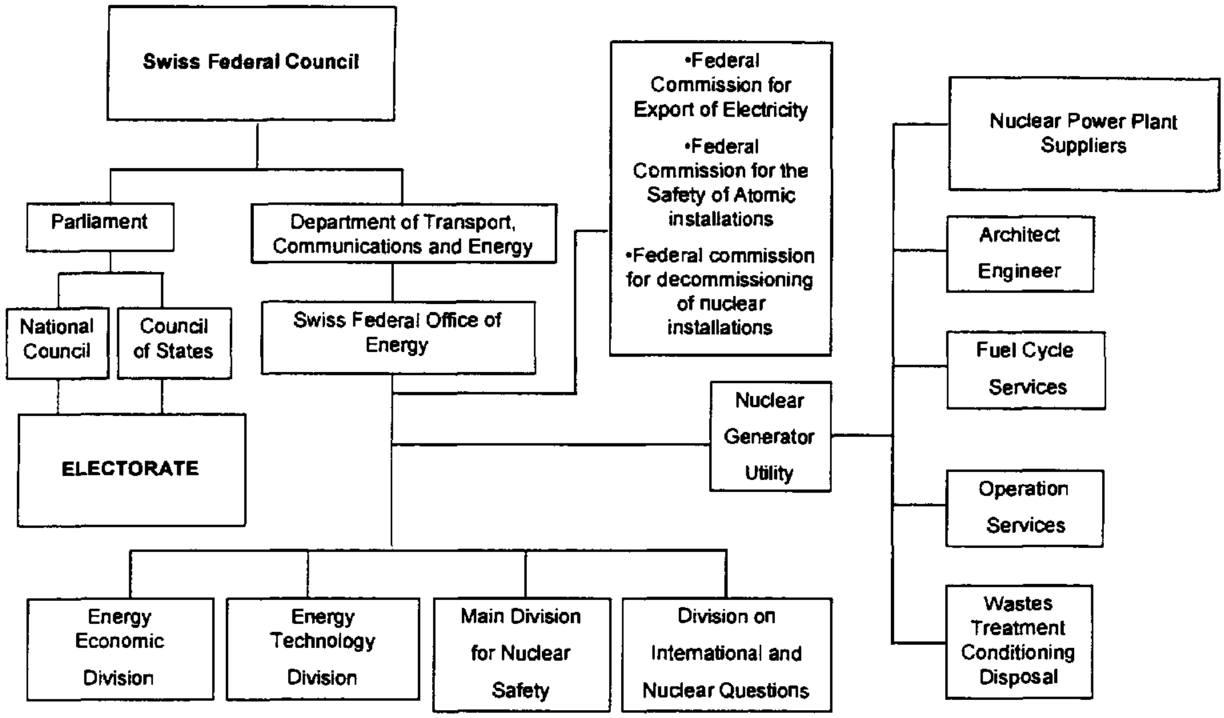


*FIG. 1. Institutional Structure*

## 4. NUCLEAR POWER INDUSTRY

### 4. 1. Supply of Nuclear Power Plants

- ABB, Asea Brown Boveri AG
  (Nuclear power plants, nuclear wastes facilities, LWR fuel, fuel channels, BWR control rods, fuel management services, nuclear services, engineering services)

- Colenco Power Consulting Ltd
  (Nuclear technology surveys, bid process, contractual advice, procurement of nuclear systems, radioactive waste conditioning/disposal, emergency training)

- Elektrowatt Engineering Services Ltd
  (Nuclear system engineering and design, containment protection features for severe accidents, probabilistic safety analysis, conditioning of radioactive solids, treatment of radioactive liquids, plasma incineration of radioactive waste. )

- GE Nuclear Energy (GETSCO)
  (Integrated, full scope services including upgrades, modifications and outage support, BWR reload fuel, control rods, fuel channels, advanced reactors 600-1300 MWe)

- Rütschi Pumpen AG
  (Pumps for all circuits in nuclear engineering, canned motor pumps, pumps with shaft seals, complete piping systems with instruments and accessories; authorized by ASME-N-Stamp Class 1, 2, 3).

- Sulzer Thermtec Ltd, Nuclear services and valves
  (Development and manufacture of valves for safety and isolating functions of NPPs. Control valves, system-medium operated valves, solenoid and pilot operated valves, inductive position indicators and transmitters, high density fuel storage racks, systems for filtered containment

venting, special devices and plant equipment, primary and secondary circuit piping systems and components, welded special constructions, structures and vessels, planning and engineering services for new design, retrofit and component requalification, plant life extension, preliminary investigations and studies, structural mechanics and fluid dynamics consulting, manufacture and procurement of equipment, planning and execution of comprehensive erection works, such as steam generator replacements, base-line and in-service inspection services, performance of leak test services).

### 4. 2. Operation of NPPs

#### *4. 2. 1. Owners/Operators*

- Bernische Kraftwerke AG, Kernkraftwerk Mühleberg.
  (BWR, 355 MWe (net); NSSS supplied by GETSCO; turbine island supplied by BBC)

- Nordostschweizerische Kraftwerke AG, Kernkraftwerk Beznau I & II.
  (PWR, 2 x 350 MWe (net); NSSS by Westinghouse, turbine island by BBC)

- Kernkraftwerk Goesgen-Daeniken AG.
  (PWR, 965 MWe (net), NSSS by KWU, turbine island by KWU)

- Kernkraftwerk Leibstadt AG.
  (BWR, 1030 MWe (net); NSSS by GESTSCO, turbine island by BBC)

#### *4. 2. 2. Operation and maintenance service suppliers*

- ABB, Asea Brown Boveri AG (see also 4. 1)

- ARC Machines, Inc.
  (Automatic orbital TIG welding/equipment. For heavy wall piping, fuel pins, instrumentation tubing, process piping. Remote control systems)

- GE Nuclear Energy (GETSCO) (see also 4. 1)

- ICT Inter Control Technology AG
  (Installations and equipments for examination of spent fuel elements and fuel rods, remote handling systems, MS manipulators, nuclear robots)

- Pedi AG
  (Systems for protection of persons for production, supervision, maintenance and emergencies; Remote handling tools, lead shielding, working tents)

- Sulzer Thermtec Ltd, Nuclear services and valves (see also 4. 1)

#### *4. 2. 3. Operator training*

- Reaktorschule PSI
  (Theoretical formation of operation personal for nuclear facilities at all levels and of engineers involved in maintenance works in nuclear facilities)

### 4. 3. Fuel Cycle and Waste Management Service Supply

#### *4. 3. 1. Uranium , Enrichment*

- none

*4. 3. 2. Fuel Transportation*

- SAR AG
  (organization of transportation, transportation of rods and such material)

- FRACHT AG
  (organization of transportation, transportation of fresh fuel bundles and such material)

*4. 3. 3. Spent Fuel Disposal*

- NAGRA
  (Swiss national co-operative for the disposal of radioactive wastes)

*4. 3. 4. Waste Management and Disposal*

- NAGRA (see also 4. 3. 3)

- Paul Scherrer Institut
  (Waste management for research, industry, medicine)

- BZL "Bundes Zwischenlager"
  (interim repository for low and medium level radioactive wastes from industry, research and medicine)

- ZWIBEZ "Zwischen Lager Beznau"
  (interim repository for low and medium level radioactive wastes from nuclear power plants Beznau I & II)

**4. 4. Research and Development Activities**

- Paul Scherrer Institut
  - (Waste management, LWR safety, reactor physics and systems engineering, material technology and nuclear processes, thermo-hydraulics)

- Ecole polytechnique fédérale de Lausanne, CRPP
  - (Physics of Alfvén wave heating, start-up assist, test of new optical diagnostics and their use to study transport phenomena, transport in Ohmic and RF heated plasma in nuclear fusion research)

- Ecole polytechnique de Lausanne, IGA
  - (research on reactor physics)

**4.5. International Cooperation in the Field of Nuclear Power Development and Implementation**

*4. 5. 1. Paul Scherrer Institut (PSI)*

The PSI participates in the following international programmes :

- Analytical evaluation of a low-power LOCA without scram (USA);

- Co-operation in the field of advanced nuclear systems (F);

- Fuel modelling at extended burn-up (IAEA);

- Actinide and fission product separation transmutation (OECD/F);

- European fast reactor AGT-3/AGT-4 (EFR);
- Passive decay-heat removal and fission-product retention systems for LWRs (USA);
- LWR safety research (D);
- HDR safety programme ((D);
- Nuclear plant life extension research (USA);
- Aerosol containment experiments (USA);
- USNRC Severe accident research, human factors research, risk and accident management programmes (USA);
- Code assessment and applications programme: ICAP (14 Countries);
- F4 representation in committee for the safety of nuclear installations (NEA/OECD);
- Halden fuels and materials (N);
- Nuclear fuels industry research group phase II (USA);
- Validation of safety-related physics calculations for low-enriched gas-cooled reactors (USA, CIS);
- Development of ELCOS-System (IL,USA);
- Development and validation of RETRAN03 (USA);
- BWR-supervision (IAEA);
- Task-force corium- reactor vessel interaction studies (10 countries).

*4. 5. 2. Ecole Polytechnique Fédérale de Lausanne,CRPP (EPFL*

The EPFL participates in the following international programme:

- Engineering Design Phase (EDA) of the International Thermonuclear Experimental Reactor (ITER) (several countries).

## 5. NUCLEAR LAWS AND REGULATIONS

### 5. 1 Regulatory Framework

The construction and operation of nuclear facilities and any changes in their purpose, nature or size require a general license prior to the granting of technical licenses. Nuclear facilities are installations designed for producing nuclear energy or for obtaining, processing, storing or rendering harmless nuclear fuels and radioactive wastes. The general license determines the site and the main features of the project. The application for a general license must be accompanied by:

- proof of need: The installation or the power to be generated must meet a real need in the country. When determining such a need, account should be taken of possible financial savings, oil substitution and the development of other forms of energy;

- proof of safe disposal: The safe long-term disposal as well as final storage of the radioactive wastes from the installation are to be provided for along with decommissioning and possible dismantling after final shutdown.

The applicant must fulfill further conditions relating to insurance cover and technical capability. The written application sent to the Federal Chancellery is published in the "Feuille Fédérale" (Swiss Official Gazette) and made available to the public along with any supporting documents. Anyone may then submit written objections to the Federal Chancellery concerning the granting of the general license, within 90 days following publication of the application. The Federal Council transmits the application to the cantons and federal Departments concerned, for consultation. It also arranges for various expert reports to be prepared, mainly by the Safety Division (Hauptabteilung fur die Sicherheit der Kernanlagen : HSK) of the Federal Office of Energy (Bundesamt für Energiewirtschaft : BEW). The outcome of the consultations and reports in the "Feuille Fédérale" mark the onset of a new 90-day period during which anyone may submit objections to the Federal Chancellery. The Federal Council then invites the cantons, federal Departments and the experts whose conclusions have been challenged to state their case. Finally, after having examined the application, the opinions given during the consultations, the experts' reports and any objection made, the Federal Council reaches a positive or negative decision; the granting of a general license must also be approved by the Federal Assembly.

Licenses for constructing, operating or modifying a nuclear installation are primarily technical since the main requirements relate to nuclear safety. The conditions to be met and the procedure are identical in all cases. The application for a license for constructing, operating or modifying a nuclear installation must be accompanied by a technical report (safety analysis report) which demonstrate the safe operation of the facility under normal, abnormal and accidental conditions. The application and the safety report are published in the "Feuille Fédérale". During a period specified by the BEW, third parties may oppose the application. The HSK prepares a safety assessment accompanied with conditions and recommendations. This assessment is published in the "Feuille Fédérale". Finally, the canton where the installation is to be located is consulted. The Federal Council is responsible for issuing such licenses, the Federal Assembly is not consulted. Construction and operating licenses may be split up: the construction license into no more than three sub-licenses, the operating license into a commissioning and an operating license proper.

In addition to the Federal Government authorization, the applicant must obtain various authorisations under cantonal law (law on construction and land use planning, protection of the environment and landscape, protection of workers, forestry, fire protection, water protection, use of river water for cooling purposes). For the import, export, transit and transportation of nuclear fuel a license is required. This license is delivered by the Swiss federal office of Energy (BEW). The transport must satisfy the rules of the Safety Series Nr. 6 of the IAEA.

The liability of the operator is unlimited. At the present time, all operators of nuclear installations must take out insurance with a Swiss insurer for at least SF 500 million for each installation, plus at least SF 50 million for interest payable and procedural costs. The same cover applies to transport operations for which the operator is liable. In the case of transit of nuclear material, insurance must amount to at least SF 50 million, plus at least SF 5 million for interest payable and procedural costs.

A Nuclear Damage Fund was set up by the Federal Council, it is independent and managed by the Federal Office of Energy (BEW). The task of the Fund is to cover nuclear operators up to SF 1,000 million for each nuclear installation or transport operation (plus SF 100 million for interest and procedural costs), in as much as the damage exceeds the amount covered by private insurance or if it is excluded from such cover. Operators and holders of transport licenses pay contributions into the Fund.

### 5. 2. Main National Laws and Regulations

Note: Reference to the original publication is given in parenthesis: (RO 732. 0).

*General legislation*

- Federal Law on the peaceful use of atomic energy (RO 732. 0)
- Bill on definitions and authorizations in the atomic energy field (RO 732. 11)
- Bill on export and transit of goods and technology in the field of ABC weapons and missiles (RO 946. 225)

*Organization and structure*

- Bill on the federal commission about the safety of nuclear installations (RO 732. 21)
- Bill on the Paul Scherrer Institut (RO 414. 163. 1)
- Bill on the national alert center (RO 732. 34)
- Bill on the coordinated atomic and chemical protection (RO 501. 4)

*Protection against Radiation*

- Federal Law on radiation protection (RO 814. 50)
- Bill on the protection against radiations (RO 814. 51)
- Bill on the training of personnel in the radioprotection field (RO 814. 532. 1)
- Bill on measures to protect the vicinity of nuclear installations in case of emergencies (RO 732. 33)
- Bill on interventions in case of increase of radioactivity levels (RO 732. 32)

*Regulatory regime for nuclear installations*

- Federal Law on the peaceful use of atomic energy (RO 732. 0)
- Federal resolution related to the atomic energy Law (RO 732. 01)
- Bill on the funding for decommissioning of nuclear installations (RO 732. 013)
- Bill on the surveillance of nuclear utilities (RO 732. 22)

*Radioactive waste management*

- Bill on preventive measures taken in respect of management of a radioactive repository (RO 732. 11)
- Bill on collecting and dispatching of radioactive wastes (RO 814. 557)

*Civil liability*

- Bill on coverage of nuclear civil liability (RO 732. 441)
- Law on civil liability in nuclear affairs (RO 732. 44)

**5. 3. International, Multilateral and Bilateral Agreements**

*AGREEMENTS WITH THE IAEA*

- Member of the International Atomic Energy Agency (1957)

| | | |
|---|---|---|
| • NPT related agreement INFCIRC/264 | Entry into force: | 6 September 1978 |
| • Improved procedures for designation of safeguards inspectors | Accepted on: | 16 January 1989 |
| • Supplementary agreement on provision of technical assistance by the IAEA | not applicable | |

- *OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 9 March 1977 |
| • EURATOM | Non-member | |
| • Agreement on privileges and immunities | Entry into force: | 16 September 1969 |
| • Convention on physical protection of nuclear material (INFCIRC/274) | Entry into force: | 8 February 1987 |
| • Convention on early notification of a nuclear accident | Entry into force: | 1 July 1988 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 1 July 1988 |
| • Conventions on civil liability for nuclear damage and joint protocol | Signature: | 21 September 1988 |
| • Convention on nuclear safety | Signature: | 31 October 1995 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |

- Acceptance of NUSS Codes — Summary: Codes are appropriate safety principles and a basis for national requirements. National practice meets requirements though are some deviations.

- Nuclear Suppliers Group — Member

*BILATERAL AGREEMENTS*

- Agreement for co-operation between the Government of Switzerland and the Government of Australia concerning peaceful uses of nuclear energy (1988).
- Agreement for co-operation between the Government of Switzerland and the Government of Canada concerning peaceful uses of nuclear energy (1989).
- Agreement for co-operation between the Government of Switzerland and the Government of China concerning peaceful uses of nuclear energy (1988).
- Agreement for co-operation between the Government of Switzerland and the Government of France concerning peaceful uses of nuclear energy (1990).
- Agreement for co-operation between the Government of Switzerland and the Government of Russia concerning peaceful uses of nuclear energy (1990).
- Agreement for co-operation between the Government of Switzerland and the Government of Sweden concerning peaceful uses of nuclear energy (1968).
- Agreement for co-operation between the Government of Switzerland and the Government of the United States of America concerning peaceful uses of nuclear energy (1966).
- Agreement between the Government of Switzerland and the Government of France on information exchange in case of incidents or accidents with possible radiological consequences (1989).
- Agreement between the Government of Switzerland and the Government of Germany on mutual information in case of construction and operation of nuclear facilities near the border (1983).
- Agreement between the Government of Switzerland and the Government of Italy on quick information exchange in case of nuclear accidents (1989).
- Agreement between the Government of Switzerland and the Government of Germany in the field of nuclear liability (1987).
- Convention between the Government of Switzerland and the Government of Germany on the radioprotection in case of an alert (1978).
- Exchange of letters between the Government of Switzerland and the Government of France for the creation of a mixed commission on nuclear safety (1989).

## REFERENCE

[1] Geschichte der Kerntechnik in der Schweiz, Die ersten 30 Jahre 1939-1969, Published by the Swiss Society of Nuclear Engineers (SOSIN).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Office Fédéral de l'Energie | |
| Affaires énergétiques | Tel. : +41-31-322 56 22 |
| internationales | Tel. : +41-31-322 56 11 |
| Organisations nucléaires | Fax: +41-31-311 09 85 |
| CH-3003 Berne, Suisse | Telex: 911570 BEW CH |
| | |
| Office Fédéral de l'Energie | |
| Division principale de la | |
| Sécurité des Installations | Tel. : +41-56-310 38 11 |
| Nucléaires | Fax: +41-56-310 39 07 |
| CH-5232 Villigen - HSK, Suisse | Telex: 827 427 ASKCH |
| | |
| Bundesamt für Energiewirtschaft | Tel. : +41-31-615632 |
| Kappellenstrasse 14 | Tel. : +41-31-615622 |
| CH-3003 Berne | Fax: +41-31-220985 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| ABB, Asea Brown Boveri AG, | |
| Abt KWN, | Tel. : +41-56-755 71 30 |
| CH-5401 Baden | Fax: +41-56-21 27 61 |
| | |
| ARC Machines, Inc, | Tel. : +41-22 36 41 064 |
| CH-1196 Gland | Fax: +41-22 36 41 809 |
| | |
| Bernische Kraftwerke AG | Tel. : +41-31-330 51 11 |
| CH-3000 Bern 25 | Fax: +41-31-330 56 35 |
| | |
| Bernische Kraftwerke AG | |
| Kernkraftwerk Mühleberg | Tel. : +41-31-754 71 11 |
| CH-3203 Mühleberg | Fax: +41-31-754 71 20 |
| | |
| Bundesamt für Energiewirtschaft | Tel. : +41-31-322 56 11 |
| CH-3003 Bern | Fax: +41-31-3382 43 07 |
| | |
| Colenco Power Engineering Ltd, | Tel. : +41-56-77 15 15 |
| CH-5405 Baden | Fax: +41-56-83 73 57 |
| | |
| Ecole polytechnique Fédérale de Lausanne, CRPP, | Tel. : +41-21-693 34 82 |
| CH-1015 Lausanne-Ecublens | Fax: +41-21-693 51 76 |
| | |
| Ecole polytechnique Fédérale de Lausanne, IGA, | Tel. : +41-21-693 33 74 |
| CH-1015 Lausanne-Ecublens | Fax: +41-21-693 44 70 |
| | |
| Elektrowatt Engineering Services Ltd, | |
| P. O. Box, | Tel. : +41-1-385 23 26 |
| CH-8034 Zürich | Fax: +41-385 24 25 |

| | |
|---|---|
| FRACHT AG,<br>Hagenholzstr 80,<br>CH-8050 Zürich | <br>Tel. : +41-1-308 91 91;<br>Fax: +41-1-308 91 00 |
| GE Nuclear Energy (GETSCO),<br>Thurgauerstr. 40,<br>CH-8050 Zürich | <br>Tel. : +41-1-303 03 12<br>Fax: +41-1-303 01 41 |
| Hauptabteilung fnr die Sicherheit der Kernanlagen<br>CH-Villigen-HSK | Tel. : +41-56-99 38 11<br>Fax: +41-56-99 39 07 |
| ICT Inter Control Technology AG,Mr.<br>Bahnhofstr 4,<br>CH-Bürglen | <br>Tel. : +41-72-44 27 22<br>Fax: +41-72-44 28 58 |
| Kernkraftwerk Goesgen-Daeniken AG<br>Postfach 55,<br>CH-4658 Daeniken | <br>Tel. : +41-62-65 16 65<br>Fax: +41-62-65 22 01 |
| Kernkraftwerk Leibstadt AG<br>CH-4353 Leibstadt | Tel. : +41-56-47 01 01<br>Fax: +41-56-47 71 11 |
| NAGRA,<br>Hardstr. 73,<br>CH-5430 Wettingen | <br>Tel. : +41-56-37 11 11<br>Fax: +41-56-37 12 07 |
| Nordostschweizerische Kraftwerke AG,<br>Postfach,<br>CH-5401 Baden | <br>Tel. : +41-56-20 31 11<br>Fax: +41-56-20 37 55 |
| Nordostschweizerische Kraftwerke AG<br>Kernkraftwerk Beznau<br>CH-5312 Doettingen | <br>Tel. : +41-56-99 71 11<br>Fax: +41-56-99 77 01 |
| Paul Scherrer Institut<br>CH-5232 Villigen-PSI | Tel. : +41-56-99 21 11<br>Fax: +41-56-99 21 99 |
| Pedi AG,<br>CH-5036 Oberentfelden | Tel. : +41-64-45 72 80<br>Fax: +41-64-45 72 98 |
| Reaktorschule PSI<br>CH-5232 Villigen-PSI | Tel. : +41-56-99 23 65<br>Fax: +41-56-99 23 25 |
| Rüstchi Pumpen AG<br>CH-5200 Brugg | Tel. : +41-56-41 04 55<br>Fax: +41-56-41 13 31 |
| SAR AG<br>Postfach 2<br>CH-5224 Unterbüzberg | <br>Tel. : +41-56-32 10 10<br>Fax: +41-56-32 10 01 |
| Sulzer Thermtec Ltd, Nuclear Services<br>CH-8404 Winterthur | Tel. : +41-52-26 26 116<br>Fax: +41-52-26 20 039 |

Sulzer Thermtec Ltd, Valves
CH-8404 Winterthur

Tel. : +41-52-26 26 771
Fax: +41-52-26 20 039

Société Suisse des Ingénieurs nucléaires (SOSIN)
c/o Paul Scherrer Institut,
CH-5232 Villigen PSI

Verband Schweizerische Elektrizitätswerke (VSE)
Gerberstr 5,
CH-8023 Zürich

Tel. : +41-1-211 51 91
Fax: +41-1-221 04 42

# UKRAINE

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UKRAINE

# 1. GENERAL INFORMATION.

## 1.1. General Overview

Ukraine is a sovereign state in Eastern Europe. It has its own territory, higher and local bodies of State power (the Supreme Rada and Local Soviets), Government, national emblem and a state flag). The capital of the Ukraine is Kiev, which has a population of about 3 million. There are 24 administrative regions and Crimean autonomous republics in Ukraine. Ukraine is bounded on the north by Belarus, on the north-east by the Russian Federation, on the west by Poland, Slovakia, on the south-west by Hungary, Romania, and Moldova, and on the south by the Black Sea and the Sea of Azov.

The total area of Ukraine is 603,700 square km. The area spans from west to east 1,300 km and from north to south 900 km. Ukraine's state border extends for a total of 7,698 km: with Russia - 2,484 km; Belarus - 952 km; Romania - 608 km; Poland - 542 km; Slovakia - 98 km; Hungary - 132 km; Moldova - 1,194 km. The total length of Ukraine's sea coast is 1,758 km (Black Sea - 1,533 km; Sea of Azov - 225 km).

Ukraine has a moderate-continental climate; in the southern most region of the Crimea the climate is sub-tropical. The largest river of Ukraine is the Dnipro. Its length is 2,201 km, of which 981 km flows through Ukraine. The largest mountainous area (the Carpathian Mountains) in Ukraine is more than 270 km long and about 100 km wide. The highest peak is the Hoverla (2061 m).

The population of Ukraine is about 52 million (Table 1): 80% of the population is Ukrainian, the remaining 20% is Russian, Belarussian, Jew, Crimean, Tatar, Moldavian, Polish, Hungarian, Rumanian, Greek, German, Bulgarian or representatives of other numerically small nationalities. The urban population comprises 66% of the total population and the population density is 86 people per square km.

TABLE 1. POPULATION INFORMATION

| | 1990 | 1991 | 1992 | 1993 | 1994 | Growth rate (%) 1990 to 1994 |
|---|---|---|---|---|---|---|
| Population (millions) | 51.9 | 52.1 | 52.2 | 52.1 | 51.7 | -0.2 |
| Population density (inhabitants/km²) | 85.9 | 86.3 | 86.4 | 86.3 | 85.6 | |
| Predicted population growth rate (%) 1993 to 2000 | -0.2 | | | | | |
| Area (1000 km²) | 603.7 | | | | | |
| Urban population in 1993 as percent of total | 66.0 | | | | | |

Source: GOSKOMATOM

The Ukraine is one of the largest republics of the former Soviet Union. As a constituent member of the USSR, the Ukrainian republic, in accordance with the Soviet Constitution, formally enjoyed certain rights and features of a sovereign state: territory, organs of state power and administration, budget, state emblem, flag, national anthem, and Constitution. In 1944, in accordance with a decision of the Supreme Council of the USSR, the Union republics, including the Ukrainian SSR, were granted the right to conduct their own foreign relations. One year later the Ukrainian SSR became a founding member of the United Nations. Despite its dependence on Union decision and structures, the international status of Ukraine as a state in its own right increased over the years. During the period of 1944-1990, Ukraine was a signatory of 156 international treaties, a member of 16 international organisations, and participated in the work of approximately 60 permanent and interim international organs.

On July 16, 1990 the Supreme Rada of Ukraine adopted an important historic document - the Act proclaiming Ukrainian state sovereignty, independence and indivisibility of power within the boundaries of Ukrainian territory, and independence and equality in conducting foreign relations. On 24 August, 1991 the Supreme Rada, in effecting this Declaration and proceeding from the right to self-determination, proclaimed the act of independence of Ukraine. Its territory was proclaimed indivisible and inviolable and the Constitution and laws of Ukraine have exclusive validity. On December 1, 1991 an all-Ukrainian referendum was held. Results of this national referendum indicated that more than 90% of the population favoured independence. Leonid Kravchuk, the former head of the Supreme Rada of Ukraine was elected President of Ukraine.

## 1.2. Economic Indicators

Table 2 shows the historical Gross Domestic Product statistics.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 83,280 | 160,606 | 155,582 | | | |
| GDP (millions of constant 1990 US$) | 84,520 | 121,750 | 155,582 | 102,720 | 79,095 | -3.0 |
| GDP by sector in 1994: | | | | | | |
| Agriculture 16.3% | | | | | | |
| Industry 42.6% | | | | | | |
| Services 41.1% | | | | | | |

Source: IAEA Energy and Economic Data Base / GOSKOMATOM

## 1.3. Energy Situation

Ukraine is an industrial and agricultural state, rich in coal, iron ore, manganese, nickel, and uranium deposits. Its major industries are: metallurgy, mining (105 million tons of iron ore, up to 165 million tons of coal), energy (500 billion kilowatt-hours), chemical, metal-working, machine-building, food and textile production. Table 3 shows the energy reserves of the country. Ukraine produces an annual gross yield of 50 million tons of grain, 7 million tons of sugar, and four million tons of meat. Its total sowing area is 32 million hectares. The building and transportation sectors are well developed.

The historical energy supply and demand data are given in Table 4. In 1994, the considerable drop of the electric power production and coal mining surpassed the appropriate indicators of previous 1993 (Table 5). At the same time, the import of the energy sources decreased. These facts lead to a lower supply of energy resources to the national economy and hence, the consumption of energy by the Ukrainian industry decreased by 20%. Table 6 shows the specific fuel consumption by the various sectors.

The five nuclear power plants in the Ukraine accounted for some 33.9% of all electrical power in the republic with 60% supplied by coal, oil and gas, and 4% from hydroelectric facilities.

Certain aspects of the Ukrainian economy are weak: its ecology is in a precarious state, there is extensive loss of soil fertility, Ukrainian plants are outfitted with outmoded industrial equipment, there are many structural defects in the national economic complex, the service industries are underdeveloped, and there is an excessive emphasis on heavy industry and production. These problems may be resolved quickly owing to a highly-trained work-force, well-developed communications and distribution systems, favourable climate, and opportunities to develop tourism, transit systems, and investments.

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 2.46 | 0.042 | 0.238 | 0.049 | 0.003 | 2.79 |

[1] *This total represents essentially recoverable reserves and is still under investigation..*

[2] *Perspective until 2000. For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability by a factor of 10.*

TABLE 4. EVOLUTION OF ENERGY SUPPLY AND DEMAND FROM 1990 TO 1993.

Mtoe

| | | 1990 | 1991 | 1992 | 1993 | 1994 | Average Annual Growth Rate(%) 1990 to 1993 |
|---|---|---|---|---|---|---|---|
| Final Energy Consumption | -Total | 293.4 | | | 236.5 | 213.8 | -6.4 |
| | -Solids | 92.7 | | | 73.4 | 63.7 | -6.9 |
| | -Liquids | 36 | | | 20 | 16.7 | -14.8 |
| | -Gases | 136.2 | | | 113.9 | 105.8 | -5.5 |
| | -Primary Electricity [1] | 28.5 | | | 29.2 | 27.6 | -0.82 |
| Primary Production | -Total | 158.3 | 147.5 | 142 | 137.2 | 129.7 | -4.4 |
| | -Solids | 83.6 | 80 | 77.9 | 70.4 | 59.4 | -5.3 |
| | -Gases | 35 | 30.6 | 28.8 | 26.6 | 27 | -8 |
| | -Liquids | 9.9 | 7.2 | 6.3 | 6.4 | 5.8 | -11.8 |
| | -Primary Electricity [1] | 29.8 | 29.7 | 29 | 33.8 | 37.5 | 4.5 |
| Net Import (Imp-Exp) | -Total | 177.6 | 172 | 153.4 | 125.2 | 106.6 | -9.8 |
| | -Solids | 15.5 | 9.6 | 8.8 | 6.5 | 5.6 | -19.3 |
| | -Liquids | 60.6 | 57.1 | 42.2 | 27.2 | 21.6 | -18.4 |
| | -Gases | 101.5 | 105.3 | 102.4 | 91.5 | 79.4 | -3.3 |

[1] Primary Electricity = Hydro + Nuclear

TABLE 5. DOMESTIC ENERGY PRODUCTION IN 1994 AND GROWTH RATES

| Resources | Production in 1994 | 1994 Vs 1993 (%) | 1993 Vs 1992 (%) |
|---|---|---|---|
| Electricity (TW·h) | 203.2 | -11.7 | -9,0 |
| Oil, including gas condensate (mln ton) | 4.2 | 1.2 | -6.7 |
| Natural gas (bln cubic metre/) | 18.3 | -4.7 | -8.2 |
| Coal (mln ton/) | 94.4 | -18.4 | -13.4 |

TABLE 6. SPECIFIC FUEL CONSUMPTION IN 1994

| Fuel type | Total in Ukraine | Sector (%) | | | |
|---|---|---|---|---|---|
| | | Industry | Construction | Agriculture | Transport |
| Coal, $10^6$ ton | 88.4 | 86.5 | 0.5 | 1.4 | 0.9 |
| Gas, $10^9$ $m^3$ | 84.9 | 65.7 | 0.8 | 2.1 | 4.2 |
| Oil and Gas condense, $10^6$ ton | 19.7 | 100 | - | - | - |
| Crude oil, $10^3$ ton | 8924.1 | 88.6 | 1.2 | 1.5 | 4.0 |
| Furnace Fuel domestic use, $10^3$ ton | 207.8 | 27.2 | 4.6 | 16.8 | 5.6 |
| Peat, $10^3$ ton | 904.9 | 96.1 | - | 0.2 | 0 |
| Firewood for heating, $10^3$ $m^3$ | 2564.7 | 32.7 | 0.4 | 13.2 | 1.7 |

## 1.4. Energy Policy.

According to 1994 projections, it was foreseen to supply $91.1*10^6$ tons of coal, $93*10^9$ $m^3$ of natural gas and $13.2*10^6$ tons of crude oil to the consumers. The needs of crude oil could be covered by the processing of $23.8*10^6$ tons of oil, including $19.6*10^6$ tons of imported oil, and the direct purchasing of $2.5*10^6$ tons. But only $77.8*10^6$ tons of coal have been supplied, $83*10^9$ ton $m^3$ of natural gas and $10.1*10^6$ tons of crude oil. This affected negatively the work of all national economy's sectors not permitting to create the necessary fuel stock for the autumn-winter heating period. Today, because of the drop in mining and extraction of the energy sources, the prices for imported fuel have increased.

According to optimistic views, about 40% of the required fuel for fossil power plants should be imported to Ukraine by 2010. At the same time, the proven uranium reserves in Ukraine will permit the existing industry to produce the required raw material for uranium dioxide production: 800 tons per year, and in the future 2,000 to 3,000 tons per year. That will be enough for producing 150 billions kW·h of electricity per year.

A complex programme on the creation of a domestic nuclear fuel cycle industry has been developed. This programme will permit to achieve total independence from foreign fossil energy supplies.

# 2. ELECTRICITY SECTOR.

## 2.1. Structure of the Electricity Sector.

The status of the electric power sector in Ukraine can be defined by the following facts:

- During the last 15 years the main growth of the generating capacity of the power system of Ukraine has been ensured by the large and comprehensive development of nuclear power in Ukraine. In the total installed electrical capacity, the Ukrainian NPPs accounted for 25% (13.8 GW(e));
- the fast development of nuclear energy resulted in the curtailment of the development of fossil fuel plants. In the 1980s, only the generating capacities at the hydroelectric plant in Zuevo (1,200 MW(e)) and at the fossil power plant-5 (470 MW(e)) in Kharkov have been commissioned;
- in the period of the large development of the nuclear industry, the volumes of funds and technical support that have been allocated for the fossil power, were considerably reduced;
- the long-term operation of the thermal power plants without renewing the main funds, low quality (non-designed) fuel utilisation and the intensive use of the thermal power plants in the base load mode. All these facts resulted in the wear of the equipment (on average, the wear topped the target by 50% and at the separate fossil power plant of the Donetsk region, the wear topped by 70-80%);
- the deterioration of the environmental situation in the region by fossil power plants has increased;
- the electric power supply to the consumer has been provided under the conditions of a critical deficiency in fossil fuels.

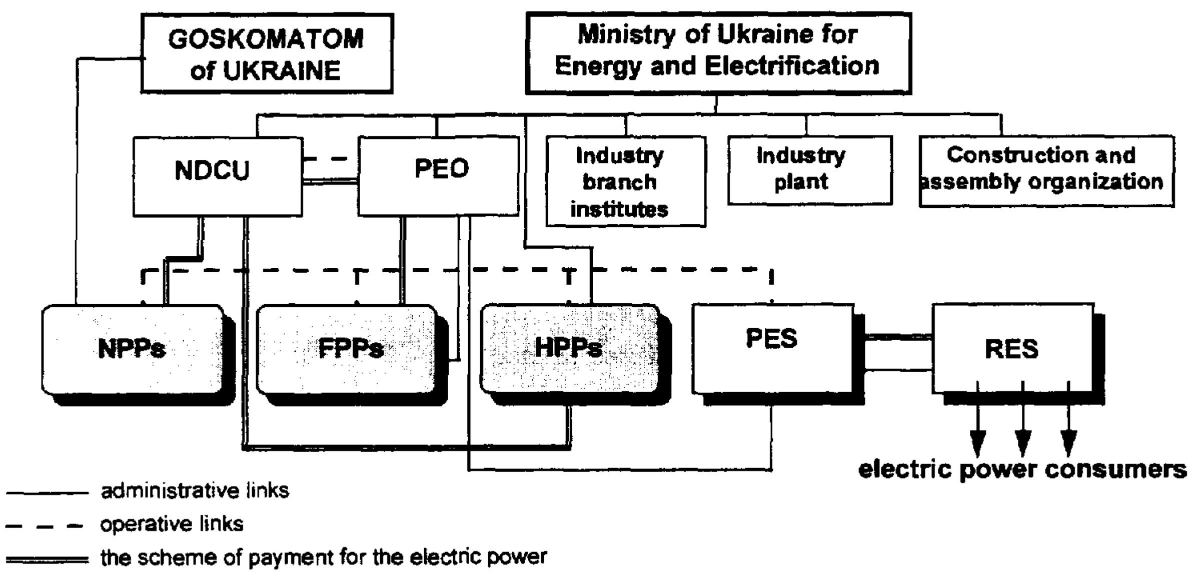
Before 1994, the organisation of the operative dispatching department in the Joint Electric Power System of Ukraine was based on the principles of the operative subordination and operational personnel responsibility. This structure has been supplemented by the administrative responsibility of the management for the decision implementation by the dispatching personnel. Later on, the operative administrative system of management was supplemented by several economic indicators that had to assure the efficiency and reliability of the National Dispatching Centre of Ukraine (NDCU). These indicators are the following:

- the tariff system for buying the electric power by NDCU from nuclear power plants (NPPs) and hydro power plants (HPPs);
- the implementation of three-zone's tariffs for buying the electric energy by the Joint Electric Power System from the NDCU;
- operational capacity of the electric power stations and energy systems;
- the ratio of electric power generation of NPPs operating in the base load mode.

In compliance with the President's Decree on "Measures on market reforming in the electric power industry of Ukraine", adopted on 21 May 1994, it is foreseen:

i) to retain the unified, Joint Electric Power System of Ukraine as guarantee of reliable electric power supply to consumers in all regions of Ukraine;
ii) to avoid the privatisation of either the main electric power transmission lines or the dispatching management in the electric power sector;
iii) to establish an independent (state) supervision body for tariff adjusting and consumer's right protection and for tariff changing policy;
iv) to create a competitive electric power market for ensuring reliable conditions for the operation of power plants;
v) to attract participation of local self-control bodies for elaboration of retail tariffs and development of local power industry;
vi) to attract investments (including foreign ones) for development of the power industry;
vii) to prevent a loss of highly qualified staff in the industry, which has become a serious problem, caused by the substantial difference in labour payment rates in Ukraine and in Russia

Figures 1 and 2 show the structures of the electric power sector and Figure 3 the structure of its regulation.




NDCU - National Dispatching Centre (planning and carrying out the control of the Joint Electric Power System)
PEO - Production energy association (8 associated in the regions)
PES, RES - Enterprises of the electric networks (regional electric networks, electric power distribution to consumers)
NPPs - Nuclear power plants
FPPs - Fossil-fired power plants
HPPs - Hydro power plants

*FIG. 1. Chart of the administrative and operative management of Ukrainian electric power sector*

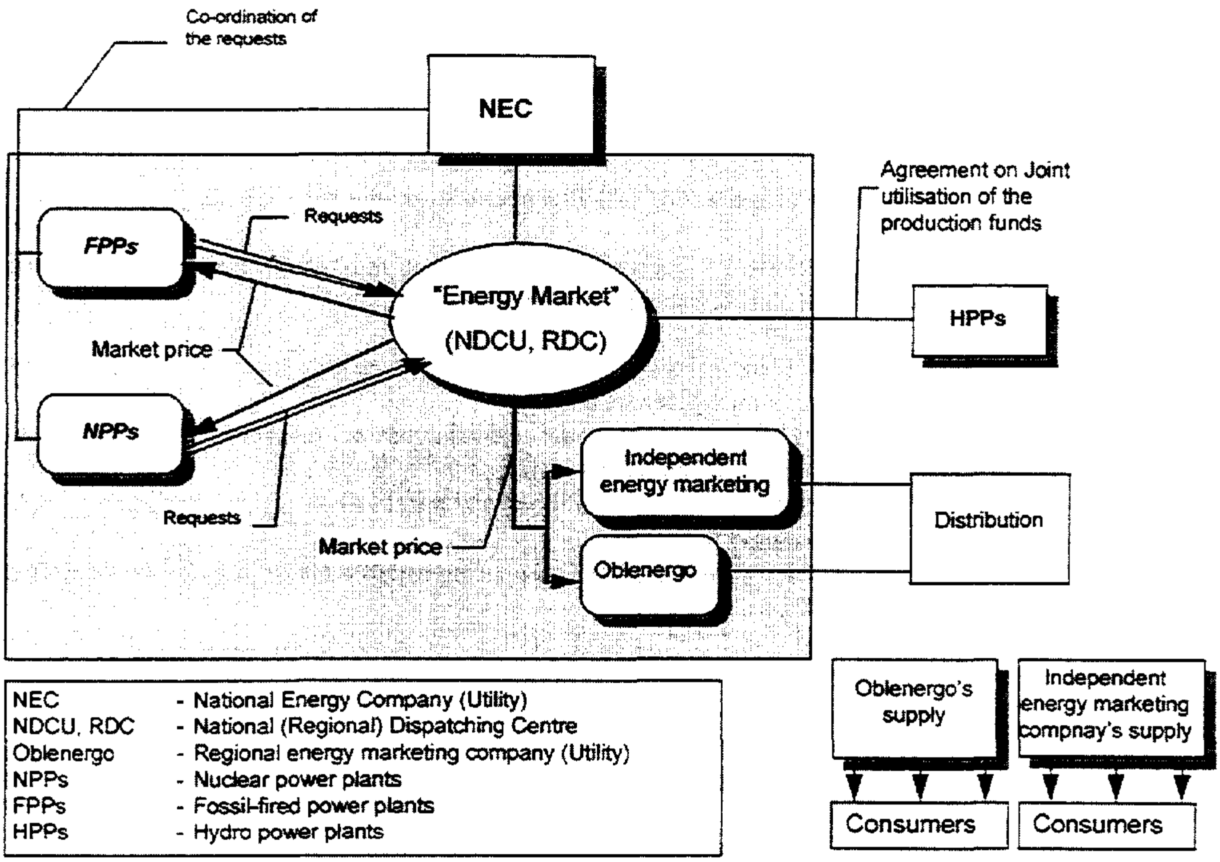



*FIG. 2. The Electric Power Market in Ukraine (during the period of the market creation)*

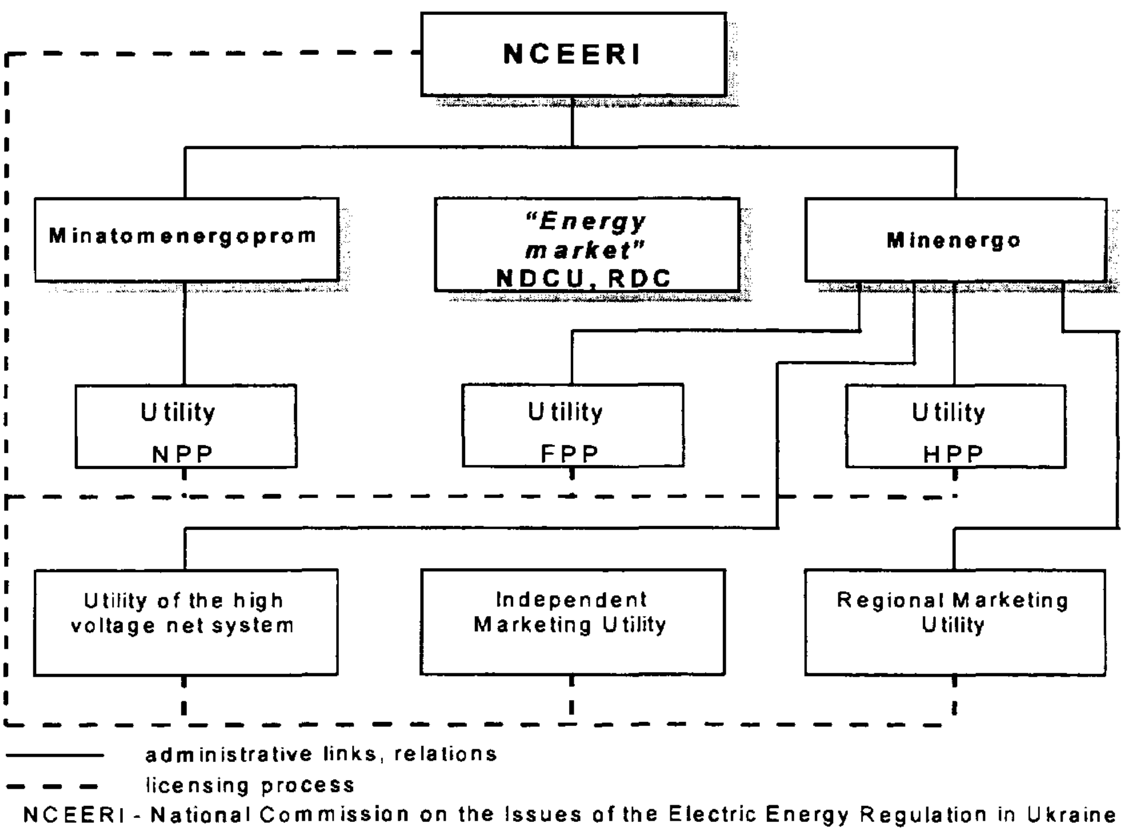



*FIG. 3. Structure of Electric Power Regulation during the period of the Energy Market Creation.*

## 2.2. Decision Making Process

The Government of Ukraine has developed the "National Energy Programme for the period until the year 2000". According to this Programme the following main measures and activities on the prospective development of electric power must be undertaken:

i. implementation of energy saving measures,

ii. orientation towards a Ukrainian fossil fuel base (coal): the refurbishment of a fossil fuel balance focused on increasing the share of coal in the electric power production and on decreasing the natural gas and crude oil utilisation.

iii. development of the nuclear industry in the future, taking into account the present deficiency in fossil fuel in Ukraine. From 1995 till 2010, the Ukraine is planning to commission 3 units with a high priority at Zaporozhe, Khmelnitsky and Rovno and 2 units with a medium priority at Khmelnitsky;

iv. the commissioning of new hydropower capacities is foreseen at Dnestr and Kanev, taking into account the deficiency of the hydropower plants whose capacity can be changed;

v. a primary task comprises the technical upgrading and rehabilitation of thermal power plants in order to extend their plant life to an additional period of 20 to 25 years and to improve their environmental and economic conditions. Before the year of 2000, the rehabilitation of thermal power plants shall be carried out by means of replacement of components and parts of turbines and boilers. After 2000, upon creating new boiler types and new technologies, it is intended to carry out a comprehensive technical upgrading in which the major equipment will be replaced with a more economical and environmentally friendly one.

In order to provide rehabilitation and technical upgrading of thermal power plants it is required to raise funds. However, the funds raised by means of tariff escalation will not be sufficient, unless other financial sources from outside, including those obtained as a result of establishment of stock-holding companies and privatisation of thermal power plants, are provided.

## 2.3. Main Indicators

By yearend 1994, the installed capacity of all electric power plants was 54.1 GW(e), i.e.:

- Minenergo's fossil power plants 32.4 GW(e) (59%);
- hydro power plants 4.7 GW(e) (8.7%) and
- nuclear power plants was 12,8 GW(e) (about 23.7%);
- fossil fired electric power units of other departments 4.2 GW(e) (i.e. 7.7%).

Table 7 and Figure 4 show the historical electricity production and installed capacity data. Figure 5 shows a comparison of the electricity generation by fuel types in 1994 and 2000.

The specific character of power production and consumption permits the presence of a high power intensive industry. However, this industry considerably depends on the primary energy sources supplied from Russia (e.g. coal, oil and gas), Poland (coal) and Turkmenistan (gas). Due to the economic difficulties mentioned in section 1.3, the considerable drop in the electric power production from 298.5 TW·h in 1990 to 203.2 TW·h in 1994 has lead to a redistribution of the consumption structure toward the domestic services industry.

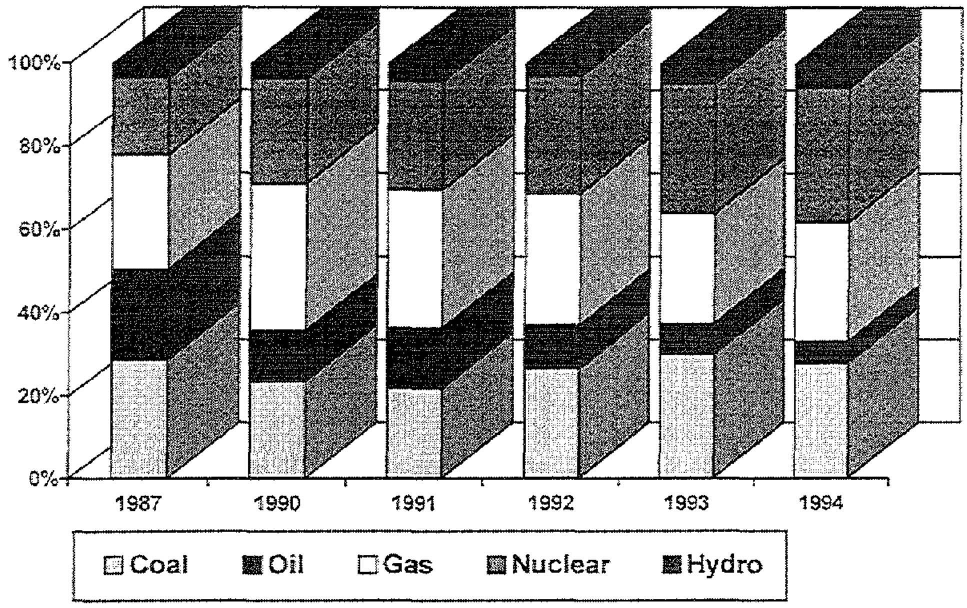



*FIG. 4. Electricity Generation by Type of Fuel (%)*

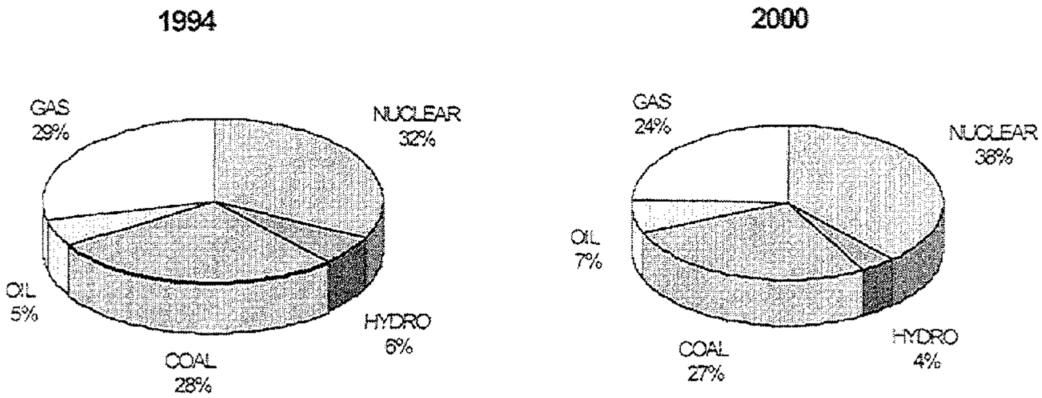



*FIG. 5. Comparison of Electricity Generation by fuel type (1994 and 2000)*

TABLE 7. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | Average Annual Growth Rate(%) 1990 to 1993 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Electricity Generation (TW·h) | -Total | 272 | 272.7 | 281.4 | 297.2 | 295.3 | 298.5 | 278.7 | 252.5 | 229.9 | 209.10 | -7.7 |
| | -Hydro/geothermal | 10.7 | 10.6 | 9.5 | 12.1 | 10.1 | 10.7 | 11.9 | 8 | 11.2 | 12.32 | 1.6 |
| | -Nuclear | 53.3 | 42.6 | 52.6 | 71.9 | 66.5 | 76.1 | 75.1 | 73.7 | 75.2 | 68.85 | -0.4 |
| | -Thermal | 208 | 219.3 | 219.3 | 213.2 | 218.7 | 211.6 | 191.6 | 170.7 | 143.4 | 127.93 | -10.7 |
| | -Imports | -23.3 | -19.1 | -19.3 | -30.8 | -27.3 | -28 | -14.3 | -4.6 | -1.1 | | 32 |
| | -Gross Domestic Consumption | 248.7 | 253.5 | 262.2 | 266.3 | 268 | 270.5 | 264.3 | 247.9 | 228.8 | | -5.1 |
| | -Own Consumption | | | | | | | | | | | |
| | -Distribution Losses | 41 | 40.3 | 42.3 | 41.2 | 40.6 | 40.9 | 40.7 | 40.2 | 39.3 | | -1.4 |
| | -Energy Branch Consumption | | | | | | | | | | | |
| | - Available Internal Market | | | | | | | | | | | |
| | - Final Consumption | 207.6 | 213.2 | 219.9 | 225.2 | 227.4 | 229.5 | 223.7 | 207.7 | 189.5 | | -5.8 |
| Electricity Power Generation Capacities (GW(e)) | -Total | 51.1 | 52.3 | 54.3 | 54.6 | 56.6 | 55.6 | 55.3 | 54.3 | 54.2 | 54.24 | -0.8 |
| | -Nuclear | 8.8 | 9.8 | 11.8 | 11.8 | 13.8 | 13.8 | 13.8 | 12.8 | 12.8 | 12.68 | -2.4 |
| | -Thermal | 37.5 | 37.8 | 37.7 | 38.1 | 38 | 37.1 | 36.8 | 36.8 | 36.7 | 36.86 | -0.3 |
| | -Hydro | 4.700 | 4.699 | 4.703 | 4.703 | 4.706 | 4.706 | 4.705 | 4.705 | 4.705 | 4.71 | 0.0 |

# 3. NUCLEAR POWER SITUATION

## 3.1. Historical Development

Nuclear energy in Ukraine started its development in the early 70s with the construction of the first nuclear reactor at Chernobyl. The reactor is an RBMK reactor with a capacity of 1000 MW(e) and commenced operation in 1977. The Ukrainian nuclear energy programme was developed as part of the nuclear energy programme of the former Soviet Union in order to ensure the military defence of the country. A close co-operation was set up between research centres and relevant industries to include all areas needed for the utilisation of nuclear energy, such as geology, ore mining and processing industry, metallurgy, chemistry, etc. A significant part of the technical and scientific nuclear complex was based in the Ukraine: - 15 power reactors (some of which are under construction, including 10 units of the 3rd generation), - uranium ore mining and processing enterprises, - metallic zirconium and hafnium production centres (used as construction materials in the new reactor types), and - some of the S&R and R&D institutes. The reactors have been built at 5 sites: Chernobyl, Rovno, South Ukraine, Zaporozhe and Khmeltnitski.

After the accident at the 4th reactor unit at Chernobyl, the Supreme Soviet of Ukraine adopted on 02.08.1996 a moratorium to build new nuclear power units in the Ukraine. The construction work at unit 6 at Zaporozhe was interrupted and the construction of 4 new VVER type reactors at Khmelnitski and Rovno was also halted.

In the second part of 1991 the break-down of the USSR has deeply affected the structure of the energy complex resulting in the separation of its enterprises and loss of the centralised management system. In that situation the Cabinet of Minister has made the NPP managers personally responsible for the NPP safe operation. Some changes were introduced into the management structures and the document needed for receiving by NPP the operational body status and permission for the operation. All these documents have been submitted to the Regulatory body - GOSATOMNADZOR.

In order to create the State management system, ensuring the safe operation of the nuclear energy, the Ukrainian State Committee on Nuclear Power Utilisation has been established (GOSKOMATOM) by the Decree of the Cabinet of Ministers of Ukraine on 16 January 1993.

At present the Nuclear Energy Complex of Ukraine includes the NPPs, the uranium ore mining, processing and enrichment enterprises, the facilities for producing metallic zirconium and hafnium, the R&D Institutes, the maintenance and repair enterprises and the enterprises for NPP completion.

One direction in the stabilisation of the nuclear energy complex situation is the creation of a national nuclear fuel cycle. The Government of Ukraine has submitted the "National Energy Programme of Ukraine for the period until 2010" to the Supreme Soviet of Ukraine for approval. This programme foresees the creation of the nuclear fuel cycle. According to this document Goskomatom of Ukraine has developed the "Complex programme of the Nuclear Fuel Cycle Creation" in Ukraine.

## 3.2. Current Policy Issues

After the breakdown of the USSR which resulted in the economical and political crisis of the industry in Ukraine, the nuclear sector was able to maintain important relations with Russia based on the Intergovernmental agreement signed on 14 January 1993. Russia is interested in co-operation with Ukraine because it has an excess production capacity for producing fresh nuclear fuel. At the same time Ukraine is interested in buying Russian fuel because it is cheaper than on the world market. The economic importance of electricity is increasing in the economic depression and crisis period. So Ukraine should analyse the possibility of putting the nuclear power units which are in an advanced stage of construction into operation

According to the status in 1991, the construction stage of unit 6 at Zaporozhe was 95%, of unit 2 at Khmelnitsky 85% and of unit 4 at Rovno 80%. All these Units could be put into operation in 1-2 years, however the moratorium on the construction of new NPPs in Ukraine has changed the situation. On 21 October 1993 the Supreme Soviet has cancelled the moratorium for new nuclear power plants construction. The preparation for start up has been recommenced at Zaporozhye (Unit 6); the construction work has been continued at Rovno (Unit 4) and Khmelnitsky (Unit 2) accordingly to the commissioning work programme.

A specific place is taken by the Chernobyl NPP in the nuclear energy programme of Ukraine. The President of Ukraine has taken the decision to close the Chernobyl NPP before the year 2000. The construction of replacing capacities and the solutions of Slavutich citizens' social problem are evaluated by experts to amount to US $ 4.4 billions. The decommissioning of Chernobyl will result in an additional annual purchase of 4.7 mln tons of fuel for the fossil power plants. Ukraine will not be able to cover all these costs without the assistance of other countries.

As the main measures and direction of the activities on the prospective development of the electric energy, the following actions must be undertaken:

i) implementation of the measures for saving energy;
   orientation toward Ukrainian fuel (coal), the refurbishing of the fuel balance focused on increasing the share of coal in the electric power production and on decreasing the share of natural gas and crude oil.
ii) taking into account the present deficiency in fossil fuel in Ukraine, the nuclear industry should be developed in the future. From 1995 till 2010, the Ukraine plans the commissioning of 3 reactors which are in an advanced stage of construction (at Zaporojye , Khmelnitsky and Rovno) and 2 reactors which are lesser advanced in construction (at Khmelnitsky).

### 3.3. Status and Trends in Nuclear Power

At present, the Ukrainian Nuclear Energy consists of the 20 nuclear reactors , of which 15 are operating nuclear power plants and 5 are under construction. The installed capacity of the operating plants is 13.8 GW(e), which is 23,6% of the total electric capacity in Ukraine. In 1996, the NPPs have produced 44% of total electric power production. The five reactors under construction have a capacity of 1,000 MW(e) each and are expected to be commissioned before 2000. Table 8 shows the status of the nuclear power plants and Fig. 6 the increase in commissioning.

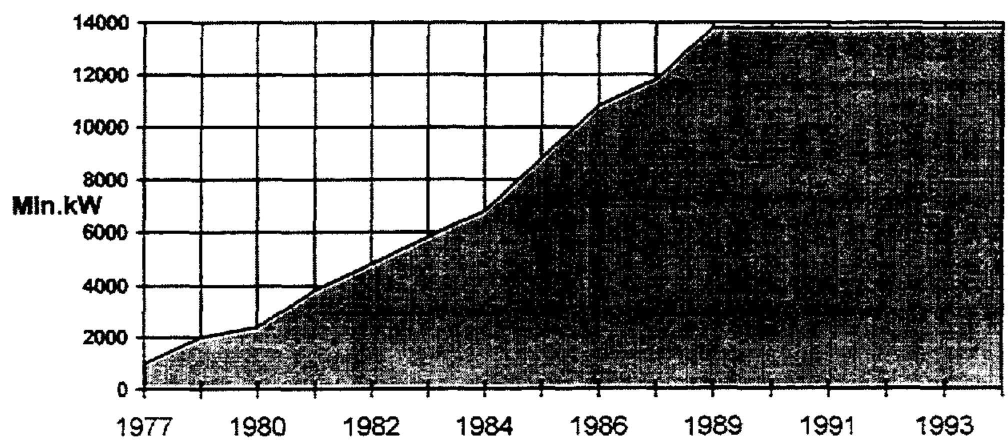



*Fig.6. Commissioning of NPPs in Ukraine*

TABLE 8. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| CHERNOBYL-1 | LWGR | 725 | GOSKOMAT | Operational | | 01-Jun.-72 | 02-Aug.-77 | 26-Sept.-77 | 27-May-78 | |
| CHERNOBYL-2 | LWGR | 925 | GOSKOMAT | Operational | | 01-Feb.-73 | 17-Nov.-78 | 21-Dec.-78 | 22-May-79 | |
| CHERNOBYL-3 | LWGR | 925 | GOSKOMAT | Operational | | 01-May-77 | 02-Jun.-81 | 10-Nov.-81 | 06-Jun.-82 | |
| KHMELNITSKI-1 | WWER | 950 | GOSKOMAT | Operational | | 01-Nov.-81 | 09-Dec.-87 | 31-Dec.-87 | 13-Aug.-88 | |
| ROVNO-1 | WWER | 363 | GOSKOMAT | Operational | | 01-Aug.-76 | 17-Dec.-80 | 31-Dec.-80 | 21-Sept.-81 | |
| ROVNO-2 | WWER | 377 | GOSKOMAT | Operational | | 01-Oct.-77 | 19-Dec.-81 | 30-Dec.-81 | 30-Jul.-82 | |
| ROVNO-3 | WWER | 950 | GOSKOMAT | Operational | | 01-Feb.-81 | 11-Nov.-86 | 24-Dec.-86 | 16-May-87 | |
| SOUTH UKRAINE-1 | WWER | 950 | MAEP | Operational | | 01-Mar-77 | 09-Dec.-82 | 22-Dec.-82 | 18-Oct.-83 | |
| SOUTH UKRAINE-2 | WWER | 950 | GOSKOMAT | Operational | | 01-Oct.-79 | 30-Dec.-84 | 06-Jan-85 | 06-Apr.-85 | |
| SOUTH UKRAINE-3 | WWER | 950 | GOSKOMAT | Operational | | 01-Feb.-85 | 01-Sept.-89 | 20-Sept.-89 | 29-Dec.-89 | |
| ZAPOROZHE-1 | WWER | 950 | GOSKOMAT | Operational | | 01-Apr.-80 | 09-Nov.-84 | 10-Dec.-84 | 14-Apr.-85 | |
| ZAPOROZHE-2 | WWER | 950 | GOSKOMAT | Operational | | 01-Apr.-81 | 28-Jun.-85 | 02-Jul.-85 | 31-Oct.-85 | |
| ZAPOROZHE-3 | WWER | 950 | GOSKOMAT | Operational | | 01-Apr.-82 | 04-Dec.-86 | 10-Dec.-86 | 22-Jan-87 | |
| ZAPOROZHE-4 | WWER | 950 | GOSKOMAT | Operational | | 01-Jan-84 | 15-Dec.-87 | 21-Dec.-87 | 25-Jan-88 | |
| ZAPOROZHE-5 | WWER | 950 | GOSKOMAT | Operational | | 01-Jul.-85 | 09-Jul.-89 | 31-Aug.-89 | 08-Oct.-89 | |
| ZAPOROZHE-6 | WWER | 950 | GOSKOMAT | Operational | | 01-Apr.-86 | 06-Oct.-95 | 19-Oct.-95 | 19-Oct.-95 | |
| KHMELNITSKI-2 | WWER | 950 | GOSKOMAT | Under Construction | | 01-Feb.-85 | | | | |
| KHMELNITSKI-3 | WWER | 950 | GOSKOMAT | Under Construction | | 01-Mar-86 | | | | |
| KHMELNITSKI-4 | WWER | 950 | GOSKOMAT | Under Construction | | 01-Feb.-87 | | | | |
| ROVNO-4 | WWER | 950 | GOSKOMAT | Under Construction | | 01-Aug.-86 | 01-Jan-97 | 01-Nov.-97 | | |
| SOUTH UKRAINE-4 | WWER | 950 | GOSKOMAT | Under Construction | | 01-Jan-87 | | | | |
| CHERNOBYL-4 | LWGR | 925 | GOSKOMAT | Shut Down | | 01-Apr.-79 | 26-Nov.-83 | 22-Dec.-83 | 26-Mar-84 | 26-Apr.-86 |

Source: IAEA Power Reactor Information System, yearend 1996

The basis of the nuclear energy of Ukraine consists of the VVER - 1,000 type reactor units. The main safety criterion, on which the VVERs - 1,000 were based, was the criterion of ensuring the safety during all design base accidents, including a break in the reactor coolant system and the failure of one of the safety systems.

In order to implement the decisions of the Goskomatom's Advisory Board and taking into account unit's operational experience and the activities realised by that time, the programme on "the highest priority works for the safety upgrading of NPP with VVER - 1,000 and - 440 type reactors" was developed accordingly to the special document "The safety upgrading of NPP with VVER- 1,000, 440 type reactors" approved by the Advisory Board of GOSKOMATOM on 11 January 1994 and GOSATOMNADZOR (the State Committee on Nuclear and Radiation Safety) on 12 January 1994.

The following classification has been adopted as the methodological base. This is a classification related to the level of influence of the current deviation from the scientific-technical data to the defence in depth. This methodology was developed during the safety analysis of NPPs with -440 type reactors conducted by several IAEA missions. Three categories have been defined:

**category I** - the issues reflecting the deviation from the recognised international practice . These problems should be analysed and discussed as a part of the activities undertaken for the solution of the most important problems.

**category II** - the problems that are important for the safety performance. They relate to the deterioration of the defence in depth. Some specific measures should be undertaken.

**category III** - very important problems for the safety performance. In this case the defence in depth is insufficient. Some corrective measures are needed.

The approach mentioned above permits to compile a list of high priority compensatory measures that deeply affect the safety of a probabilistic safety analysis and can be implemented in the nearest 4 years.

The directions of the work are the following:

1. The implementation of the technical and organization measures focused on the intensification of the defence in depth (capacity management, fuel cooling, radioactive materials confining - category III accordingly to the IAEA classification).

2. The implementation of technical and organization measures aimed to the prevention of the initiating events (the operational experience and feedback in the regions, the personnel training, technical support; equipment and technology systems testing and inspection, operational procedures and emergency operating instructions development, the development of the instructions on the radioactivity protection, functional test procedures).

3. The implementation of the technical and organization measures for the accident management and its consequences' mitigation and elimination (the strategy of the accident management, the personnel training, accident management instruction, emergency response facilities, accident consequence's evaluation and radiological monitoring).

4. The preparation of the materials on the design validation for taking into account the collateral effects. (The realisation of the probabilistic safety analysis - PSA).

Accordingly to the results of the experts' evaluation, technical and organization measures, that deeply will affect the safety of the nuclear power plants in Ukraine.are being planned It is foreseen to implement all measures in two stages. At the first stage, the following main documents should be prepared:

i. on the accident's initiators;
ii. on the measures for the accident consequences' mitigation (accord. to the category 3); and
iii. on the measures for the emergency management (based on the existing analysis and the list of accidents).

At the second stage, other important measures will be elaborated and realised. At the same time, the obtained safety level should be evaluated using the probabilistic safety criteria.

During the special specific measure's development focused on the safety upgrading, taken into the following will be taken into account:

- new systems should meet the requirements of the current safety regulation documents (codes and standards). Taking into account the high priority of the category 3 measures, it is foreseen to use the equipment that now is being produced by the industry but does not meet all standards/codes requirements;

- the project of measures should take into consideration the necessity of the time minimisation for the unit's shutdown during the refurbishment;

- the realisation of the measures said above should not result in the multiple, repeated refurbishment of the same elements;

- a comprehensive Quality Assurance programme is to be implemented.

The safety level obtained during the implementation of the programme "The Safety upgrading of NPP with VVER-1000, 440 type reactors" will be evaluated after carrying out the probabilistic safety analysis, which will permit to show the contribution of each measure into the safety upgrading. Currently GOSKOMATOM and Ukrainian NPPs are conducting this kind of analysis, but its performance needs considerable expenditures of money and time. Nevertheless, based on the operational experience and experts' evaluations, decisions for carrying out some refurbishing work to upgrade the safety level of the units in operation have been taken. This work must be executed in spite of the future calculations' results. Therefore, the modernisation of VVER - 1,000, 440 power units will result in their safety upgrading according to the following phases:

Phase 1 - the measures' implementation in the nearest period of 4 years. ("The safety upgrading of NPPs with VVER- I 000, 440 type reactors".)

Phase 2- the identification of the directions for the future modernisation of NPPs after the realisation of PSA and activities on the safety evaluation of operational units according to the National Programme.

A very specific place in the Nuclear Power of Ukraine is occupied by the Chernobyl NPP with 2 operational RBMK type reactor. After the accident at the Unit 4 in 1986 the large complex of the long-term and prioritised measures has been elaborated and implemented. The fundamental changes (such as: the changes of the physical characteristics of the reactor core, modernisation of the safety and the control of device and construction, the changes in the management systems, protection and blocking systems, strict technical regulation's requirement, additional metal monitoring and maintenance inspection have been foreseen as the first priority measures. The first priority measures which have been listed in the "Plan of the measures for the NPPs safety with RBMK type reactors" adopted and approved on June 26, 1986, were implemented at all units in 1986-1987, during the spade-work for the units start-up and the first years of their operation. Starting from 1987 the work on the safety improvement of all former Soviet Union's NPPs has been carried out according to the combined measures that were being corrected during their implementation in 1988 and in 1990. So, accordingly to the conclusion of the RBMK Chief designer:

- All the measures which have been planned for RBMK type power units after 1986 were realised.
- The unit 1 & 3 safety level is not inferior to the units 1 3 of the Kursk NPP and Smolensk NPP (in Russia).

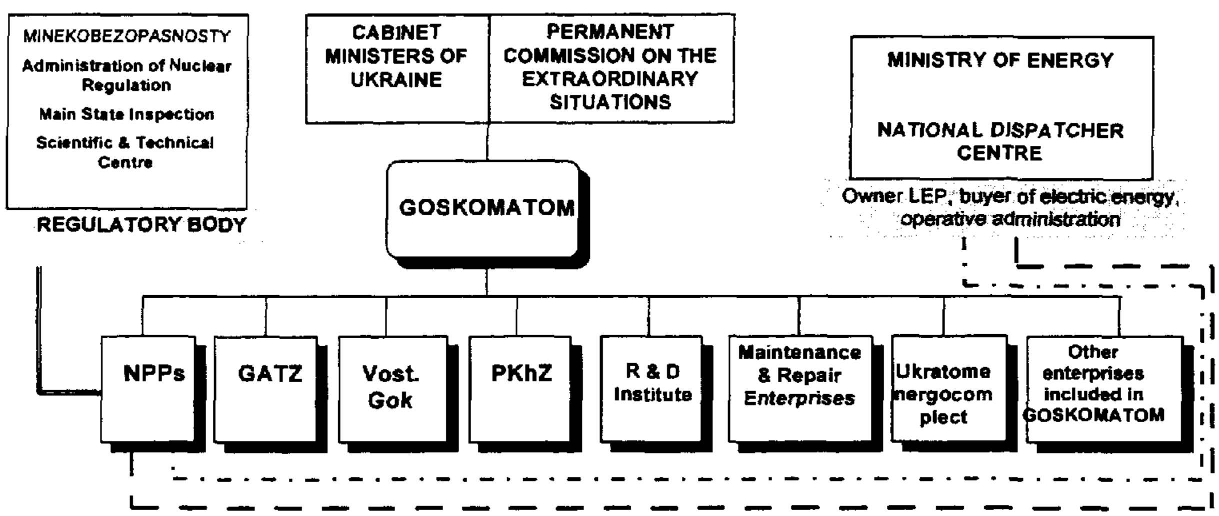
The life-cycle of the VVER-1000 & 440 units is to be 30 years. Nevertheless, because they do not meet the full safety requirements of the standards, rules and codes, a large and considerable refurbishment of the units is needed.

During the period from 2013 till 2020 eight VVER-1000 type units and two VVER-440 type units will be shut down. If the decision on the further nuclear power development is not be taken today, the nuclear power will finish its existence in 2020. Thus, taking into account its exceptional importance for the economical and political independence of Ukraine and the sluggishness of the important investments into the nuclear power sector, the first priority task of the Ukrainian National Economy is the decision on the development of the nuclear power industry. From many points of view such as: ecological, economical and strategically, from the view of the provision with the new fresh fuel, the final choice of the 21st century's reactor is extremely important for Ukraine.

### 3.4. Organisation Charts and Scheme of the Nuclear Sector Structure.

At present, the refurbishment of the nuclear energy sector (Fig. 7) is being carried out in order to:

i. to provide the population and national economy with reliable electric energy supply;
ii. to create the own nuclear fuel cycle and scientific-technical and engineering support of the nuclear energy;
iii. to complete the market reforms in the electric energy systems of Ukraine;
iv. to improve their efficiency during state property refurbishing.




administrative links — operative administration
licensing process — payment for electric energy

NPPS - 5 Nuclear power plants (incl. object "Shelter" at ChNPP)
GATZ - State Emergency-Technical Centre for helping NPP
Vost. Gok - Scientific and Production Association
Production Association - "Pridnestrovsky Chemistry Plant"
R & D Institute - Eievenergoprojekt", Kharkovenergoproject", etc.
Maintenance and Repair Enterprises - "Lvovenrgoremont", "Atomenergoremont"
LEP - Electric transmission Lines
***Status by 01.07.1995)***

*FIG. 7. Nuclear Energy Complex of Ukraine*

## 4. NUCLEAR POWER INDUSTRY

### 4.1. Supply of NPPS.

| | |
|---|---|
| Scientific management of NPP development | "Kurchatov Institute" (Russia) |
| NPP design | "Kievenergoproject"<br>"Kharkovenergoproject" |
| Energy equipment development | NIKIET, OKB "Hydropres", NPO "ZKTI" (Russia) |
| Equipment production and supply | "Atommash", "Izhorsky Plant", LMZ<br>PEO " Electrosila"; Podolsky machine manufacturing plant (Russia)<br>PO "Turboatom", PO "Zaporozhtransformator" (Ukraine) |

### 4.2. Operation of NPPs

All Ukrainian NPPs are state organisations. On 16 November 1995 the State committee of Nuclear power Utilisation - GOSKOMATOM - was established by the Decree of the Cabinet of Ministers to create the state management system and to ensure the safe operation of the Nuclear energy facilities.

According to this Decree the rights of the Operating organisations have been channelled to GOSKOMATOM. At the same time GOSKOMATOM has the right to channel some of the operating body's functions to the Nuclear power plants. GOSKOMATOM also includes the enterprises that ensure the normal operation and safety of NPPs.

Analysing the current situation in the NPP personnel training in Ukraine, we could make the following conclusions:

i. the majority part of the specialists came to the plants from the educational institutes beyond the borders of Ukraine;

ii. currently we face the difficulties due to some of the following reasons:

- the shortage of well trained and high qualified instructors;
- the shortage of the technical support, i.e. the simulators for the personnel training;
- the lack of the methodological support that is not developed enough to cover all needs and without which the complex personnel training is not possible;
- the organisation for the NPP managers and personnel training are beyond the Ukrainian borders;
- in Ukraine there are not state organisations, office, institutes providing the NPPs facilities with the permanent methodological, scientific, information assistance in the Personnel training area.

Therefore we should develop the basic documents on the personnel training. Other documents and materials are also to be developed and we have to agree and approve them according to established procedure.

For this lack elimination and to train and support the high personnel skill's level of the we need to create the complex system of the Personnel training for Nuclear Power and Industry of Ukraine. With this purpose GOSKOMATOM have developed two specific documents: the Special Conception on the Personnel Training for the Ukrainian Nuclear Power and Industry and the State Programme on the Creation of the National Personnel training system.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management Service Supply

One of the directions in the stabilisation of the nuclear energy complex in Ukraine is to create its own nuclear fuel cycle. The feasibility analysis of the national nuclear fuel cycle creation shows the necessity to produce nuclear fuel for the VVER type reactors in Ukraine. The Government of Ukraine has announced a tender for producing nuclear fuel, the results of which will be known by the end of 1995. Westinghouse, ABB, Siemens, Framatom and Minatom of Russia are participating in this tender.

Today, activities for creating a provisional dry spent fuel storage are being conducted in Ukraine. At Zaporozhe NPP, the first concrete casks will be produced with the assistance of "Duke Engineering" by the end of 1995.

One year operation of all Ukrainian NPPs results in the accumulation of low and medium level radioactive waste of the following types:

i) compacted waste - 900 $m^3$
ii) incinerated waste - 4500 $m^3$
iii) metals - 400 $m^3$
iv) pitches - 250 $m^3$.

At the same time, the nuclear power plants are producing 3-4% high-level waste of its fuel and a reprocessing technology has not yet been identified. The radioactive wastes are considered to be stored in a special storage (disposal) for a long time. As a rule, these wastes are the construction materials of the reactor equipment.

Today the NPPs in Ukraine (except for Zaporozhe) do not have any equipment for processing solid nuclear wastes. They continue to accumulate and store the waste in special cells in the specific technological building-storage. Today, according to its design equipment, the Zaporozhe NPP is operating a special facility for radwaste incineration which capacity is 50 rg per hour and the compressor (500 rH) which is packing the compressed waste in the metal canisters (drums). Liquid waste of the NPPs is processed by means of evaporation in a special evaporation installation.

Analyses of the nuclear waste accumulation at the Ukrainian NPPs show that the design capacities of the radwaste storage facilities will be used by 1999, if no special measures are undertaken. For this purpose the special Programme for creating the special branch of NPPs' Nuclear Waste management industry has been developed. The implementation of this programme will permit to create in GOSKOMATOM the acting industry-production structure, which modern technologies and scientific developments will ensure the radiation and hygienic safety of the Ukrainian population and NPP personnel during the nuclear power and industrial facilities' operation in Ukraine

### 4.4. Research and Development Activities

After the USSR break down the considerable part of the scientific and technical support of the nuclear power remained in Russia. Without such basis the Ukrainian nuclear power is not able to exist and it must not. In Ukraine there is a sufficiently powerful scientific basis, but it was insufficiently specialised on the problems of the nuclear power field. Ukraine needs to create something new, that did not exist originally in the nuclear science in Ukraine. This is the Operational Support Institute, the main task of which is to analyse and summarise the operational experience of NPPS, and to provide the NPPs with the scientific and technical information, creating and supporting the R&D documentation system.

In Ukraine we have such specific installation, as "Shelter" and the Zone and we have the problems on the NPP decommission. For this purpose it is the Shelter is to be expanded. Establishing the Programme on Nuclear Power development in Ukraine the Cabinet of Ministers proceeded from the assumption that Ukraine which is taking the path of the road of market economy creation, needs the deep social and economic reorganisations and transformations, the effectiveness of the energy policy. At the same time we should take into account the power resources balance, the competitiveness of the different energy sources , the ecological, political, social and economic consequences of the different ways of the country's power development. Today all these facts are assuming the special significance.

**4.5. International Co-operation in the Field of Nuclear Power Development and Implementation**

VARTA - the Intention Protocol on the co-operation with GOSKOMATOM has been signed on 15 March 1994 for a storage battery supply.

SIEMENS - an agreement on the supply of a cask for radwaste accumulation, storage and transportation has been signed on 21 April 1995.

WESTINGHOUSE ELECTRIC - co-operation in advanced technology supply and I&C systems.

EDF - the permanent group is working within the TACIS framework at Rovno NPP.

CEGELEC - the development of new modifications "Zentralog" for I&C; the preparation of the project on Zaporozhe NPP physical protection.

DUKE ENGINEERING - the contract on the construction of a dry storage cask at Zaporozhe NPP has been signed.

COGEMA - negotiations on a joint uranium ore mining.

**5. REGULATORY FRAMEWORKS.**

During the period of 1992-1995 the activities in the nuclear energy field and radiation protection have been based on the safety rules and regulations of the former Soviet Union that have been put into force by the Decree of GOSATONMNADZOR of Ukraine on 04. 01. 1995. The Rules and Regulations that are in force in Ukraine now don't meet the international requirements and standards and also the social -economic relations in Ukraine. The extreme necessity to create the new legislation in Ukraine regulating the Nuclear energy utilisation and radiation safety, has been appeared. At present in this area some important laws, regulations and decrees have been adopted by the Government of Ukraine. The System of the Regulatory , the Main Safety standards and the radwaste management standard; the QA standards are under development now.

**5.1. Safety Authority and Licensing Process**

The special permission for Nuclear facilities operation and its control are carried out according to the Decree of Cabinet of Ministers of 15.04.1991 and 13.01.1993. The GOSATOMNADZOR of Ukraine has developed the "Provisional Statement on Licensing process". This document is used by the persons and organisation that directly operate the Nuclear facilities, the Research reactors , the Nuclear materials storages.

The licence for operation is issued by GOSATOMNADZOR based on the results of the following documents analysis:

- the Safety feasibility report of the NPP.
- the sanitary passport, issued by GAN
- the Act of the Nuclear facility Acceptance by the special commission
- the list of the violations of the safety rules and regulations in force; the compensating measures
- the technological regulation on the safe Nuclear facility operation.
- instruction on accident liquidation.
- plan of the measures on the accident liquidation

- the attestation certificates of the personnel
- the QA Programme

**5.2. Main National Laws and Regulations**

From 1992 to 1994 the activities in the Nuclear power area and radiation protection were based on the laws and regulations on the Safety in the Nuclear Power field of the former Soviet Union. These laws have been implemented in Ukraine accordingly to the Decree N I issued by the Regulatory Authorities of Ukraine on 4 January 1992.

Today the Ukrainian laws and regulations on the Nuclear and Radiation Safety acting in Ukraine do not meet all the international requirements in many areas of the Nuclear Power field and social economic areas in Ukraine.

Ukraine needs to create urgently new legislation regulating the Nuclear Power utilisation and the radiation safety issues. The Ukrainian Government have just adopted some of the laws, regulations and decrees in this area. The System of the legal regulation is being created and the main standards on the Safety are being developed now, i.e.: the Standards for the Nuclear Waste management, the Standards and Guides on the Quality Assurance.

On 8 February 1995, the Supreme Rada adopted the law **"On the Nuclear Power Utilisation and the Radiation Safety"**. It is the basic, fundamental law of the Nuclear Legislation System. It defines the priority of the people's safety and environment, the rights and the duties of citizens in the area of the Nuclear Power utilisation. This law regulates and controls the activity related to the operation of the nuclear facilities and ionising radiation, and defines the legal basis of the international obligations of Ukraine in the Nuclear Energy field. The basic nuclear third party liability rules are set out in this basic law.

The main provisions of the law are:

- The basic principles of the Government policy in the field of the Nuclear power utilisation and Radiation Safety.
- The rights and the obligations in the field of the Nuclear Power utilisation and Radiation Safety.
- The regulation of the Nuclear power Utilisation's Safety by Government.
- The legal status of the judicial and physical persons who are engaged in the work in the Nuclear Power Utilisation and Radiation Safety area.
- The placing and construction, commissioning and decommission of the nuclear facilities and sites reserved for the nuclear waste management.
- The Specific Safety rules for the territories where there are the nuclear facilities and sites, reserved for the nuclear waste management.
- Specific conditions for the safety regulation of the crafts, aircraft's, spaceships with the nuclear installation or the ionising radiation sources.
- Nuclear Waste Management.
- The transportation of the ionising radiation sources.
- Physical protection of the nuclear materials and nuclear facilities.
- The Prevention of the utilisation of the nuclear materials, equipment and technology with the military purposes.
- the Indemnification for the nuclear damages.
- the liability for the legislation violation in the Nuclear Power Utilisation and Radiation Safety field.
- Export/import of the nuclear installations, equipment technologies nuclear materials and ionising radiation sources, specific non-nuclear materials and services in the Nuclear Power Utilisation area.
- International Co-operation of Ukraine in the field of the Nuclear Power Utilisation.

Other important laws and Government's Decrees related to the utilisation of nuclear power and radiation safety are:

- The Law on Civil defence.

  It defines the following basic tasks of the State Authorities: the prevention of the emergency; the reduction of the, damages and losses after the accident; the early notification of the population about the emergency. This law creates the system of the analysis and control; the system of early notification and communication; the special system for the oversight, control and monitoring of the radioactive contamination. This law constantly supports their readiness, preparedness for the systems' stable functioning in cases of emergency.

- The Law on Environment Protection.

  It demands to develop and to take some measures aimed to the prevention of the accidents and liquidation of their consequences. These functions, obligations have been charged on the owner of the dangerous nuclear facility and the operating organisation.

- The Cabinet of Ministers' Decree on the Creation of the Permanent Government Commission on the Ecological Safety and Emergency issued on August 10, 1994.

  This commission should quickly resolve the problems that are related to the realisation of the Ukrainian citizens' rights to protect their life and their health from the consequences of the accidents, catastrophes, ecological and moral damages. This decree is focused on the co-ordination and control of all complex of works at the Government level.

- The Decree of the Cabinet of Ministers of Ukraine on the Creation of the State Committee on Nuclear Power Utilisation - GOSKOMATOM, issued on January 16, 1993.

  According to this Decree GOSKOMATOM is responsible for the Creation of the State System for the management and the operation of the Nuclear Power facilities in Ukraine.

- The Decree of the Cabinet of Ministers of Ukraine on the Creation of "State Emergency Response Centre" on the basis of the "SPEZATOM" liquidated by the same decree. (July 16, 1993).

  This centre should ensure the permanent preparedness for the quick and effective measures in case of the accidents at the Nuclear Power facilities, radiation accident in the industry. This Centre should work accordingly to the Ukraine's international obligations that are meeting the requirements of I the International Atomic Energy Agency (IAEA) to create the National System for the liquidation of the nuclear 'dent and catastrophes' consequences.

- The President's Decree on the Creation of the Ministry of the Environment protection and Radiation Safety of Ukraine. (On the basis of the Ministry of the Environmental protection and the Ukrainian State Committee for Nuclear and Radiation Safety, which were liquidated by the same Decree of December 15, 1994).

  This Decree was aimed toward the improvement of the environmental protection and radiation safety system.

- Provisional Interdepartmental rules of the acceptance of the completed NPPs power units for the operation, approved on June 22, 1994.

  This document establishes the procedures of the acceptance of the completed NPPs for the operation, the acceptance of their separate units and separate buildings at the NPP territory.

- The President's Decree on the measures for the physical protection of the nuclear materials and facilities. (28 December 1993).

  The decree will permit to create the physical protection system that meets the international requirements.

- The Cabinet of Ministers' Decree on the Measures for the stabilisation of the NPP Work and Operation, and for the solution of the first priority tasks in the Nuclear Power development. (October 3, 1994)

  The Decree defines the special tasks of the Operating organisation: GOSKOMATOM and GOSATOMNADZOR in the further execution of the scientific-technical expertise and safety evaluation of the NPP units in operation or under construction.

In spite of the shortage of the financing (1992-1994) for the creation of the legal basis of the nuclear and radiation safety, Ukraine had created the State Structure for the Management and Regulation in the area of the Nuclear Power Utilisation and Radiation Safety. Currently, the Ukrainian Authorities hope to proceed to a specific law or Regulation on Nuclear Third Party Liability.

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Supplementary agreement on provision of technical assistance by the IAEA | Entry into force: | 21 September 1990 |
| • Comprehensive safeguards agreement under NPT | Entry into force: | 13 January 1995 |
| • Safeguards Agreement INFCIRC/153 | Signed on: | 21 September 1995 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Accession: | 5 December 1994 |
| • Agreement on privileges and immunities | Entry into force: | 5 October 1966 |
| • Convention on physical protection of nuclear material | Entry into force: | 5 August 1993 |
| • Convention on early notification of a nuclear accident | Entry into force: | 26 February 1987 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 26 February 1987 |
| • Convention on the protection . from the ionising radiation | Ratified in | 1968 |
| • Vienna convention on civil liability for nuclear damage | Non-Party | |

| | | |
|---|---|---|
| • Joint protocol | Non-Party | |
| • Convention on nuclear safety | Signature: | 20 September 1994 |
| • Nuclear Export Guidelines | Not adopted (but see Art.5 of the Agreement on the Basic Principles (Att.2)). | |
| • Acceptance of NUSS Codes | No reply | |

*BILATERAL AGREEMENTS*

- A bilateral agreement with the US government has been concluded, providing a State Guarantee (Indemnity Statement).

## REFERENCES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[2] Economic report of the President of Ukraine in the Supreme Soviet, (1994) (in Russian)

[3] Draft of the national Energy programme of Ukraine for the period till 2010.

[4] The comprehensive programme of the nuclear fuel cycle creation in Ukraine, GOSKOMATOM, (1995).

[5] The Wholesale Energy Market of Ukraine, Minenergo of Ukraine, (1995).

[6] The Regulations of Ukraine (Reference books).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL NUCLEAR ENERGY AUTHORITIES*

| | |
|---|---|
| National Regulatory Authority<br>(GOSATOMNADZOR)<br>Ministry of Environmental Protection<br>and Nuclear Safety<br>5 Khreshchatyk St.<br>252601, Kiev, Ukraine | Tel.: +7-044-226 24 28<br>Fax: +7-044-229 83 83<br>Tel.: +7-044-226 06 44 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Ukrainian State Committee on Nuclear Power Utilisation<br>(GOSKOMATOM)<br>Arsenalnaya Str. 9/11<br>Kiev 252011, Ukraine | Tel.: 294.48.14 and 294.48.75<br>Fax: 294.44.12 |
| National Commission on Scientific Relations with the IAEA<br>Nuclear Research Institute<br>Academy of Sciences<br>Prospect Nauki, 47<br>252028 Kiev-28, Ukraine | Tel.: +7-044-265 23 49<br>+7-044-265 14 56<br>Fax: +7-044-265 44 63 |

*ORGANISATIONS WITHIN THE GOSKOMATOM'S STRUCTURE.*

- Consortium of Ukrainian Nuclear Plants(includ. "Shelter" at ChNPP)
  "Ukratomenergoprom"
- State Emergency Technical Center
  Prypya — Tel: +7-044 225-53-24;
- "VOSTGOK" the ore Mining and Processing Plant
  Zhelty Vody, Dniepropetrovsk region — Tel: +8- 056-52-9-35-58;
- PO "Pridnieprovsky Chemistry Plant"
  Dneprodzerginsk — Fax/Tel: +8-056-92-3-00-43
- R&D Institute "Kievenergoproject"
  Kiev — Fax: 274-60-61
- R&D Institute "Kharkovenergoproject"
  Kharkov — Fax: +8-057-2-22-50-29
- Maintenance Enterprise "Lvovenergoremont"
  Lvov — Fax: 032-2-42-23-94
- Maintenance Enterprise "Atomenergoremont"
  Neteshin, Khmelnitsky Region — Fax: +8-038-48-3-42-44

# UNITED KINGDOM

## UNITED KINGDOM

# 1. GENERAL INFORMATION

## 1.1. General Overview

United Kingdom (UK) is an abbreviated form of United Kingdom of Great Britain and Northern Ireland. The UK consists of England, Northern Ireland, Scotland and Wales and lies in north-western Europe, occupying the major portion of the British Isles. The country's only land boundary is with the Republic of Ireland. The UK is separated from the coast of western Europe by the English Channel to the south and by the North Sea to the east. The northern and western shores are washed by the Atlantic Ocean.

As a result of the relative warmth of the nearby seas, the UK has a moderate climate, rarely marked by extremes of heat or cold. The mean annual temperature ranges between 11.1°C in the south and 8.9°C in the north-east. Seasonal temperatures vary between a mean of about 16.1°C during July, the hottest month of the year, and 4.4°C during January, the coldest month. Fogs, mists, and overcast skies are frequent, particularly in the Pennine and inland regions. Precipitation, heaviest during October, averages about 760 mm annually in most of the UK.

During the Industrial Revolution the country became rapidly urbanised, and today more than 70% of the total population of 57.6 millions (1991 est.) is concentrated in cities occupying 10% of the total land area. It has a mean population density of 235.1 persons per square km with an annual growth of 0.3%, (1990). The population is highly urbanised, and the United Kingdom is the fourth most densely populated nation in Europe (after the Netherlands, Belgium, and West Germany). The most densely populated part of the United Kingdom is England, with 354 persons per square km; Scotland has a density of 65 per square km; Wales, 134 per square km; and Northern Ireland, 110 per square km. Population in 1994 was 58.4 millions and is expected to grow to 59.4 millions in 2000. Table 1 shows the population statistics.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 52.5 | 55.8 | 56.5 | 57.6 | 58.1 | 58.3 | 0.2 |
| Population density (inhabitants/km²) | 214.5 | 227.9 | 230.8 | 235.3 | 237.4 | 238.1 | |
| Predicted population growth rate (%) 1993 to 2000 | 0.3 | | | | | | |
| Area (1000 km²) | 244.9 | | | | | | |
| Urban population in 1993 as percent of total | 89.0 | | | | | | |

Source: IAEA Energy and Economic Data Base / ONS forecasts for year 2000 from Government Actuaries

## 1.2. Economic Indicators

Gross Domestic Product (GDP) increased from US$1,024,368 million in 1994 to US$1,106,215 million in 1995. Gross Domestic Product (GDP) statistics are given in Table 2.

## 1.3. Energy Situation

Extensive coal deposits occur around the eastern and western edges of the Pennines, in South Wales, in the Midlands (Birmingham area), and in the Scottish Central Lowland. Easily accessible coal seams are, however, largely exhausted. Fortunately for the energy-hungry British economy, large deposits of petroleum and natural gas under the North Sea came into commercial production in 1975 and at present the United Kingdom is self-sufficient in petroleum (Table 3).

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 123,758 | 537,937 | 981,046 | 945,976 | 1,023,634 | 4.7 |
| GDP (millions of constant 1990 US$) | 628,014 | 760,010 | 981,046 | 975,445 | 1,012,948 | 2.1 |
| GDP per capita (current US$/capita) | 2,218 | 9,517 | 17,026 | 16,270 | 17,555 | 4.5 |
| GDP by sector (1991): | | | | | | |
| Agriculture 2% | | | | | | |
| Industry 28% | | | | | | |
| Services 60% | | | | | | |

Source: IAEA Energy and Economic Data Base / ONS

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 107.95 | 22.47 | 20.76 | | 0.90 | 152.08 |

[1] *This total represents essentially recoverable reserves*

[2] *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1992) by a factor of 10*

Source: IAEA Energy and Economic Data Base / DTI

Energy consumption by the industrial sector has fallen dramatically since 1970, with a sharp reduction in the use of coal outweighing the increased consumption of gas and electricity. The greatest growth in energy consumption has been in the transport sector mainly due to the high level of transport activity, but electricity accounts for just under 1% of total energy consumption by this sector and is used only for rail transportation. Table 4 shows the basic energy statistics.

### 1.4. Energy Policy

The formal aim of the UK Government's energy policy is to ensure secure, diverse, and sustainable supplies of energy in the forms that people and businesses want, and at competitive prices. The Government believes that this aim will best be achieved by means of competitive energy markets working within a stable framework of law and regulation to protect health, safety, and the environment. Government policies also aim to encourage consumers to meet their needs with less energy input, through improved energy efficiency.

The key elements of the policy are:

i) to encourage competition among producers and choice for consumers, and to establish a legal and regulatory framework to enable markets to work well;

ii) to ensure that service is provided to customers in a commercial environment in which customers pay the full cost of the energy resources they consume;

iii) to ensure that the discipline of the capital markets is applied to state owned industries by privatising them where possible;

iv) to monitor and improve the performance of the remaining state-owned industries, while minimising distortion;

v) to have regard to the impact of the energy sector on the environment, including adopting policies and taking measures to meet international commitments;

vi) to promote energy efficiency and renewable sources of energy;

vii) to safeguard health and safety.

In pursuit of these policies, the UK Government has privatised almost all the former state-owned energy sector (coal, electricity, gas). The only part of the generating sector remaining in public ownership is the newly formed company, Magnox Electric plc, which operates the UK's older magnox nuclear power stations.

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 6.86 | 8.70 | 8.43 | 8.85 | 9.16 | 9.20 | 1.03 | 0.63 |
| - Solids[2] | 4.96 | 3.90 | 2.98 | 2.66 | 2.22 | 2.03 | -2.51 | -2.71 |
| - Liquids | 1.85 | 4.03 | 3.26 | 3.25 | 3.26 | 3.38 | 2.86 | 0.26 |
| - Gases | | 0.47 | 1.80 | 2.19 | 2.69 | 2.80 | 37.56 | 3.22 |
| - Primary electricity[3] | 0.05 | 0.30 | 0.39 | 0.75 | 0.99 | 0.99 | 10.86 | 6.80 |
| Energy production | | | | | | | | |
| - Total | 5.01 | 4.42 | 8.33 | 8.71 | 9.21 | 10.04 | 2.58 | 1.34 |
| - Solids | 4.95 | 3.68 | 3.18 | 2.33 | 1.64 | 1.17 | -2.18 | -6.89 |
| - Liquids | | 0.01 | 3.37 | 3.85 | 4.21 | 5.33 | 40.71 | 3.32 |
| - Gases | | 0.43 | 1.38 | 1.90 | 2.53 | 2.71 | 36.23 | 4.93 |
| - Primary electricity[3]) | 0.05 | 0.30 | 0.39 | 0.63 | 0.83 | 0.83 | 10.86 | 5.47 |
| Net import (import - export) | | | | | | | | |
| - Total | 1.91 | 4.28 | 0.60 | 0.32 | 0.05 | -1.18 | -5.66 | -4.95 |
| - Solids | -0.18 | -0.10 | 0.08 | 0.37 | 0.51 | 0.39 | 4.09 | 12.23 |
| - Liquids | 2.09 | 4.35 | 0.10 | -0.34 | -0.61 | -1.65 | -14.07 | -22.09 |
| - Gases | | 0.04 | 0.42 | 0.29 | 0.15 | 0.08 | 46.24 | -10.79 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy*
[2] *Solid fuels include coal, lignite and commercial wood*
[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind*
Source: IAEA Energy and Economic Data Base

The Government has no direct operational control over any part of the energy sector, which (apart from Magnox Electric) comprises private companies operating on the basis of their own commercial criteria and judgement. This includes such things as what fuels to use for power generation, their source, and the location of facilities (although this remains subject to local planning permissions).

The gas and electricity industries are overseen by independent regulators, appointed by Government, whose role is to promote competition where possible and to protect consumers by providing a proxy for competition in areas of continuing monopoly. The requirement for regulatory intervention will diminish over time, as more sectors of the energy market become open to competition; but there will always be a need for regulation of monopoly infrastructure (the pipes and wires).

Competition has been introduced into gas and electricity markets, initially for large industrial consumers and more recently for medium sized ones. In 1998, competition will be introduced for the supply of energy to domestic and small industrial energy consumers. A pilot trial of competition for gas, to prove the systems and accounting arrangements and involving about 500,000 consumers, began in the South West region of England in April 1996; this will be extended to another 1,500,000 consumers in Southern England in 1997 before going nation-wide in 1998. The electricity industry is working on the arrangements which it will need in 1998.

The Government remains responsible for establishing the framework of environmental regulation within which the energy sector operates, including permissible levels of emissions and disposal of wastes. But within these broad parameters, it is for companies to decide how best to meet the particular environmental requirements relevant to them.

## 2. ELECTRICITY SECTOR

### 2.1. Structure of the Electricity Sector

Until 1990, when the institutional reform enacted for England and Wales by the Electricity Act 1989 was put into practice, the United Kingdom's power system had been organized as follows:

- England and Wales: power generation and transmission was in the hands of the Central Electricity Generating Board (CEGB) - a power company exerting monopoly rights over these activities, who was responsible for supplying the twelve Regional Electricity Companies (RECs) in charge of distribution. The Electricity Council, an intercompany co-ordination agency, was in charge of assessing demand forecasts, investment and financing needs, and representing the industry.

- Scotland: the system was supplied by two vertically integrated companies, the South of Scotland Electricity Board (SSEB) and the North of Scotland Hydro-Electric Board (NSHEB).

- Northern Ireland: supplied by a vertically integrated monopolistic company, the Northern Ireland Electricity (NIE).

In 1990, the electricity supply industry, except for the nuclear generators, was privatised. In 1996 the UK's newest nuclear power stations, the AGRs and PWR, were privatised under the holding company British Energy, formed with two subsidiaries, Nuclear Electric Ltd and Scottish Nuclear. The older magnox stations were retained in the public sector and operated by Magnox Electric plc. In the case of England and Wales, generation is now mostly carried out by four large generation companies, National Power, PowerGen, British Energy and Magnox Electric (the first three now privately owned). There are twelve privately owned regional distribution companies with temporary monopolistic rights over a part of the market in their assigned regional area. Until December 1995 these twelve companies owned the National Grid Company (NGC) which operated the transmission system, manages dispatch and administers the market in wholesale power. At that time it was floated on the London Stock Exchange.

In the case of Scotland, there are now two integrated private sector regional companies - Scottish Power and Scottish Hydro-Electric and the privatised nuclear company British Energy. In addition to the established generating companies new independent entrants to the market are emerging. One project is already supplying electricity to the grid, three others are under construction and there is the prospect of more to follow.

The twelve distribution companies in England and Wales and the two integrated companies in Scotland are the "Public Electricity Supply (PES)" companies.

The supervision of companies, which were privatised as of 1990, is the responsibility of the regulatory agency, the Office of Electricity Regulation (OFFER). Although OFFER's Director is appointed by the government it is an important part of the regulatory system that he is independent. OFFER's main responsibility is to enact the regulatory framework; prevent uncompetitive behaviour of the various players involved in the electricity supply industry; and protect users against discriminatory behaviour on the part of suppliers.

In Northern Ireland, generation and distribution were privatised independently. However, unlike England and Welsh case, no new generating companies were established, and the power plants were sold to already existing companies (Tractebel from Belgium and British Gas).

### 2.2. Decision Making Process

Responsibility for formulating energy policy and for most of the measures to implement it rest with the central government. Within government, lead responsibility on energy matters outside Northern Ireland rested until 12th April 1992, with the Secretary of State for Energy. On 13th April 1992, the Secretary of State's responsibilities were transferred to the Secretary of State for Trade and Industry, except for energy efficiency which was transferred to the Secretary of State for the Environment. Northern Ireland energy matters are the responsibility of the Secretary of State for Northern Ireland. The Secretary of State for Scotland is responsible for the electricity industry in Scotland. Because of the cross cutting nature of the issues many Ministers are involved particularly on policy for the efficient use of energy and for safety and the environment. Co-ordination between Ministers and Departments is achieved through the Cabinet, Ministerial and official committees and interdepartmental consultation.

The Secretary of State for Trade and Industry appoints the Director General of Electricity Supply who heads the Office of Electricity Regulation which now has over 200 staff including regional offices. The relevant Secretary of State and the Director General are the principal regulators of the industry and have been given specific powers in the new regime. Those of the Secretary of State include licensing and the regulation of certain matters related to the development of the physical electricity supply system, fuel stocking and the quality of the electricity supply. Those of the Director General include economic regulation and general supervision and enforcement of the licence regime (including the issue of new licences).

The building of a new power station with a capacity of over 50 MW requires the consent of the relevant Secretary of State. Environmental assessment is mandatory in most cases and is normally required in all other cases.

### 2.3. Main Indicators

Contrasting with the 60s, since the mid 70s, power consumption growth rate has been moderate (under 1.3% accrued rate). The system was affected by market stagnation during the first five years of the 80s, primarily due to the behaviour of industrial demand which decreased 17% between 1979 and 1983. During the last years demand growth seems to have increased, with rates slightly above 2% per year. In this context, the expansion of public service's installed capacity has been very limited since 1985, and a gradual obsolescence of generating facilities must also be considered. In spite of fluctuations affecting electricity demand, its share in the country's energy requirements has been steadily increasing. In fact, in 1970 electricity accounted for 12% of final energy consumption, though its penetration steadily increased and reached 16% in 1991. The share of electricity was even more important in the industrial sector during the same period, and rose from 11% in 1970 to almost 21% in 1991.

Electricity has increased its share of final energy consumption, which has been steadily rising from 7% in 1960 to 11% in 1970 and 16% in 1991, mainly at the expense of coal and oil, and has been particularly successful in gaining an increased share of the industrial and commercial sectors. Electricity's share of industrial energy consumption has more than doubled since 1970, rising from 10% to 22% in 1991, due to structural changes and technological innovations. Electricity's share over energy consumption in the commercial sector increased significantly over the period from 18% in 1970 to 32% in 1991. The growth in electricity consumption was associated with increased use of air conditioning, growth in Information Technology applications and improvement in the standard of lighting in the commercial sector. Electricity, maintained its share of about 19% of energy consumption in the domestic sector due to the availability of lower priced off-peak electricity, growth in ownership of electrical appliances and more diverse applications.

The total electricity production in 1995 was 332.9 TW.h and the total installed electrical capacity was 69 GW(e). Fossil fuels contributed 74% to the electricity generated and hydro and nuclear

2% and 24%, respectively. Table 5 shows the historical electricity production and installed capacities and Table 6 the energy related ratios.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[(1)] | 136.97 | 247.98 | 283.75 | 318.97 | 323.07 | 325.38 | 3.71 | 0.98 |
| - Thermal | 131.76 | 217.34 | 242.79 | 253.31 | 237.34 | 239.10 | 3.10 | -0.11 |
| - Hydro | 3.13 | 4.63 | 3.94 | 7.06 | 5.72 | 6.54 | 1.15 | 3.69 |
| - Nuclear | 2.08 | 26.01 | 37.02 | 58.60 | 79.80 | 79.40 | 15.49 | 5.60 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 36.70 | 62.06 | 73.64 | 73.01 | 69.05 | 68.94 | 3.54 | -0.47 |
| - Thermal | 35.17 | 56.48 | 64.73 | 56.49 | 52.81 | 52.90 | 3.10 | -1.43 |
| - Hydro | 1.17 | 2.15 | 2.45 | 4.17 | 4.23 | 4.25 | 3.76 | 4.01 |
| - Nuclear | 0.36 | 3.43 | 6.46 | 12.34 | 11.95 | 11.72 | 15.53 | 4.35 |
| - Wind | | | | 0.01 | 0.06 | 0.07 | | |

[(1)] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Data Base

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 131 | 156 | 149 | 154 | 158 | 158 |
| Electricity per capita (kW·h/capita) | 2,607 | 4,142 | 4,691 | 5,403 | 5,512 | 5,570 |
| Electricity production/Energy production (%) | 26 | 50 | 31 | 33 | 32 | 30 |
| Nuclear/Total electricity (%) | 2 | 11 | 14 | 20 | 26 | 26 |
| Ratio of external dependency (%)[(1)] | 28 | 49 | 7 | 4 | 1 | -13 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 43 | 46 | 44 | 50 | 53 | 54 |
| - Thermal | 43 | 44 | 43 | 51 | 51 | 52 |
| - Hydro | 31 | 25 | 18 | 19 | 15 | 18 |
| - Nuclear | 66 | 87 | 65 | 54 | 76 | 77 |

[(1)] *Net import / Total energy consumption*
Source: IAEA Energy and Economic Data Base

Traditionally, the United Kingdom's power system generation structure has relied on domestic coal. It should be pointed out that since the 60s, there has been a mutual dependence between the power and the coal industries. Coal fired plants contributed 60 and 70% to power generation thus becoming the major consumer and supporter of the country's coal industry.

While the power sector was in the hands of the State, its relationship with the coal industry was strongly supported, in spite of the discovery of important gas fields in the Northern Sea at the end of the 60s and of the early development of nuclear power generation, which also started during the 60s.

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

In 1954 the Atomic Energy Authority Act established the United Kingdom Atomic Energy Authority (UKAEA) with responsibility for the UK nuclear power programme. The programme was to concentrate on the development of gas cooled reactors. The world's first industrial scale nuclear power station to demonstrate the commercial potential of generating electricity through nuclear fission, at Calder Hall in Cumbria, was commissioned by the UKAEA in 1956. Calder Hall was soon followed by a station of similar design, Chapelcross in Scotland; now operated by British Nuclear Fuels plc (BNFL), both these stations continue to generate electricity today after 40 years service.

Calder Hall and Chapelcross were magnox prototypes, and nine full scale magnox power stations were subsequently commissioned in the UK between 1962 and 1971. The magnox stations were so-called from the magnesium alloy used to make the fuel can which contains the natural uranium fuel elements. These stations are now owned by Magnox Electric and six are still in operation, while three are in the process of being decommissioned.

In 1964 it was decided that the UK-developed advanced gas cooled reactor, the AGR, should succeed the magnox as the principal source of nuclear power in the UK. Seven AGR stations, making use of enriched uranium fuel, were commissioned between 1976 and 1988 and these are now operated by British Energy's subsidiaries, Nuclear Electric and Scottish Nuclear.

As part of the reorganisation of the UKAEA under the Atomic Energy Authority Act in 1971, BNFL was set up as a private limited company and subsequently transformed into a public limited company. The fuel cycle operations previously undertaken by the UKAEA were transferred to BNFL. BNFL now provides the full range of nuclear fuel cycle services to the UK and international markets and in 1994 it sheared its first irradiated fuel in the Thermal Oxide Reprocessing Plant (THORP), constructed to reprocess domestic and overseas spent fuel from AGR and PWR reactors.

In 1978 the Government had decided that for future nuclear power station design it would be appropriate to pursue the Pressurised Water Reactor (PWR) option, the most widely used design outside the UK. Subsequently the site at Sizewell in Suffolk was chosen and construction began in 1988 after a lengthy public inquiry. This station, Sizewell B, first supplied electricity to the national grid in February 1995.

The United Kingdom Nuclear Industry Radioactive Waste Executive was set up in 1982. It was incorporated in 1985 as United Kingdom Nirex Ltd. The company's principal activity is to carry out research, development and design with a view to developing and managing commercial facilities for disposal of solid intermediate and low level radioactive waste. High level waste is managed by its producers, BNFL and the UKAEA.

In its 1988 White Paper "Privatising Electricity", the Government announced its intention to privatise the UK electricity supply industry. However, it later removed the nuclear stations from its privatisation plans for economic reasons and also because of concerns about the operational performance of AGRs at that time and uncertainties over the financing of any new PWRs. The Government did however recognise that there were advantages to be gained from the continued operation of existing nuclear power stations, in their contribution to security of supply and protection of the environment. Two new publicly owned electricity generating companies (Nuclear Electric and Scottish Nuclear) were formed from the Central Electricity Generating Board (CEGB) and South of Scotland Electricity Board.

When announcing the Government decision not to privatise nuclear power, the Secretary of State for Energy also announced that there was to be a moratorium on public sector construction of new nuclear stations (the Sizewell B PWR was already being built) until the Government conducted a review of the prospects for nuclear power.

### 3.2. Current Policy Issues

The conclusions of the Government's nuclear review into the prospects for nuclear power in the United Kingdom were announced in May 1995. The review confirmed the Government's commitment to nuclear power, provided it remained competitive and was able to maintain rigorous standards of safety and environmental protection. However, the Government recognised, against the background of the current electricity market, that providing public sector support for a new nuclear power station would constitute a significant intervention in the electricity market and that current and foreseeable circumstances did not warrant such an intervention.

The review also concluded that moving as much of the nuclear generating industry as was practicable into the private sector, with its associated liabilities, would bring benefits for the industry, electricity consumers and the taxpayer. Back in 1989, the nuclear stations had had to be excluded from the privatisation of the other parts of the electricity supply industry. However, the review recognised that the overall performance of the nuclear generators had been transformed in the period since. They had removed many of the uncertainties about the costs of managing spent fuel and waste and decommissioning plant. The performance of the Advanced Gas-cooled Reactors (AGRs) had vastly improved and a Pressurised Water Reactor (PWR), Sizewell B, was now in operation and performing excellently.

Accordingly the nuclear generating industry was reorganised to enable its more modern part, with its associated liabilities, to be transferred to the private sector Two subsidiaries, Nuclear Electric Ltd (NEL) and Scottish Nuclear (SN) are now owned by a Great Britain-wide holding company, British Energy plc which is responsible for seven AGRs and Sizewell B. British Energy was privatised in July 1996.

The older plant, six operating magnox stations, three closed magnox stations and the associated liabilities, remain in the public sector. Initially these stations are the responsibility of a stand alone company Magnox Electric plc, but ultimately Magnox Electric will be integrated with British Nuclear Fuels plc (BNFL), the UK's government owned supplier of reprocessing and other nuclear fuel cycle services, who operate two magnox stations of their own.

### 3.3. Status and Trends of Nuclear Power

Thirty-five nuclear units are in operation in the United Kingdom, representing a total capacity of about 12 GW(e) and supplying 26% of the electricity generated in 1996. Table 7 shows the status of the nuclear power plants in the UK. The first PWR unit built in the UK, Sizewell B, was connected to the grid in February 1995 and achieved full load in September 1995.

Sizewell B is an advanced PWR, built by the UK industry under a licence from the American manufacturer Westinghouse, which incorporates a number of enhanced safety features to meet more stringent safety standards. The unit was completed on schedule and within the provisional budget. All the other nuclear units in operation in the UK are gas cooled reactors of magnox and advanced gas cooled (AGR) types. Substantial improvements in the performance of the AGRs have been attained during recent years. The Prototype Fast Breeder at Dounreay, which was commissioned in 1976, is currently under-going decommissioning.

As of April 1995, the national safety authority, Nuclear Installations Inspectorate (NII), has authorised lifetime extension for all the magnox units which had reached thirty years of operation. Although the authorisations from NII do not specify the duration of the lifetime extension, the British regulators have indicated that no safety factors have been identified which would limit the operation of the magnox reactors to less than 40 years. The Wylfa reactors in Wales received permission to continue operation until at least 2004 following completion of the last of the long-term safety reviews of magnox reactors.

British Energy has said it does not plan to invest in any form of new generation in the short term because the future of UK energy prices is insufficiently certain. While the company announced in December 1995 that it had abandoned plans to proceed with the early construction of two new nuclear power stations in the UK (i.e. Sizewell C and Hinkly Point C), British Energy has made clear that new nuclear build remains a part of its business strategy provided it offers an appropriate return to its shareholders. Notwithstanding British Energy's decision, the Government has concluded that it is reasonable to assume that the existing technology will not be lost and that the option to build new nuclear power stations will be available for some time to come, albeit with first-of-kind costs attached. Through Sizewell B, which is a modern PWR reactor built only recently in line with international standards, British Energy has access to the latest technology in this area. The company has made clear that it will be able to keep up with the latest developments, both through operating its new station and by taking on overseas consultancy projects.

In November 1995, the Atomic Energy Authority Act 1995 became law, enabling the Authority to privatise its commercial activities which have been known in recent years as AEA Technology.

### 3.4. Organizational Chart

A simplified chart of main operations of the United Kingdom nuclear power programme is shown in Figure 1.

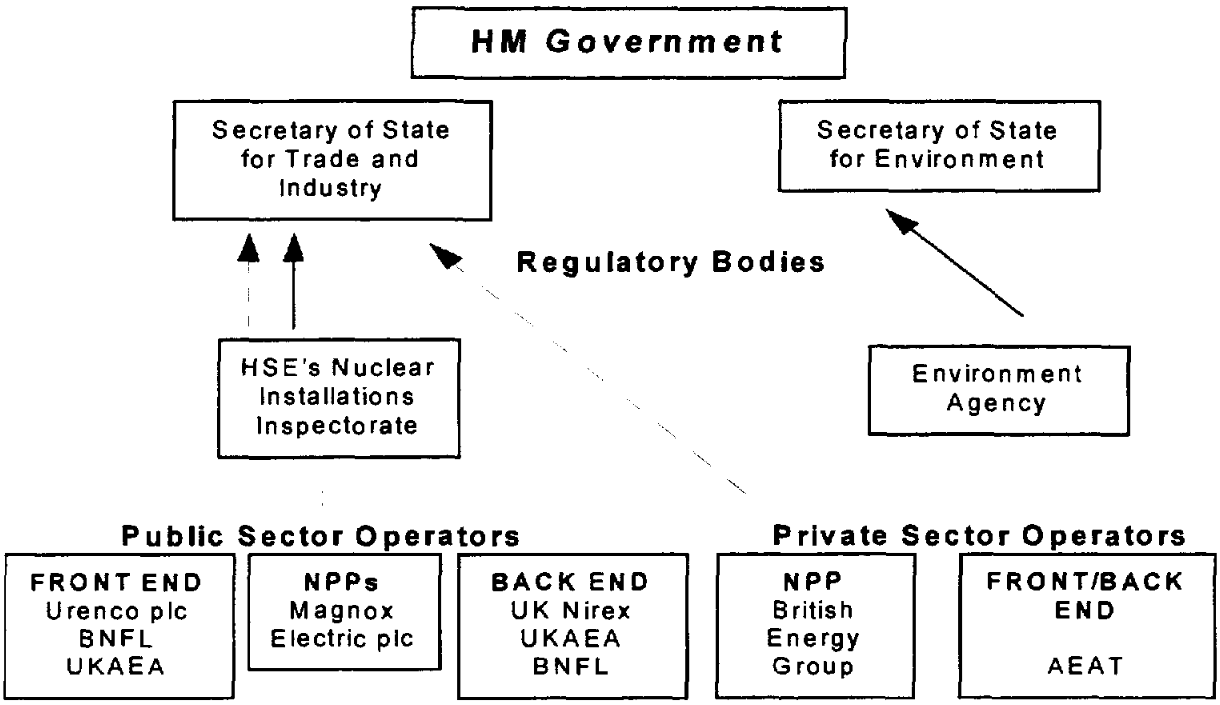


*FIG. 1. Structure of the main Operations of UK's Nuclear Power Programme*

## 4. NUCLEAR POWER INDUSTRY

The UK nuclear industry has been highly successful in pioneering and developing commercial nuclear power. The UK has about 14000 MW of installed nuclear capacity and generates over a quarter of all electricity in the UK. After early teething problems the UK nuclear power plants have been performing extremely well with high load factors comparable to the best achieved world-wide. The UK has a comprehensive nuclear industry capacity which embraces research and development; design, construction and supply of nuclear plant and their operation; full fuel cycle capability including manufacture, enrichment and reprocessing; and a very high quality safety culture underpinned by an independent nuclear regulator. This has resulted in an outstanding safety record for the commercial stations operating in the UK over a period of 40 years.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| BRADWELL | GCR | 123 | NE | Operational | TNPG | 01-Jan-57 | 01-Aug.-61 | 01-Jul.-62 | 01-Jul.-62 | |
| BRADWELL | GCR | 123 | NE | Operational | TNPG | 01-Jan-57 | 01-Apr.-62 | 06-Jul.-62 | 12-Nov.-62 | |
| CALDER HALL | GCR | 50 | BNFL | Operational | UKAEA | 01-Aug.-53 | 01-May-56 | 27-Aug.-56 | 01-Oct.-56 | |
| CALDER HALL | GCR | 50 | BNFL | Operational | UKAEA | 01-Aug.-53 | 01-Dec.-56 | 01-Feb.-57 | 01-Feb.-57 | |
| CALDER HALL | GCR | 50 | BNFL | Operational | UKAEA | 01-Aug.-55 | 01-Mar-58 | 01-Mar-58 | 01-May-58 | |
| CALDER HALL | GCR | 50 | BNFL | Operational | UKAEA | 01-Aug.-55 | 01-Dec.-58 | 01-Apr.-59 | 01-Apr.-59 | |
| CHAPELCROSS | GCR | 50 | BNFL | Operational | UKAEA | 01-Oct.-55 | 01-Nov.-58 | 01-Feb.-59 | 01-Mar-59 | |
| CHAPELCROSS | GCR | 50 | BNFL | Operational | UKAEA | 01-Oct.-55 | 01-May-59 | 01-Jul.-59 | 01-Aug.-59 | |
| CHAPELCROSS | GCR | 50 | BNFL | Operational | UKAEA | 01-Oct.-55 | 01-Aug.-59 | 01-Nov.-59 | 01-Dec.-59 | |
| CHAPELCROSS | GCR | 50 | BNFL | Operational | UKAEA | 01-Oct.-55 | 01-Dec.-59 | 01-Jan-60 | 01-Mar-60 | |
| DUNGENESS-A | GCR | 220 | NE | Operational | TNPG | 01-Jul.-60 | 01-Jun.-65 | 21-Sept.-65 | 28-Oct.-65 | |
| DUNGENESS-A | GCR | 220 | NE | Operational | TNPG | 01-Jul.-60 | 01-Sept.-65 | 01-Nov.-65 | 30-Dec.-65 | |
| DUNGENESS-B1 UNIT A | AGR | 555 | NE | Operational | APC | 01-Oct.-65 | 23-Dec.-82 | 03-Apr.-83 | 01-Apr.-85 | |
| DUNGENESS-B2 UNIT B | AGR | 555 | NE | Operational | APC | 01-Oct.-65 | 04-Dec.-65 | 29-Dec.-85 | 01-Apr.-89 | |
| HARTLEPOOL-A1 UNIT A | AGR | 605 | NE | Operational | NPC | 01-Oct.-68 | 24-Jun.-83 | 01-Aug.-83 | 01-Apr.-89 | |
| HARTLEPOOL-A2 UNIT B | AGR | 605 | NE | Operational | NPC | 01-Oct.-68 | 09-Sept.-84 | 31-Oct.-84 | 01-Apr.-89 | |
| HEYSHAM-1 UNIT A | AGR | 575 | NE | Operational | NPC | 01-Dec.-70 | 06-Apr.-83 | 09-Jul.-83 | 01-Apr.-89 | |
| HEYSHAM-1 UNIT B | AGR | 575 | NE | Operational | NPC | 01-Dec.-70 | 03-Jun.-84 | 11-Oct.-84 | 01-Apr.-89 | |
| HEYSHAM-2 UNIT A | AGR | 625 | NE | Operational | NPC | 01-Aug.-80 | 23-Jun.-88 | 12-Jul.-88 | 01-Apr.-89 | |
| HEYSHAM-2 UNIT B | AGR | 625 | NE | Operational | NPC | 01-Aug.-80 | 01-Nov.-88 | 11-Nov.-88 | 01-Apr.-89 | |
| HINKLEY POINT-A | GCR | 235 | NE | Operational | EE/B&W/T | 01-Nov.-50 | 01-May-64 | 16-Feb.-65 | 30-Mar-65 | |
| HINKLEY POINT-A | GCR | 235 | NE | Operational | EE/B&W/T | 01-Nov.-57 | 01-Oct.-64 | 19-Mar-65 | 05-May-65 | |

Source: IAEA Power Reactor Information System, Yearend 1996

TABLE 7. CONTINUED, STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| HINKLEY POINT-B UNIT A | AGR | 610 | NE | Operational | TNPG | 01-Sept.-67 | 24-Sept.-76 | 30-Oct.-76 | 02-Oct.-78 | |
| HINKLEY POINT-B UNIT B | AGR | 610 | NE | Operational | TNPG | 01-Sept.-67 | 01-Feb.-76 | 05-Feb.-76 | 27-Sept.-76 | |
| HUNTERSTON-B1 UNIT A | AGR | 595 | SN | Operational | TNPG | 01-Nov.-67 | 31-Jan-76 | 06-Feb.-76 | 06-Feb.-76 | |
| HUNTERSTON-B2 UNIT B | AGR | 595 | SN | Operational | TNPG | 01-Nov.-67 | 27-Mar-77 | 31-Mar-77 | 31-Mar-77 | |
| OLDBURY-A | GCR | 217 | NE | Operational | TNPG | 01-May-62 | 01-Aug.-67 | 07-Nov.-67 | 31-Dec.-67 | |
| OLDBURY-A | GCR | 217 | NE | Operational | TNPG | 01-May-62 | 01-Dec.-67 | 06-Apr.-68 | 30-Sept.-68 | |
| SIZEWELL-A | GCR | 210 | NE | Operational | EE/B&W/T | 01-Apr.-61 | 01-Jun.-65 | 21-Jan-66 | 25-Mar-66 | |
| SIZEWELL-A | GCR | 210 | NE | Operational | EE/B&W/T | 01-Apr.-61 | 01-Dec.-65 | 09-Apr.-66 | 15-Sept.-66 | |
| SIZEWELL-B | PWR | 1188 | NE | Operational | PPC | 18-Jul.-88 | 31-Jan-95 | 14-Feb.-95 | 22-Sept.-95 | |
| TORNESS UNIT A | AGR | 625 | SN | Operational | NNC | 01-Aug.-80 | 25-Mar-88 | 25-May-88 | 25-May-88 | |
| TORNESS UNIT B | AGR | 625 | SN | Operational | NNC | 01-Aug.-80 | 23-Dec.-88 | 03-Feb.-89 | 03-Feb.-89 | |
| WYLFA | GCR | 475 | NE | Operational | EE/B&W/T | 01-Sept.-63 | 01-Nov.-69 | 24-Jan-71 | 01-Nov.-71 | |
| WYLFA | GCR | 475 | NE | Operational | EE/B&W/T | 01-Sept.-63 | 01-Sept.-70 | 21-Jul.-71 | 03-Jan-72 | |
| BERKELEY | GCR | 138 | NE | Shut Down | TNPG | 01-Jan-57 | 01-Aug.-61 | 12-Jun.-62 | 12-Jun.-62 | 31-Mar-89 |
| BERKELEY | GCR | 138 | NE | Shut Down | TNPG | 01-Jan-57 | 01-Mar-62 | 24-Jun.-62 | 20-Oct.-62 | 26-Oct.-88 |
| DOUNREAY FR | FBR | 14 | UKAEA | Shut Down | UKAEA | 01-Mar-55 | 14-Nov.-59 | 01-Oct.-62 | 01-Oct.-62 | 01-Mar-77 |
| HUNTERSTON-A1 | GCR | 150 | SN | Shut Down | GEC | 01-Oct.-57 | 01-Aug.-63 | 05-Feb.-64 | 05-Feb.-64 | 30-Mar-90 |
| HUNTERSTON-A2 | GCR | 150 | SN | Shut Down | GEC | 01-Oct.-57 | 01-Mar-64 | 01-Jun.-64 | 01-Jul.-64 | 31-Dec.-89 |
| PFR DOUNREAY | FBR | 234 | UKAEA | Shut Down | TNPG | 01-Jan-66 | 01-Mar-74 | 10-Jan-75 | 01-Jul.-76 | 31-Mar-94 |
| TRAWSFYNYDD | GCR | 195 | NE | Shut Down | APC | 01-Jul.-59 | 01-Sept.-64 | 14-Jan-65 | 24-Mar-65 | 06-Feb.-91 |
| TRAWSFYNYDD | GCR | 195 | NE | Shut Down | APC | 01-Jul.-59 | 01-Dec.-64 | 02-Feb.-65 | 24-Mar-65 | 04-Feb.-91 |
| WINDSCALE AGR | AGR | 32 | UKAEA | Shut Down | VARIOUS | 01-Nov.-58 | 09-Aug.-62 | 01-Feb.-63 | 01-Mar-63 | 03-Apr.-81 |
| WINFRITH SGHWR | SGHWR | 92 | UKAEA | Shut Down | ICL/FE | 01-May-63 | 01-Sept.-67 | 01-Dec.-67 | 01-Jan-68 | 11-Sept.-90 |

Source: IAEA Power Reactor Information System, Yearend 1996

### 4.1. Supply of Nuclear Power Plants

The UK pioneered nuclear technology and as a result has developed technology and operational experience in a wide range of different reactor types. The major part of the UK programme has been based on Gas Cooled Reactors (magnox and AGRs) but also includes the SGHWR (Steam Generated Heavy Water Reactor - an LWR using pressure tubes), the fast reactor (PFR) and more recently PWR technology with the construction of Sizewell B PWR, which represents a state of the art design incorporating the latest advanced safety features now required for future plant.

The Services provided by AEA Technology, British Energy, British Nuclear Fuels, and many more industrial companies cover a very wide range of activities. These include component supply, fuel supply, fuel reprocessing, services in the area of radwaste management and aspects of advanced reactor engineering.

### 4.2. Operation of Nuclear Power Plants

The UK's AGRs and single PWR are now owned and operated by the holding company British Energy through its subsidiaries Nuclear Electric Ltd in England and Wales, and by Scottish Nuclear Ltd. in Scotland. The magnox stations are to be kept in the public sector, initially in a stand alone company (Magnox Electric), but in due course to be transferred to British Nuclear Fuels plc (BNFL). BNFL already owns and operates two magnox stations in both England and Scotland.

### 4.3. Fuel Cycle, Spent Fuel and Waste Management Service Supply

Apart from raw uranium mining, the UK has an independent nuclear fuel cycle capability. The full range of the nuclear fuel cycle services - from fuel enrichment and manufacture through to spent fuel reprocessing, transport, waste management and decommissioning - are provided to the UK and international markets by British Nuclear Fuels plc (BNFL), which is wholly owned by the Government. Part of the Government's 1995 review into the future prospects of nuclear power in the United Kingdom confirmed that BNFL would continue to offer customers the full range of nuclear fuel cycle services and restated the Government's continuing support for the company in developing its overseas markets.

Fuel enrichment in the UK is carried out at Capenhurst near Chester by Urenco Capenhurst Limited, a wholly owned subsidiary of Urenco Ltd, the holding company for the Urenco Group. The Urenco Group is the joint Anglo-Dutch-German organization which operates uranium enrichment plants in all three countries using centrifuge technology.

Uranium refining and conversion are carried out at BNFL's Springfields site which processes several tonnes of uranium each year for UK and overseas customers. Springfields has the expertise to manufacture fuel for all major reactor designs world-wide and a new, integrated fuels complex was officially opened in July 1996.

Spent fuel from the UK's magnox and AGRs reactors, overseas LWRs, and in the future PWR reactors, are reprocessed at BNFL's Sellafield site. The company's flagship project is the Thermal Oxide Reprocessing Plant (THORP). The plant began operations in March 1994 and has so far sheared and dissolved more than 300 tonnes of spent fuel. It is expected that some 7,000 tonnes of spent nuclear fuel will be reprocessed in its first ten years of operations.

In 1985 the Nuclear Industry Radioactive Waste Executive was established as UK Nirex. It is owned by Magnox Electric, British Energy, British Nuclear Fuels (BNFL) and the United Kingdom Atomic Energy Authority (UKAEA). It is charged with developing a deep disposal facility for intermediate and long lived low level wastes, and is currently investigating a site adjacent to BNFL's Sellafield works. Subject to receiving the necessary planning and regulatory consents, it hopes to begin to accept wastes into the facility by 2012.

Most low level waste (LLW) is disposed of at either BNFL's Drigg surface disposal facility or at the disposal facilities at UKAEA's Dounreay site. Long lived LLW is stored and will be disposed of in Nirex' proposed facility. Intermediate level waste (ILW) is currently stored, mainly at the centres of production, and will be disposed of in Nirex' proposed facility. High level wastes are currently stored, either raw or in vitrified form, mainly by BNFL at its Sellafield site, for a minimum of 50 years to cool. No decisions on disposal have yet been taken, but the Government has recently begun a research project to identify the best means of disposing of these wastes.

Nuclear sites are licensed by the Nuclear Installations Inspectorate (NII), the regulator responsible for ensuring their safe operation. Disposals of radioactive wastes may only be made under authorisations granted by the Environment Agency (or in Scotland the Scottish Environmental Protection Agency), which succeeded their respective countries' pollution inspectorates on 1 April 1996, but under operational agreements between them and the NII, the latter oversees waste operations on licensed sites.

### 4.4. R&D Activities

Nuclear accounted for some 47% of the DTI's Energy R&D expenditure in 1995-96 (45% in 1994-95). This expenditure went on research into decommissioning and radioactive waste management services, safety and health, fusion and safeguards commissioned with the UK Atomic Energy Authority (a public corporation) and the Joint European Torus (JET) project run by Euratom.

British Energy and BNFL are directly responsible for their own research expenditure.

### 4.5. International Co-operation related to Nuclear Power Plant Development and Implementation

The United Kingdom is a member of the European Union (EU), the OECD/NEA and the IAEA as well as other bilateral and multilateral organizations. The United Kingdom Government supports EU programmes in the field of nuclear safety and nuclear waste management and participates in many OECD/NEA and IAEA projects.

## 5. NUCLEAR LAWS AND REGULATIONS

### 5.1. Nuclear Regulatory Framework

The safety of UK nuclear installations, and the protection of employees and the public from the potential hazards caused by them, is governed principally by provisions in the Nuclear Installations Act 1965, the Health and Safety at Work etc. Act 1974, the Ionising Radiation Regulations 1985 made under it and the Radioactive Substances Act 1993. No site may be used for the construction or operation of a commercial nuclear installation unless appropriate approval or planning permission has been given and a nuclear site licence is granted by the Health and Safety Executive (HSE). The Nuclear Installations Inspectorate (NII) is that part of the HSE with delegated responsibility for administering the licensing function.

The NII will not grant a nuclear site licence unless satisfied that an applicant has the capacity to meet all their stringent safety requirements from design through to decommissioning, in adherence to the licence conditions attached to the site licence. So as to demonstrate to the NII that safety will be properly controlled at all stages of the plant's life, the applicant is required to produce a comprehensive written 'safety case' for each plant. The safety case must be continually revised and updated throughout the plant's operation, to take account of any changes in its operating conditions.

Ultimate responsibility for the safety of a nuclear installation is legally the responsibility of the operating company. They must execute all licence requirements to the NII's satisfaction. The principle is the same whether the operating company is in the public or private sector. The NII carefully monitors the performance of nuclear installations against exacting standards and conditions. Should there be any doubt about a licensee's ability to meet its obligations, the Inspectorate has extensive powers. It can, for example, include additional licence conditions at any time, direct the cessation of plant operation, and ultimately direct that it be shut down altogether. An operating company may surrender a licence or it may be revoked by the NII, but still retains responsibility for safety of the site until either a new licence for the site is issued or the HSE is satisfied that there ceases to be a danger from ionising radiation from the site.

The disposal of radioactive material from licensed sites is strictly controlled by means of authorisations granted by the Environment Agency and the Minister of Agriculture Fisheries and Food (MAFF) in England and Wales; and in Scotland by the Scottish Environmental Protection Agency. There is close liaison between NII, the Environment Agency and the Scottish Environmental Protection Agency under the terms of Memoranda of Understanding which set out the lead roles of the organizations and requirements for liaison and consultation.

### 5.2. Main National Laws and Regulations

*GENERAL LEGISLATION*

- Atomic Energy Authority Act 1995 (Chapter 37)
- Atomic Energy Act 1946Ch 80.
- Atomic Energy Authority Act 1954 Ch 32.
- Nuclear Installations (Amendment) Act 1965 Ch 6.
- Nuclear Installations Act 1965 Ch 57.
- Nuclear Installations Act 1969 Ch 18.
- Radiological Protection Act 1970 Ch 46.
- Atomic Energy Authority Act 1971 Ch 11.
- Health and Safety at Work etc. Act 1974 Ch 7.
- Nuclear Industry (Finance) Act 1977 Ch 7.
- Atomic Energy (Miscellaneous Provisions) Act 1981 Ch 48.
- Criminal Justice Act 1982.
- Energy Act 1983 Ch 25.
- The Atomic Energy Authority Act 1986 Ch 3.
- Atomic Energy Act 1988 Ch 7.
- Electricity Act 1989.
- Criminal Law Act 1989.
- Environmental Protection Act 1990 Ch 43.
- Radioactive Material (Road Transport) Act 1991 Ch 27.
- Atomic Weapons Establishment Act 1991 Ch 46.
- Radioactive Substance Act 1993 Ch 12.
- Nuclear Installations (Dangerous Occurrences ) Regulations 1965 (SI 1965/1824).
- The Nuclear Installations (Insurance Certificate )(Amendment) Regulations 1969 SI 1969/64).
- The Nuclear Installations Regulations 1971 (SI 1971/1381).
- The Nuclear Installations Act 1965 etc. (Repeals and Modifications) Regulations 1974 (SI 1974/2056).
- Nuclear Installations (Expected Matter) Regulations 1978 (SI 1978/1779).
- Nuclear Installations (Prescribed Sites) Regulations 1983 (SI 1983/919).
- The Nuclear Installations Act 1965 (Repeal and Modifications) Regulations 1990(SI 1990/1918)
- The Ionising Radiations Regulations 1985 (SI 1985/1333).
- The Fire Certificate (Special Premises) Regulations 1976 (SI 1976/2003).
- The Notification of Installations Handling Hazardous Substances Regulations 1982 (SI 1982/1357).
- Air Navigation (Restriction of Flying) (Nuclear Installations) Regulations 1988 (SI 1988/1138).
- Environmental Protection (Prescribed Processes and Substances) (Amendment) Regulations 1992 (SI 1991/614).

- The Radioactive Substances (Carriage by Road) (Great Britain) Regulations 1974 (SI 1974/1735).
- The Radioactive Substances (Road Transport Workers) (Great Britain) (Amendment) Regulations 1975 (SI 1975/1522).
- The Radioactive Substances (Carriage by Road) (Great Britain) (Amendment) Regulations 1985 (SI 1985/1729).
- Control of Pollution (Radioactive Waste) Regulations 1976 (SI 1976/959).
- The Control of Pollution (Radioactive Waste) Regulations 1989 (SI 1989/1158).
- Radioactive Substances (Records of Convictions) Regulations 1992 (SI 1992/1685).
- The Health and Safety (Fees) Regulations 1991 (SI 1991/1921).
- The Public Information for Radioactive Emergencies Regulations 1992 (SI 1992/2997).
- The Ionising Radiations (Outside Workers) Regulations 1993 (SI 1993/2379).
- The Nuclear Material (Offences) Act 1983 (Commencement) Order 1991 (SI 1991/1716).
- Extradition (Protection of Nuclear Material) Order 1991 (SI 1991/1720).
- The Nuclear Installations (Application of Security Provisions) Order 1993 (SI 1993/687).
- The Exports of Goods (Control) Order 1992 (SI 1992/3092).
- The Radioactive Substances (Prepared Uranium and Thorium Compounds) Exemption Order 1962 (SI 1962/2711).
- The Atomic Energy (Mutual Assistance Convention) Order 1990 (SI 1990/235).
- Environmental Protection Act 1990 (Commencement N° 3) Order 1990 (SI 1990/2565 (Ch 67)).
- The Radioactive Substance (Substances of Low Activity) Exemption (Amendment) Order 1992 (SI 1992/647).
- The Radioactive Substances (Uranium and Thorium) Exemption (Scotland) Order 1962 (SI 1962/2766).
- Radioactive Substance (Testing Instruments) Exemption Order 1985 (SI 1985/1049).
- The Radioactive Substances (Substances of Low Activity) Exemption Order 1986 (SI 1986/1002).
- The Radioactive Substances (Waste Cloud Sources) Exemption Order 1963 (SI 1963/1831).
- The Radioactive Substances (Uranium and Thorium) Exemption Order 1962 (SI 1962/2710).
- The Environment Protection Act 1990 (Commencement N° 7) Order 1991 (SI 1991/1042).
- The Radioactive Substances (Substances of Low Activity) Exemption (Amendment) Order 1992 (SI 1992/647).
- The National Radiological Protection Board (Extension of Functions) Order 1974 (SI 1974/1230).

### 5.3. International, Multilateral and Bilateral Agreements

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Voluntary offer INFCIRC/263 | Entry into force: | 14 August 1978 |
| • Improved procedures for designation of safeguards inspectors | Both proposals not acceptable. Offers support in improving procedures | 17 February 1989 |
| • Supplementary agreement on provision of technical assistance (for Hong Kong) by the IAEA | Entry into force: | 4 February 1983 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 27 November 1968 |
| • EURATOM | Member | |

| | | |
|---|---|---|
| • Agreement on privileges and immunities | Entry into force: | 19 September 1961 |
| • Convention on physical protection of nuclear material | Entry into force: | 6 October 1991 |
| • Convention on early notification of a nuclear accident | Entry into force: | 12 March 1990 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 12 March 1990 |
| • Conventions on civil liability for nuclear damage and joint protocol | Signature of Vienna Convention: | 11 November 1964 |
| Paris Convention: | | 23 February 1966 |
| Joint Protocol: | | 21 September 1988 |
| • Convention on nuclear safety | Entry into force: | 24 October 1996 |
| • ZANGGER Committee | Member | |
| • Nuclear Export Guidelines | Adopted | |
| • Acceptance of NUSS Codes | Summary: Codes found appropriate as guidelines. Generally consistent with national regulatory requirements. | 11 October 1988 |
| • Nuclear Suppliers Group | Member | |

# ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| Export Control and Non-Proliferation Directorate (XNP)<br>Department of Trade and Industry<br>Kingsgate House<br>Victoria Street<br>London, SW1E 6SW<br>United Kingdom | Tel.: +44-171-215.4321<br>Fax: +44-171-215.4379 |
| AEA Technology<br>Lower Regent Street<br>London, SW1Y 4LR<br>United Kingdom | Tel.: +44-171-389.6553<br>Fax: +44-171-389.6570 |

*OTHER NUCLEAR ORGANIZATIONS*

| | |
|---|---|
| Nuclear Electric Ltd<br>Barnett Way,<br>Barnwood,<br>Gloucester GL4 5PR<br>Main activities: Responsible for operating AGR and PWR nuclear power stations in England and Wales | Tel.: +44-1452-65.2222<br>Fax: +44-1452-65.2776 |
| Scottish Nuclear Ltd<br>3 Redwood Crescent<br>Peel Park<br>East Kilbride G74 5PR<br>Main activities Responsible for operating AGR nuclear power stations in Scotland | Tel.: +44-13552-62.000<br>Fax: +44-13552-62.626 |
| Magnox Electric plc<br>Berkeley Centre<br>Berkeley<br>Gloucestershire GL13 9PB<br>Main activities: Responsible for operating magnox nuclear power stations in the UK. | Tel.: +44-1453-81.0451<br>Fax.: +44-1453-81.2529 |
| United Kingdom Atomic Energy Authority<br>Building 521<br>Harwell<br>Didcot<br>Oxfordshire OX11 0RA | Tel.: +441-235-43.3690 |
| AEA Technology<br>Building 329<br>Harwell<br>Didcot<br>Oxfordshire OX11 0RA | Tel.: +441-235-43.3124 |

British Nuclear Fuels plc (Head Office)
Risley
Warrington — Tel.: +441-925-83.2000
Cheshire WA3 6AS — Fax: +441-925-82.2711

British Nuclear Fuels plc (Fuel Manufacture)
Preston — Tel.: +44-1772-76.2000
Lancashire PR4 0XJ — Fax: +44-1772-76.2155

British Nuclear Fuels plc (Fuel Enrichment)
Capenhurst, Near Chester — Tel.: +44-151-339.4101
Cheshire, CH1 6ER — Fax: +44-151-347.3661

British Nuclear Fuels plc (Reprocessing)
Seascale — Tel.: +44-19467-28.333
Cumbria CA20 1PG — Fax: +44-19467-28.987

Urenco Ltd
Oxford Road
Marlow — Tel.: +44-1628-48.6941
Buckinghamshire SL7 2NL — Fax: +44-1628-47.5867

Department of the Environment
Romney House
43 Marsham Street
London SW1P 3PY — Tel.: +44-171-276.3000

H M Nuclear Installations Inspectorate
Rose Court
2 Southwark Bridge
London SE1 9HS — Tel.: +44-171-717.6000

# UNITED STATES OF AMERICA

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## UNITED STATES OF AMERICA

## 1. GENERAL INFORMATION

The United States of America (U.S.) nuclear power industry is large and comprehensive, covering all phases of the nuclear fuel cycle, from uranium exploration and mining through nuclear waste disposal. This document contains an overview of the U.S. nuclear industry, the Federal and State government's role in the industry, and selected information about activities of the private sector. At the start, it is important to note that the U.S. nuclear industry is, for the most part, privately owned and highly decentralised. There is a significant amount of diversity in power plant operations and a large array of privately operated companies supporting the nuclear plants. Federal and State governments also play a significant role in the affairs of the industry.

### 1.1. General Overview

The U.S. is the fourth largest country in the world in both area and population. The U.S. covers the entire midsection of North America, stretching from the Atlantic Ocean in the east to the Pacific Ocean in the west. It also includes Alaska, in the north-west corner of North America; and Hawaii, far out in the pacific. Total area of the U.S. is over 3.5 million square miles (9.4 million square kilometres)

The climate of the U.S. varies greatly from place to place. Average annual temperatures range from 9 degrees Fahrenheit (-13 degrees Celsius) in Barrow, Alaska, to 78 degrees Fahrenheit (26 degrees Celsius) in Death Valley, California. Precipitation varies from a yearly average of less than 2 inches at Death Valley to about 460 inches at Mount Waialeale in Hawaii. In general, however, most parts of the U.S. have seasonal changes in temperature and moderate precipitation. The Midwest, the Middle Atlantic States, and New England experience warm summers and cold, snowy winters. In the South, summers are long and hot, and winters are mild. Along the Pacific Coast, and in some other areas near large bodies of water, the climate is relatively mild all year. The moderate climate in much of the U.S. has encouraged widespread population settlement.

The population in the U.S. is over 250 million people (Table 1). The Population density is about 28 persons per square kilometre, with 76% living in urban areas and 24% rural.

TABLE 1. POPULATION INFORMATION

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|
| Population (millions) | 180.7 | 205.1 | 227.8 | 249.9 | 257.9 | 260.6 | 1.0 |
| Population density (inhabitants/km$^2$) | 19.3 | 21.9 | 24.3 | 26.7 | 27.5 | 27.8 | |

| | |
|---|---|
| Predicted population growth rate (%) 1993 to 2000 | 0.9 |
| Area (1000 km$^2$) | 9373.0 |
| Urban population in 1993 as percent of total | 76.0 |

Source: IAEA Energy and Economic Data Base

### 1.2. Economic Indicators

Table 2 shows the historical Gross Domestic Product (GPD) statistics.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

| | 1970 | 1980 | 1990 | 1993 | 1994 | Growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|
| GDP (millions of current US$) | 1,011,544 | 2,708,147 | 5,489,500 | 6,284,305 | 6,738,398 | 6.7 |
| GDP (millions of constant 1990 US$) | 3,237,782 | 4,223,169 | 5,489,500 | 5,779,239 | 6,015,052 | 2.6 |
| GDP per capita (current US$/capita) | 4,933 | 11,891 | 21,965 | 24,365 | 25,854 | 5.7 |

Source: IAEA Energy and Economic Data Base

### 1.3. Energy Situation

Table 3 shows the US energy reserves and Table 4 the historical energy statistics

TABLE 3. ENERGY RESERVES

Exajoule

| | Estimated energy reserves in 1993 | | | | | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium [1] | Hydro [2] | Total |
| Total amount in place | 5549.32 | 149.52 | 173.66 | 35.67 | 50.95 | 5959.12 |

[1] *This total represents essentially recoverable reserves*

[2] *For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1992) by a factor of 10*

Source: IAEA Energy and Economic Data Base

TABLE 4. ENERGY STATISTICS

Exajoule

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Energy consumption | | | | | | | | |
| - Total[1] | 44.35 | 67.51 | 74.80 | 79.49 | 82.71 | 89.19 | 2.65 | 1.27 |
| - Solids[2] | 10.15 | 13.40 | 17.27 | 19.85 | 19.91 | 24.29 | 2.70 | 2.47 |
| - Liquids | 19.27 | 28.21 | 31.82 | 31.32 | 31.84 | 32.70 | 2.54 | 0.20 |
| - Gases | 13.44 | 23.24 | 20.30 | 19.83 | 21.97 | 22.73 | 2.08 | 0.81 |
| - Primary electricity[3] | 1.49 | 2.65 | 5.41 | 8.48 | 8.99 | 9.47 | 6.65 | 4.08 |
| Energy production | | | | | | | | |
| - Total | 42.09 | 63.45 | 64.34 | 69.27 | 66.56 | 73.16 | 2.15 | 0.92 |
| - Solids | 11.13 | 15.55 | 19.84 | 23.59 | 21.17 | 26.89 | 2.94 | 2.19 |
| - Liquids | 16.09 | 22.41 | 20.10 | 17.81 | 16.99 | 16.84 | 1.12 | -1.25 |
| - Gases | 13.42 | 22.86 | 19.26 | 19.37 | 19.66 | 20.36 | 1.82 | 0.40 |
| - Primary electricity[3]) | 1.45 | 2.63 | 5.15 | 8.49 | 8.75 | 9.07 | 6.55 | 4.13 |
| Net import (import - export) | | | | | | | | |
| - Total | 2.74 | 5.61 | 12.14 | 13.92 | 17.04 | 17.83 | 7.73 | 2.78 |
| - Solids | -0.98 | -1.83 | -2.09 | -2.35 | -1.46 | -1.59 | 3.88 | -1.96 |
| - Liquids | 3.56 | 6.62 | 13.22 | 14.69 | 16.10 | 16.72 | 6.78 | 1.69 |
| - Gases | 0.16 | 0.82 | 1.02 | 1.57 | 2.40 | 2.70 | 9.78 | 7.21 |

[1] *Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.*

[2] *Solid fuels include coal, lignite and commercial wood.*

[3] *Primary electricity = Hydro + Geothermal + Nuclear + Wind.*

Source: IAEA Energy and Economic Data Base

### 1.4. Energy Policy

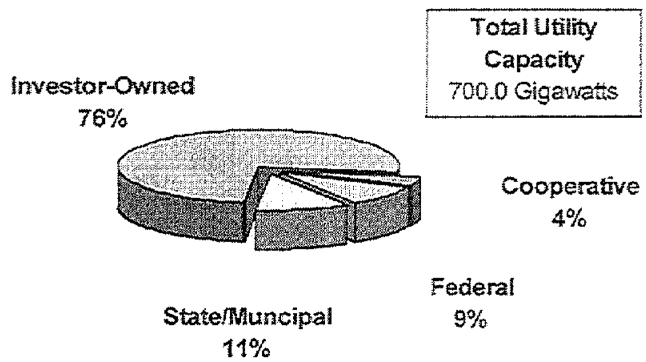
The U.S. is a market driven economy. Decisions affecting energy resources, energy prices, development of energy technology, and other matters pertaining to energy are made primarily by the private sector. However, through funding of research and development, tax reduction allowances, and other mechanisms, the U.S. Government encourages development and use of certain types of energy resources. Current government policy is contained in the Energy Policy Act of 1992. This legislation covers a wide variety of issues, such as energy efficiency standards, development of alternate fuels, development of renewable energy, and many other areas. Regulation of energy prices is another area in which the U.S. Government exerts its influence. Although this is not energy policy as such, price regulation can affect the distribution and consumption of energy resources.

## 2. ELECTRIC POWER SECTOR

### 2.1. Structure of the Electric Power Sector

The U.S. electric power industry is a combination of traditional and non-traditional electricity-producing companies. The traditional electric utility industry is comprised of investor owned, publicly owned, Federal, and co-operative electric utilities. The Public Utilities Regulatory Policies Act (PURPA) of 1978 and the continued deregulation of the industry have led to the emergence of non-traditional electricity producing companies or non-utility power producers.

Investor-Owned Electric Utilities. Investor-owned electric utilities currently account for more than 75% of all U.S. electric utility generating capability (Figure 1). Like all private businesses, the fundamental objective of an investor-owned utility is to produce a return for investors. Most investor-owned electric utilities are operating companies that provide basic services for the generation, transmission, and distribution of electricity. The majority of investor-owned electric utilities perform all three functions.




*Source: Energy Information Administration, "Electric Power Annual 1993" DOE/EIA-0348(93). (Washington DC, December 1994)*

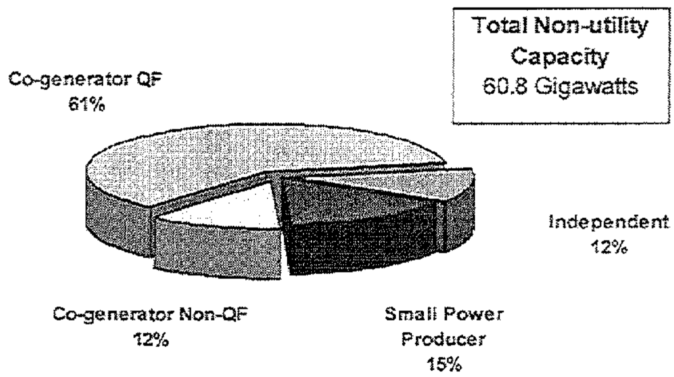
***FIG. 1. Generating Capability at US Electric Utilities by Class of Ownership, 1993***

Publicly Owned Electric Utilities. Publicly owned electric utilities in the U.S. are non-profit local government agencies established to serve their communities and nearby consumers at cost, returning excess funds to the consumer in the form of community contributions, economic and efficient facilities, and lower rates. Publicly owned electric utilities include municipal, public power districts, State authorities, irrigation districts, and other State organizations. Most municipal electric utilities simply distribute power, although some larger ones produce and transmit electricity as well.

U.S. Federal Electric Utilities. Power produced by U.S. Federal electric utilities is not generated for profit. As required by law, preference in purchasing the electricity produced is given to publicly owned and co-operative utilities and to other non-profit entities. The Federal Government is primarily a producer and wholesaler of electricity.

Co-operative Electric Utilities. Co-operative electric utilities in the U.S. are owned by their members and are established to provide electricity to those members. The Rural Electrification Administration, U.S. Department of Agriculture, was established under the Rural Electric Act of 1936 with the purpose of extending electric service to small rural communities and farms where it was more expensive to provide service.

U.S. non-utility power producers are comprised of co-generators and small power producers, which qualify under the Public Utility Regulatory Policies Act of 1978 (PURPA)[these facilities are generally referred to as qualifying facilities (QF's)], and other non-utility generators (including independent power producers) without a designated franchise service area. QF's receive certain benefits under PURPA. Co-generators are generating facilities that produce electricity and another form of useful thermal energy for industrial, commercial, heating, or cooling purposes. To receive status as a QF, the co-generator must met certain ownership, operating, and efficiency criteria established by the Federal Energy Regulatory Commission (FERC). The FERC is responsible for the implementation of PURPA. Over 60% of the installed capacity of non-utility generating facilities is classified as a cogeneration QF facility (Figure 2).




Note: QF = Qualified facility

*Source: Energy Information Administration, "Electric Annual 1993" DOE/EIA-0348(93) (Washington DC, December 1994)*

***FIG. 2. Installed Capacity at US Non-utility Generating Facilities by type of Facility, 1993***

The Independent Power Producers (IPP) in the U.S. are wholesale electricity producers that are unaffiliated with franchised utilities in the area in which the IPP's are selling power. A facility that has QF status under PURPA is not an IPP. IPP's do not posses transmission facilities and do not sell in any retail service territory.

A new class of IPP's--exempt wholesale generators (EWG's) was established by the Energy Policy Act of 1992 (EPACT). This Act modified the Public Utility Holding Company Act (PUHCA) to create this new class of IPP's by exempting them from the corporate and geographic restrictions that PUHCA imposes. Public utility holding companies are allowed to own interest in IPP facilities and can form corporate subsidiaries to develop and operate independent power projects anywhere in the world.

## 2.2. Policy and Decision Making Process

In the U.S., public policy covering electric utilities is implemented through legislation and regulation of the industry. Because electricity generation in the U.S. is decentralised and the electric utility industry and non-utility generators are, for the most part, privately owned, decision making in the industry is decentralised, subject to Federal and State laws and regulations.

There are 6 major pieces of Federal legislation covering the electric utility industry. These laws cover a multitude of factors including the structure of the industry, regulation of interstate commerce, environmental issues, and operating procedures (see Section 5.2 for a brief description of these laws).

Federal regulation of electric power is based on the Commerce Clause of the U.S. Constitution, which holds that only the Federal Government may regulate interstate commerce. Thus not only is the Federal Government authorized to regulate interstate commerce, but State governments are prohibited from doing so. In this way Federal regulation complements State regulation by focusing on the interstate activities of electricity producers, leaving the regulation of intrastate activities to the States.

Three laws, the Federal Power Act, PURPA, and the EPACT form the basis for Federal involvement in the regulation of wholesale electric power transactions. The Federal Energy Regulatory Commission (FERC) is the primary agency responsible for enforcing Federal regulation of electric power transactions.

Regulation of most activities of privately owned electric utilities is conducted by the States (Federal, State, municipal, co-operative, and other utilities are often not regulated directly). The primary responsibility of State Public Utility Commissions (PUCs), which exist in all States with privately owned utilities, is to regulate the prices for electricity that privately owned utilities may charge to retail customers.

## 2.3. Main Indicators

Table 5 shows the historical electricity production data and installed capacities and Table 6 the energy related ratios.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 | Average annual growth rate (%) 1960 to 1980 | Average annual growth rate (%) 1980 to 1994 |
|---|---|---|---|---|---|---|---|---|
| Electricity production (TW·h) | | | | | | | | |
| - Total[1] | 844.19 | 1639.77 | 2354.38 | 3011.75 | 3145.89 | 3267.43 | 5.26 | 2.37 |
| - Thermal | 694.12 | 1366.75 | 1820.28 | 2130.91 | 2238.46 | 2326.58 | 4.94 | 1.77 |
| - Hydro | 149.52 | 250.70 | 277.92 | 286.10 | 276.46 | 281.56 | 3.15 | 0.09 |
| - Nuclear | 0.52 | 21.80 | 251.12 | 576.78 | 610.29 | 639.36 | 36.23 | 6.90 |
| - Geothermal | 0.03 | 0.53 | 5.07 | 15.06 | 16.77 | 16.49 | 28.63 | 8.78 |
| Capacity of electrical plants (GW(e)) | | | | | | | | |
| - Total | 186.53 | 360.33 | 630.11 | 733.33 | 760.40 | 769.64 | 6.28 | 1.44 |
| - Thermal | 153.05 | 298.00 | 495.97 | 537.23 | 558.08 | 566.30 | 6.06 | 0.95 |
| - Hydro | 33.18 | 55.75 | 76.65 | 92.36 | 98.65 | 99.73 | 4.28 | 1.90 |
| - Nuclear | 0.30 | 6.49 | 56.49 | 99.33 | 98.78 | 98.78 | 30.01 | 4.07 |
| - Geothermal | 0.01 | 0.08 | 1.01 | 2.65 | 3.07 | 3.08 | 24.78 | 8.33 |
| - Wind | | | | 1.77 | 1.81 | 1.75 | | |

[1] *Electricity losses are not deducted.*
Source: IAEA Energy and Economic Database

TABLE 6. ENERGY RELATED RATIOS

| | 1960 | 1970 | 1980 | 1990 | 1993 | 1994 |
|---|---|---|---|---|---|---|
| Energy consumption per capita (GJ/capita) | 245 | 329 | 328 | 318 | 321 | 342 |
| Electricity per capita (kW·h/capita) | 4,698 | 8,008 | 10,455 | 12,059 | 12,308 | 12,708 |
| Electricity production/Energy production (%) | 19 | 25 | 35 | 42 | 46 | 43 |
| Nuclear/Total electricity (%) | | 1 | 11 | 19 | 19 | 20 |
| Ratio of external dependency (%)[(1)] | 6 | 8 | 16 | 18 | 21 | 20 |
| Load factor of electricity plants | | | | | | |
| - Total (%) | 52 | 52 | 43 | 47 | 47 | 48 |
| - Thermal | 52 | 52 | 42 | 45 | 46 | 47 |
| - Hydro | 51 | 51 | 41 | 35 | 32 | 32 |
| - Nuclear | 20 | 38 | 51 | 66 | 71 | 74 |

[(1)] *Total net import / Total energy*

Source: IAEA Energy and Economic Data Base

## 3. NUCLEAR POWER SITUATION

### 3.1. Historical Development

In 1942, the first sustained-fission reaction was achieved from a "pile" of graphite and natural uranium by Fermi and others involved in the ultra-secret Manhattan Project. This clearly marked the birth of nuclear power. Then, in August 1945, the U.S. demonstrated the awesome destructive potential of nuclear power as the Hiroshima and Nagasaki bombings brought World War II to a close.

After World War II, the early growth of commercial nuclear power was spurred by President Eisenhower's Atoms for Peace program to permit nuclear power applications for peacetime purposes while still retaining a strong nuclear weapons technology.

The Atomic Energy Act of 1954 made possible several reactor demonstration and development programs. Numerous joint industry-government study groups were established to examine power reactor concepts. Also in 1954, the AEC proposed a "Five Year Power Reactor Development Program," which called for building five separate reactor technologies. The program prepared the way for private industrial participation in the nuclear power field. In 1957, the first nuclear power station in the U.S. began operation in Shippingport, Pennsylvania.

From the mid-1960's through the mid-1970's, utilities placed numerous orders for large reactor systems, many of which were cancelled or deferred as electricity demand projections were reduced and construction cost escalated. Although many units were cancelled or delayed, nuclear electricity generation continued to grow until 1979, the year of the accident at Three Mile Island. During 1979 and 1980 nuclear power output declined due to regulatory concerns associated with the accident. Since 1980 annual nuclear electricity generation has more than doubled, reaching 610 TW·h in 1993, which accounted for 21% of total generation in that year.

### 3.2. Current Policy Issues

Federal government policies concerning civilian nuclear power are carried out primarily by the U.S. Department of Energy (DOE). Two DOE programs of significant importance are new reactor technology and radioactive waste management.

The objective of DOE's Advanced Light Water Reactor Program (ALWR) is to make commercially standardized advanced light water reactors available at the earliest possible time. The ALWR program budget for fiscal year 1995 is $51.0 million. This program co-funds design certification rulemaking proceeding for securing the Nuclear Regulatory Commission (NRC) certification for the General Electric Advanced Boiling Water Reactor (ABWR) and the Combustion Engineering System 80+ Advanced Pressurised Water Reactor. In the summer of 1994, the NRC gave final design approval to the ABWR and the System 80+. This paves the way for their final design certification in December of 1995 and actual construction if a utility so desires.

Co-funding of design work will continue on smaller (600 megawatts) passively-designed light-water reactors. Westinghouse's AP-600 and the General Electric Simplified Boiling Water Reactor are further away from certification. NRC does not anticipate granting final design approval for the AP-600 until September 1996 and design certification until December 1997. The SBWR's schedule is less definite. In August 1994, General Electric requested suspension of the NRC evaluation so the vendor could reassess its test, analyse the program, and revise its schedule.

Somewhat related to the certification program is the DOE's cost-shared program with the utility industry for first-of-a-kind engineering activities to produce Advanced Light Water Reactor (ALWR) designs suitable for commercial standardisation. In fiscal year 1993, the General Electric ABWR and the Westinghouse AP-600 Advanced Pressurised Water Reactor were selected for this program, and detailed design engineering began. During fiscal year 1995 detailed design engineering will be completed for 65% of the major and balance-of-plant systems. Standardized commercial designs, together with advanced safety features built into these new ALWR's, are expected to resolve problems which burdened the nuclear power industry in the past.

The DOE's Office of Civilian Radioactive Waste Management (OCRWM) is responsible for disposal of the Nation's spent nuclear fuel and high-level radioactive waste. Successful implementation of a waste disposal program is one of the most important issues affecting the nuclear power industry in the U.S.. Currently, the plan is to store the radioactive waste in a deep geologic repository. Yucca Mountain Nevada has been selected as a possible site, and extensive testing is under way to determine the suitability of the site. The total fiscal year 1995 funding for the program is $532.2 million.

### 3.3. Status and Trends of Nuclear Power

The growth of nuclear power can be attributed to the construction programs in the 1960's and 1970's when nuclear was considered to be a cheap and a widely accepted source of electricity. Nuclear power has become the 2nd largest source of electricity generation. Texas Utilities' Comanche Peak 2, a 1,150-MW(e) PWR, received its full-power license in 1993. One unit, Portland General Electric Company's Trojan, ceased operation in 1993 due to steam generator problems. At year-end 1993, there were 109 operable nuclear power plants with a total capacity of 99.0 GW(e), accounting for 21% of total generation. Although 1993 marked the first year since 1990 that nuclear power generation declined, nuclear capacity factors remained above 70%. Table 7 shows the current statues of nuclear power plants.

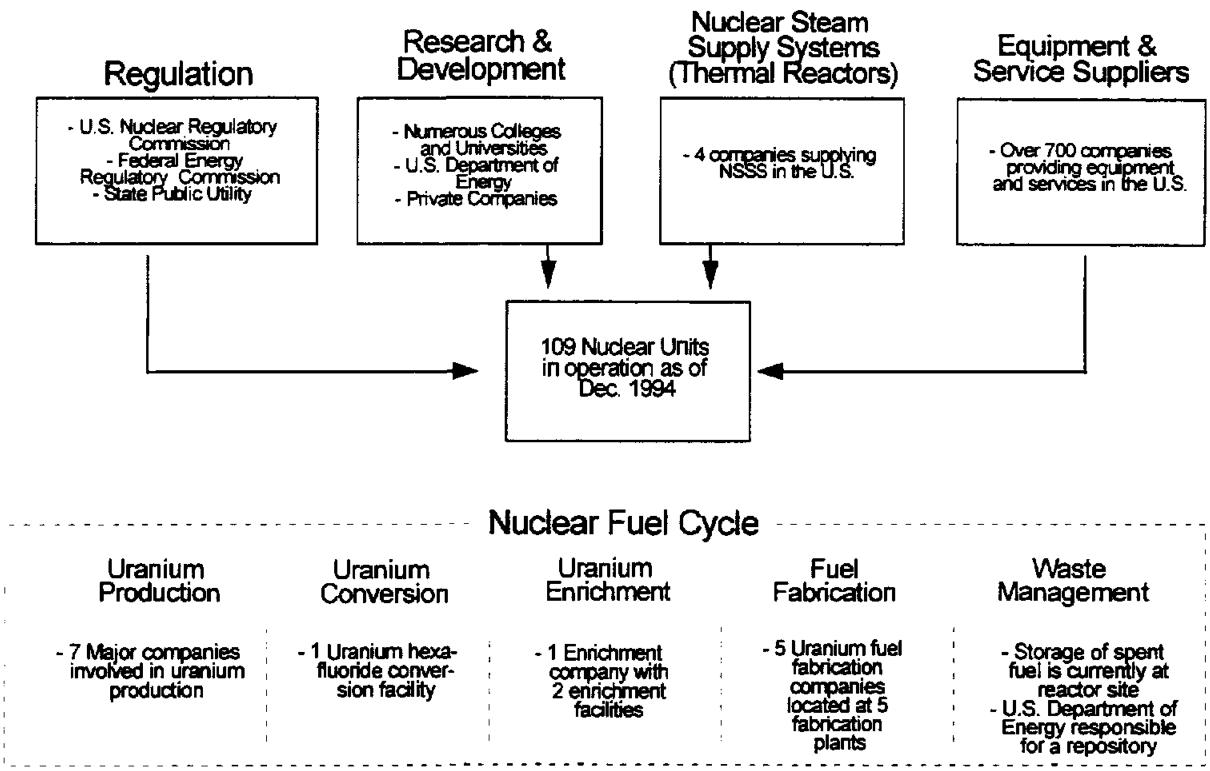
Although nuclear capacity has grown over the past few decades, nuclear capacity is projected to decline over the next 15 years. High operating cost relative to other sources of electricity and an unresolved nuclear waste disposal problem are two primary reasons for the projected decline in the U.S. nuclear power industry. On December 12, 1994, TVA announced that it will not complete three units already in the construction pipeline. Therefore, leaving only Watts Bar 1 which is expected to receive its full-power license early 1996. TVA will reconsider completing the units if willing financial partners can be found. TVA which has already spent an estimated $6 billion into the project could not justify spending an additional $9 billion for the completion of these units.

Nuclear capacity was 100.7 GW(e) at year-end 1996. This was achieved by the addition of Tennessee Valley's Watts Bar 1. It will remain constant until 2007 at which time four units are projected to retire (Haddam Neck, Palisades, Turkey Point 3 and 4). A total of 2.6 GW(e) will be retiring from service. By 2010 nuclear capacity will be in the range of 87.1 GW(e) and 91.1 GW(e). The most optimistic case (high case) is that 55 reactors will be life extended for an additional 20 years beyond their current retirement dates.

The future of nuclear power will depend on several factors. Resolution of the nuclear waste problem, reduction in nuclear operating and maintenance costs, and improvement of the public's perception of nuclear power. The NRC has revised its regulations to streamline the licensing process for future nuclear power reactors. The changes should substantially improve the entire licensing process.

### 3.4. Organizational Chart

Supporting the operation of nuclear power plants in the U.S. is a an extensive industrial base, including reactor vendor manufactures, numerous companies supplying major system components, both mechanical and electrical, and an array of companies supplying equipment and services to the plant. Figure 3 displays an overview of the organizational structure and major segments of the nuclear power industry.




*Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternative Fuels (Washington DC, January 1995)*

***FIG. 3. Overview of the Organizational Structure of the US Nuclear Power Industry, 1994***

## 4. NUCLEAR POWER INDUSTRY

As mentioned previously, the commercial nuclear power industry in the U.S. is large and comprehensive, covering all aspects of the fuel cycle. For the most part, nuclear power plants in the U.S. are privately owned, subject to safety regulations administered by the Federal Government and the State Governments in which plants are located. Economic regulations are also administered by the Federal and State governments, but they apply to the entire electric power industry, and are not unique to the nuclear segment. Regulation of the industry has already been discussed in a previous section. The following paragraphs briefly discuss the other segments of the industry. Annex 1 of this document contains a list of selected companies that are active in the nuclear power industry.

TABLE 7. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| ARKANSAS ONE-1 | PWR | 836 | APL | Operational | B&W | 01-Oct.-68 | 06-Aug.-74 | 17-Aug.-74 | 19-Dec.-74 | |
| ARKANSAS ONE-2 | PWR | 858 | APL | Operational | CE | 01-Jul.-71 | 05-Dec.-78 | 26-Dec.-78 | 26-Mar-80 | |
| BEAVER VALLEY-1 | PWR | 810 | DUQUESNE | Operational | WEST | 01-Jun.-70 | 10-May-76 | 14-Jun.-76 | 01-Oct.-76 | |
| BEAVER VALLEY-2 | PWR | 820 | DUQUESNE | Operational | WEST | 01-May-74 | 04-Aug.-87 | 17-Aug.-87 | 17-Nov.-87 | |
| BIG ROCK POINT | BWR | 67 | CPC | Operational | GE | 01-May-60 | 27-Sept.-62 | 08-Dec.-62 | 29-Mar-63 | |
| BRAIDWOOD-1 | PWR | 1090 | COMED | Operational | WEST | 01-Aug.-75 | 29-May-87 | 12-Jul.-87 | 29-Jul.-88 | |
| BRAIDWOOD-2 | PWR | 1090 | COMED | Operational | WEST | 01-Aug.-75 | 08-Mar-88 | 25-May-88 | 17-Oct.-88 | |
| BROWNS FERRY-1 | BWR | 1065 | TVA | Operational | GE | 01-May-67 | 17-Aug.-73 | 15-Oct.-73 | 01-Aug.-74 | |
| BROWNS FERRY-2 | BWR | 1065 | TVA | Operational | GE | 01-May-67 | 20-Jul.-74 | 28-Aug.-74 | 01-Mar-75 | |
| BROWNS FERRY-3 | BWR | 1065 | TVA | Operational | GE | 01-Jul.-68 | 08-Aug.-76 | 12-Sept.-76 | 01-Mar-77 | |
| BRUNSWICK-1 | BWR | 767 | CPL | Operational | GE | 01-Sept.-69 | 08-Oct.-76 | 04-Dec.-76 | 18-Mar-77 | |
| BRUNSWICK-2 | BWR | 754 | CPL | Operational | GE | 01-Sept.-69 | 20-Mar-75 | 29-Apr..-75 | 03-Nov.-75 | |
| BYRON-1 | PWR | 1120 | COMED | Operational | WEST | 01-Apr..-75 | 02-Feb.-85 | 01-Mar-85 | 16-Sept.-85 | |
| BYRON-2 | PWR | 1120 | COMED | Operational | WEST | 01-Apr..-75 | 09-Jan.-87 | 06-Feb.-87 | 21-Aug.-87 | |
| CALLAWAY-1 | PWR | 1125 | UNION | Operational | WEST | 01-Sept.-75 | 02-Oct.-84 | 24-Oct.-84 | 19-Dec.-84 | |
| CALVERT CLIFFS-1 | PWR | 835 | BGE | Operational | CE | 01-Jun.-68 | 07-Oct.-74 | 03-Jan.-75 | 08-May-75 | |
| CALVERT CLIFFS-2 | PWR | 840 | BGE | Operational | CE | 01-Jun.-68 | 30-Nov.-76 | 07-Dec.-76 | 01-Apr..-77 | |
| CATAWBA-1 | PWR | 1129 | DUKE | Operational | WEST | 01-May-74 | 07-Jan.-85 | 22-Jan.-85 | 29-Jun.-85 | |
| CATAWBA-2 | PWR | 1129 | DUKE | Operational | WEST | 01-May-74 | 08-May-86 | 18-May-86 | 19-Aug.-86 | |
| CLINTON-1 | BWR | 930 | IPC | Operational | GE | 01-Oct.-75 | 27-Feb.-87 | 24-Apr..-87 | 24-Nov.-87 | |
| COMANCHE PEAK-1 | PWR | 1150 | TUC | Operational | WEST | 01-Oct.-74 | 03-Apr..-90 | 24-Apr..-90 | 13-Aug.-90 | |
| COMANCHE PEAK-2 | PWR | 1150 | TUC | Operational | WEST | 01-Oct.-74 | 24-Mar-93 | 09-Apr..-93 | 03-Aug.-93 | |
| COOPER | BWR | 778 | NPPD | Operational | GE | 01-Jun.-68 | 21-Feb.-74 | 10-May-74 | 01-Jul.-74 | |
| CRYSTAL RIVER-3 | PWR | 812 | FPC | Operational | B&W | 01-Jun.-67 | 14-Jan.-77 | 30-Jan.-77 | 13-Mar-77 | |
| DAVIS BESSE-1 | PWR | 873 | TOLED | Operational | B&W | 01-Sept.-70 | 12-Aug.-77 | 28-Aug.-77 | 31-Jul.-78 | |
| DIABLO CANYON-1 | PWR | 1073 | PGEC | Operational | WEST | 01-Aug.-68 | 29-Apr..-84 | 11-Nov.-84 | 07-May-85 | |
| DIABLO CANYON-2 | PWR | 1087 | PGEC | Operational | WEST | 01-Dec.-70 | 19-Aug.-85 | 20-Oct.-85 | 13-Mar-86 | |
| DONALD COOK-1 | PWR | 1000 | IMPCO | Operational | WEST | 01-Mar-69 | 18-Jan.-75 | 10-Feb.-75 | 27-Aug.-75 | |
| DONALD COOK-2 | PWR | 1060 | IMPCO | Operational | WEST | 01-Mar-69 | 10-Mar-78 | 22-Mar-78 | 01-Jul.-78 | |
| DRESDEN-2 | BWR | 772 | COMED | Operational | GE | 01-Jan.-66 | 07-Jan.-70 | 13-Apr..-70 | 09-Jun.-70 | |
| DRESDEN-3 | BWR | 773 | COMED | Operational | GE | 01-Oct.-66 | 31-Jan.-71 | 22-Jul.-71 | 16-Nov.-71 | |
| DUANE ARNOLD-1 | BWR | 528 | IELP | Operational | GE | 01-Jun.-70 | 23-Mar-74 | 19-May-74 | 01-Feb.-75 | |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 7. CONTINUED. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| ENRICO FERMI-2 | BWR | 1100 | DETED | Operational | GE | 01-May-69 | 21-Jun.-85 | 21-Sept.-86 | 23-Jan.-88 | |
| FARLEY-1 | PWR | 815 | ALP | Operational | WEST | 01-Oct.-70 | 09-Aug.-77 | 18-Aug.-77 | 01-Dec.-77 | |
| FARLEY-2 | PWR | 825 | ALP | Operational | WEST | 01-Oct.-70 | 05-May-81 | 25-May-81 | 30-Jul.-81 | |
| FITZPATRICK | BWR | 800 | PASNY | Operational | GE | 01-Sept.-68 | 17-Nov.-74 | 01-Feb.-75 | 28-Jul.-75 | |
| FORT CALHOUN-1 | PWR | 476 | OPPD | Operational | CE | 01-Jun.-68 | 06-Aug.-73 | 25-Aug.-73 | 20-Jun.-74 | |
| GRAND GULF-1 | BWR | 1173 | MP&L | Operational | GE | 01-May-74 | 18-Aug.-82 | 20-Oct.-84 | 01-Jul.-85 | |
| H.B. ROBINSON-2 | PWR | 683 | CPL | Operational | WEST | 01-Apr..-67 | 20-Sept.-70 | 26-Sept.-70 | 07-Mar-71 | |
| HADDAM NECK | PWR | 560 | CYAPC | Operational | WEST | 01-May-64 | 24-Jul.-67 | 07-Aug.-67 | 01-Jan.-68 | |
| HATCH-1 | BWR | 759 | GP | Operational | GE | 01-Sept.-68 | 12-Sept.-74 | 11-Nov.-74 | 31-Dec.-75 | |
| HATCH-2 | BWR | 813 | GP | Operational | GE | 01-Feb.-72 | 04-Jul.-78 | 22-Sept.-78 | 05-Sept.-79 | |
| HOPE CREEK-1 | BWR | 1031 | PSEG | Operational | GE | 01-Mar-76 | 28-Jun.-86 | 01-Aug.-86 | 20-Dec.-86 | |
| INDIAN POINT-2 | PWR | 931 | CONED | Operational | WEST | 01-Oct.-66 | 22-May-73 | 26-Jun.-73 | 15-Aug.-74 | |
| INDIAN POINT-3 | PWR | 980 | PASNY | Operational | WEST | 01-Nov.-68 | 06-Apr..-76 | 27-Apr..-76 | 30-Aug.-76 | |
| KEWAUNEE | PWR | 519 | WPS | Operational | WEST | 01-Aug.-68 | 07-Mar-74 | 08-Apr..-74 | 16-Jun.-74 | |
| LASALLE-1 | BWR | 1048 | COMED | Operational | GE | 01-Sept.-73 | 21-Jun.-82 | 04-Sept.-82 | 01-Jan.-84 | |
| LASALLE-2 | BWR | 1048 | COMED | Operational | GE | 01-Oct.-73 | 10-Mar-84 | 20-Apr..-84 | 19-Oct.-84 | |
| LIMERICK-1 | BWR | 1055 | PEC | Operational | GE | 01-Apr..-70 | 22-Dec.-84 | 13-Apr..-85 | 01-Feb.-86 | |
| LIMERICK-2 | BWR | 1115 | PEC | Operational | GE | 01-Apr..-70 | 12-Aug.-89 | 01-Sept.-89 | 08-Jan.-90 | |
| MAINE YANKEE | PWR | 870 | MYAPC | Operational | CE | 01-Oct-68 | 23-Oct-72 | 08-Nov.-72 | 28-Dec.-72 | |
| MCGUIRE-1 | PWR | 1129 | DUKE | Operational | WEST | 01-Apr.-71 | 08-Aug.-81 | 12-Sept.-81 | 01-Dec.-81 | |
| MCGUIRE-2 | PWR | 1129 | DUKE | Operational | WEST | 01-Apr.-71 | 08-May-83 | 23-May-83 | 01-Mar-84 | |
| MILLSTONE-1 | BWR | 641 | NNEC | Operational | GE | 01-May-66 | 26-Oct-70 | 29-Nov.-70 | 01-Mar-71 | |
| MILLSTONE-2 | PWR | 873 | NNEC | Operational | CE | 01-Nov.-69 | 17-Oct-75 | 09-Nov.-75 | 26-Dec.-75 | |
| MILLSTONE-3 | PWR | 1120 | NNEC | Operational | WEST | 01-May-74 | 23-Jan.-86 | 12-Feb.-86 | 23-Apr.-86 | |
| MONTICELLO | BWR | 544 | NSP | Operational | GE | 01-Jun.-67 | 10-Dec.-70 | 05-Mar-71 | 30-Jun.-71 | |
| NINE MILE POINT-1 | BWR | 6017 | NMPC | Operational | GE | 01-Apr.-65 | 05-Sept.-69 | 09-Nov.-69 | 01-Dec.-69 | |
| NINE MILE POINT-2 | BWR | 1026 | NMPC | Operational | GE | 01-Aug.-75 | 23-May-87 | 08-Aug.-87 | 11-Mar-88 | |
| NORTH ANNA-1 | PWR | 893 | VEPCO | Operational | WEST | 01-Feb.-71 | 05-Apr.-78 | 17-Apr.-78 | 06-Jun.-78 | |
| NORTH ANNA-2 | PWR | 897 | VEPCO | Operational | WEST | 01-Nov.-70 | 12-Jun.-80 | 25-Aug.-80 | 14-Dec.-80 | |
| OCONEE-1 | PWR | 846 | DUKE | Operational | B&W | 01-Nov.-67 | 19-Apr.-73 | 06-May-73 | 15-Jul.-73 | |
| OCONEE-2 | PWR | 846 | DUKE | Operational | B&W | 01-Nov.-67 | 11-Nov.-73 | 05-Dec.-73 | 09-Sept.-74 | |
| OCONEE-3 | PWR | 846 | DUKE | Operational | B&W | 01-Nov.-67 | 05-Sept.-74 | 18-Sept.-74 | 16-Dec.-74 | |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 7. CONTINUED. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| OYSTER CREEK | BWR | 619 | GPU | Operational | GE | 01-Jan.-64 | 03-May-69 | 23-Sept.-69 | 01-Dec.-69 | |
| PALISADES | PWR | 762 | CPC | Operational | CE | 01-Feb.-67 | 24-May-71 | 31-Dec.-71 | 31-Dec.-71 | |
| PALO VERDE-1 | PWR | 1270 | APS | Operational | CE | 01-May-76 | 25-May-85 | 10-Jun.-85 | 28-Jan.-86 | |
| PALO VERDE-2 | PWR | 1270 | APS | Operational | CE | 01-Jun.-76 | 18-Apr.-86 | 20-May-86 | 19-Sept.-86 | |
| PALO VERDE-3 | PWR | 1270 | APS | Operational | CE | 01-Jun.-76 | 25-Oct-87 | 28-Nov.-87 | 08-Jan.-88 | |
| PEACH BOTTOM-2 | BWR | 1093 | PEC | Operational | GE | 01-Jan.-68 | 16-Sept.-73 | 18-Feb.-74 | 05-Jul.-74 | |
| PEACH BOTTOM-3 | BWR | 1093 | PEC | Operational | GE | 01-Jan.-68 | 07-Aug.-74 | 01-Sept.-74 | 23-Dec.-74 | |
| PERRY-1 | BWR | 1169 | CEI | Operational | GE | 01-Oct-74 | 06-Jun.-86 | 19-Dec.-86 | 18-Nov.-87 | |
| PILGRIM-1 | BWR | 689 | BOSTED | Operational | GE | 01-Aug.-68 | 16-Jun.-72 | 19-Jul.-72 | 01-Dec.-72 | |
| POINT BEACH-1 | PWR | 493 | WEP | Operational | WEST | 01-Jul.-67 | 02-Nov.-70 | 06-Nov.-70 | 21-Dec.-70 | |
| POINT BEACH-2 | PWR | 441 | WEP | Operational | WEST | 01-Jul.-68 | 30-May-72 | 02-Aug.-72 | 01-Oct-72 | |
| PRAIRIE ISLAND-1 | PWR | 514 | NSP | Operational | WEST | 01-May-68 | 01-Dec.-73 | 04-Dec.-73 | 16-Dec.-73 | |
| PRAIRIE ISLAND-2 | PWR | 513 | NSP | Operational | WEST | 01-May-69 | 17-Dec.-74 | 21-Dec.-74 | 21-Dec.-74 | |
| QUAD CITIES-1 | BWR | 769 | COMED | Operational | GE | 01-Feb.-67 | 18-Oct-71 | 12-Apr.-72 | 18-Feb.-73 | |
| QUAD CITIES-2 | BWR | 769 | COMED | Operational | GE | 01-Feb.-67 | 26-Apr.-72 | 23-May-72 | 10-Mar-73 | |
| R.E. GINNA | PWR | 470 | RGE | Operational | WEST | 01-Apr.-66 | 08-Nov.-69 | 02-Dec.-69 | 01-Jul.-70 | |
| RIVER BEND-1 | BWR | 936 | GSU | Operational | GE | 01-Mar-77 | 31-Oct-85 | 03-Dec.-85 | 16-Jun.-86 | |
| SALEM-1 | PWR | 1106 | PSEG | Operational | WEST | 01-Jan.-68 | 11-Dec.-76 | 25-Dec.-76 | 30-Jun.-77 | |
| SALEM-2 | PWR | 1106 | PSEG | Operational | WEST | 01-Jan.-68 | 08-Aug.-80 | 03-Jun.-81 | 13-Oct-81 | |
| SAN ONOFRE-2 | PWR | 1070 | SCE | Operational | CE | 01-Mar-74 | 26-Jul.-82 | 20-Sept.-82 | 08-Aug.-83 | |
| SAN ONOFRE-3 | PWR | 1080 | SCE | Operational | CE | 01-Mar-74 | 29-Aug.-83 | 25-Sept.-83 | 01-Apr.-84 | |
| SEABROOK-1 | PWR | 1155 | PSNH | Operational | WEST | 01-Jul.-76 | 13-Jun.-89 | 29-May-90 | 19-Aug.-90 | |
| SEQUOYAH-1 | PWR | 1111 | TVA | Operational | WEST | 01-May-70 | 05-Jul.-80 | 22-Jul.-80 | 01-Jul.-81 | |
| SEQUOYAH-2 | PWR | 1106 | TVA | Operational | WEST | 01-May-70 | 05-Nov.-81 | 23-Dec.-81 | 01-Jun.-82 | |
| SHEARON HARRIS-1 | PWR | 860 | CPL | Operational | WEST | 01-Jan.-74 | 03-Jan.-87 | 19-Jan.-87 | 02-May-87 | |
| SOUTH TEXAS-1 | PWR | 1251 | HLP | Operational | WEST | 01-Sept.-75 | 08-Mar-88 | 30-Mar-88 | 25-Aug.-88 | |
| SOUTH TEXAS-2 | PWR | 1251 | HLP | Operational | WEST | 01-Sept.-75 | 12-Mar-89 | 11-Apr.-89 | 19-Jun.-89 | |
| ST. LUCIE-1 | PWR | 839 | FPL | Operational | CE | 01-Jul.-70 | 22-Apr.-76 | 07-May-76 | 21-Dec.-76 | |
| ST. LUCIE-2 | PWR | 839 | FPL | Operational | CE | 01-Jun.-76 | 02-Jun.-83 | 13-Jun.-83 | 08-Aug.-83 | |
| SURRY-1 | PWR | 801 | VEPCO | Operational | WEST | 01-Jun.-68 | 01-Jul.-72 | 04-Jul.-72 | 22-Dec.-72 | |
| SURRY-2 | PWR | 801 | VEPCO | Operational | WEST | 01-Jun.-68 | 07-Mar-73 | 10-Mar-73 | 01-May-73 | |

Source: IAEA Power Reactor Information System, yearend 1996

TABLE 7. CONTINUED. STATUS OF NUCLEAR POWER PLANTS

| Station | Type | Capacity | Operator | Status | Reactor Supplier | Construction Date | Criticality Date | Grid Date | Commercial Date | Shutdown Date |
|---|---|---|---|---|---|---|---|---|---|---|
| SUSQUEHANNA-1 | BWR | 1090 | PP&L | Operational | GE | 01-Nov.-73 | 10-Sept.-82 | 16-Nov.-82 | 08-Jun.-83 | |
| SUSQUEHANNA-2 | BWR | 1094 | PP&L | Operational | GE | 01-Nov.-73 | 08-May-84 | 03-Jul.-84 | 12-Feb.-85 | |
| THREE MILE ISLAND-1 | PWR | 786 | GPU | Operational | B&W | 01-May-68 | 05-Jun.-74 | 19-Jun.-74 | 02-Sept.-74 | |
| TURKEY POINT-3 | PWR | 666 | FPL | Operational | WEST | 01-Apr.-67 | 20-Oct-72 | 02-Nov.-72 | 14-Dec.-72 | |
| TURKEY POINT-4 | PWR | 666 | FPL | Operational | WEST | 01-Apr.-67 | 11-Jun.-73 | 21-Jun.-73 | 07-Sept.-73 | |
| VERMONT YANKEE | BWR | 496 | VYNPC | Operational | GE | 01-Dec.-67 | 24-Mar-72 | 20-Sept.-72 | 30-Nov.-72 | |
| VIRGIL C. SUMMER-1 | PWR | 885 | SCEG | Operational | WEST | 01-Mar-73 | 22-Oct-82 | 16-Nov.-82 | 01-Jan.-84 | |
| VOGTLE-1 | PWR | 1164 | GP | Operational | WEST | 01-Aug.-76 | 09-Mar-87 | 27-Mar-87 | 01-Jun.-87 | |
| VOGTLE-2 | PWR | 1164 | GP | Operational | WEST | 01-Aug.-76 | 28-Mar-89 | 10-Apr.-89 | 20-May-89 | |
| WATERFORD-3 | PWR | 1075 | LPL | Operational | CE | 01-Nov.-74 | 04-Mar-85 | 18-Mar-85 | 24-Sept.-85 | |
| WATTS BAR-1 | PWR | 1170 | TVA | Operational | WEST | 01-Dec.-72 | 01-Jan.-96 | 06-Feb.-96 | 05-May-96 | |
| WOLF CREEK | PWR | 1167 | KGE | Operational | WEST | 01-Jan.-77 | 22-May-85 | 12-Jun.-85 | 03-Sept.-85 | |
| WPPSS-2 | BWR | 1107 | WPPSS | Operational | GE | 01-Aug.-72 | 19-Jan.-84 | 27-May-84 | 13-Dec.-84 | |
| ZION-1 | PWR | 1040 | COMED | Operational | WEST | 01-Dec.-68 | 19-Jun.-73 | 28-Jun.-73 | 31-Dec.-73 | |
| ZION-2 | PWR | 1040 | COMED | Operational | WEST | 01-Dec.-68 | 24-Dec.-73 | 26-Dec.-73 | 17-Sept.-74 | |
| BONUS | BWR | 17 | DOE/PRWR | Shut Down | GNEPRWRA | 01-Jan.-60 | 01-Jan.-64 | 14-Aug.-64 | | 01-Jun.-68 |
| CVTR | PHWR | 17 | CVPA | Shut Down | WEST | 01-Jan.-60 | 01-Mar-63 | 18-Dec.-63 | | 01-Jan.-67 |
| DRESDEN-1 | BWR | 197 | COMED | Shut Down | GE | 01-May-56 | 15-Oct-59 | 15-Apr.-60 | 04-Jul.-60 | 31-Oct-78 |
| ELK RIVER | BWR | 22 | RCPA | Shut Down | AC | 01-Jan.-59 | 01-Nov.-62 | 24-Aug.-63 | 01-Jul.-64 | 01-Feb.-68 |
| ENRICO FERMI-1 | FBR | 65 | DETED | Shut Down | UEC | 01-Aug.-56 | 23-Aug.-63 | 05-Aug.-66 | | 29-Nov.-72 |
| FORT ST. VRAIN | HTGR | 330 | PSCC | Shut Down | GA | 01-Sept.-68 | 31-Jan.-74 | 11-Dec.-76 | 01-Jul.-79 | 29-Aug.-89 |
| HUMBOLDT BAY | BWR | 63 | PGEC | Shut Down | GE | 01-Nov.-60 | 16-Feb.-63 | 18-Apr.-63 | 01-Aug.-63 | 02-Jul.-76 |
| INDIAN POINT-1 | PWR | 257 | CONED | Shut Down | B&W | 01-May-56 | 02-Aug.-62 | 16-Sept.-62 | 01-Oct-62 | 31-Oct-74 |
| LACROSSE | BWR | 48 | DPC | Shut Down | AC | 01-Mar-63 | 11-Jul.-67 | 26-Apr.-68 | 07-Nov.-69 | 30-Apr.-87 |
| PATHFINDER | BWR | 59 | NSP | Shut Down | AC | 01-Jan.-59 | 01-Jan.-64 | 25-Jul.-66 | | 01-Oct-67 |
| PEACH BOTTOM-1 | HTGR | 40 | PEC | Shut Down | GA | 01-Feb.-62 | 03-Mar-66 | 27-Jan.-67 | 01-Jun.-67 | 01-Nov.-74 |
| RANCHO SECO-1 | PWR | 873 | SMUD | Shut Down | B&W | 01-Apr.-69 | 16-Sept.-74 | 13-Oct-74 | 17-Apr.-75 | 07-Jun.-89 |
| SAN ONOFRE-1 | PWR | 436 | SCE | Shut Down | WEST | 01-May-64 | 14-Jun.-67 | 16-Jul.-67 | 01-Jan.-68 | 30-Nov.-92 |
| THREE MILE ISLAND-2 | PWR | 880 | GPU | Shut Down | B&W | 01-Nov.-69 | 27-Mar-78 | 21-Apr.-78 | 30-Dec.-78 | 28-Mar-79 |
| TROJAN | PWR | 1095 | PORTGE | Shut Down | WEST | 01-Feb.-70 | 15-Dec.-75 | 23-Dec.-75 | 20-May-76 | 09-Nov.-92 |
| YANKEE NPS | PWR | 167 | YAEC | Shut Down | WEST | 01-Nov.-57 | 19-Aug.-60 | 10-Nov.-60 | 01-Jul.-61 | 01-Oct-91 |

Source: IAEA Power Reactor Information System, yearend 1996

### 4.1. Suppliers to Nuclear Power Plants

*Nuclear Steam Supply Systems*

Nuclear steam supply systems currently operating in the U.S. were supplied by four companies. Westinghouse Corporation has the majority of reactors in operation with a total of 50 pressurised-water reactors (PWR) operating. ABB Combustion Engineering has 15 PWR's operating and Babcock & Wilcox has 7 PWRs operating. General Electric, the only company supplying boiling-water reactors (BWR) in the U.S., has 37 currently operating.

*Equipment and Service Suppliers*

In the U.S., there are over 700 companies providing equipment and services to the nuclear power industry. These services cover the entire nuclear fuel cycle spectrum, from suppliers of main components to companies supplying routine equipment and services found in most power plants.

To help assure high quality products, the American Society of Mechanical Engineers (ASME) has a certification program for nuclear equipment suppliers. In order to obtain an ASME nuclear certificate of authorisation, the company must comply with quality assurance requirements set forth by the ASME. This program is open to foreign companies as well as companies in the U.S.. Currently there are over 200 foreign and U.S. companies holding ASME nuclear certificates of authorisation.

### 4.2. Operation of Nuclear Power Plants

*Plant Operation*

As noted previously, there are 109 nuclear units operating in the U.S.. These units are located at 70 nuclear plants throughout the U.S.. Most of the nuclear plants are located in the eastern region of the country (Figure 4). These plants, mostly privately owned, are operated by 49 companies having a nuclear power reactor license granted by the NRC.

*Training Services*

Various training services are also available. Over 20 private companies are involved in training for nuclear plant operators. Perhaps one of the most widely used training programs in the U.S. is sponsored by the Institute of Nuclear Power Plant Operations (INPO). The institute was founded in 1979, as an industry initiative in response to the Three Mile Island accident, to promote the highest levels of safety and reliability in commercial nuclear power plants. Among many activities, INPO manages a nuclear utility training accreditation program.

### 4.3. Fuel Cycle and Waste Management Service Supply

All activities of the commercial nuclear fuel cycle are conducted in the U.S., with the exception of spent fuel reprocessing.

*Uranium Production and Uranium Conversion*

Because the nuclear industry in the U.S. is not expected to grow in the near to intermediate future, and for other economic factors such as the relatively low market price of uranium, companies actively involved in uranium production and uranium conversion in the U.S. are few. At the end of 1994 there were seven major companies involved in uranium production, four of which were operating commercially at the end of the year. One uranium hexafloride conversion plant is operating currently in the U.S..

*Uranium Enrichment*

In 1993 the uranium enrichment business in the U.S. was transferred from DOE to a private company, the U.S. Enrichment Corporation. This company was created by the Energy Policy Act of 1992 with the objective to privatise the U.S. enrichment business in order to help make it more competitive in the world-wide enrichment industry. The USEC has 2 enrichment facilities (which are currently rented from DOE); one at Paducah, Kentucky, and the other at Portsmith, Ohio. Both facilities employ gaseous diffusion technology.

*Fuel Fabrication*

Five companies are currently operating uranium fuel fabrication facilities in the U.S.. These facilities are designed for fabrication of light-water reactor fuel.

*Nuclear Waste Management*

Currently, most spent fuel from commercial nuclear reactors is stored onsite at the nuclear plant; a small amount has been shipped to offsite storage facilities. In the U.S. there are numerous private companies providing the necessary equipment and services to support management and storage of spent fuel. As of the end of 1993, approximately 28.0 thousand metric tons of spent fuel have been discharged from commercial nuclear reactors. As mentioned elsewhere in this paper, the U.S. DOE has the responsibility to construct a permanent repository for commercial spent fuel. The DOE is currently in the process of establishing a site to accomplish this task.

**4.4. Research and Development Activities**

Research and Development (R&D) in the nuclear industry is conducted by both private industry and the Federal Government. Private companies are actively involved in R&D covering reactor technology, enrichment technology (i.e. advanced laser isotope separation, AVLIS), and nuclear fuel design. One of the main mechanisms for private funding of research is through membership in the Electric Power Research Institute (EPRI). EPRI, through membership fees, conducts R&D in many nuclear related areas as well as other areas of the electric power industry.

The Federal Government supports R&D through specific budget allocations and through the national laboratories operated by the U.S. DOE. The DOE operates 26 laboratories and institutes, many of which conduct research in various aspects of the nuclear fuel cycle.

**4.5. International Co-operation in the Field of Nuclear Power**

Because the nuclear power industry in the U.S. is decentralised and consists mainly of private companies, information on all co-operative efforts between organizations in the U.S. and other countries is not available. However, some of the major co-operative efforts can be presented.

The U.S. Department of Energy has begun work with Ukraine to set up an international nuclear safety and environmental research centre at Slavutich near the Chernobyl station. The U.S. will provide funds over the next two years, and will work with its G-7 partners to encourage other countries to help.

The U.S. government signed an agreement with North Korea establishing under international law the Korean Energy Development Organization (KEDO) . The main purpose of KEDO is to provide an estimated $4-billion in funding to supply two light water reactors to North Korea.

In 1994, Westinghouse Corporation and Russia's Ministry of Atomic Energy(Minatom) signed a broad business agreement aimed at joint development of nuclear products and services for the Russian Federation, the rest of the former Soviet Union, and export. The agreement could, in time, lead to establishing in Russia associate companies of Westinghouse, but using technology from both Westinghouse and Minatom.

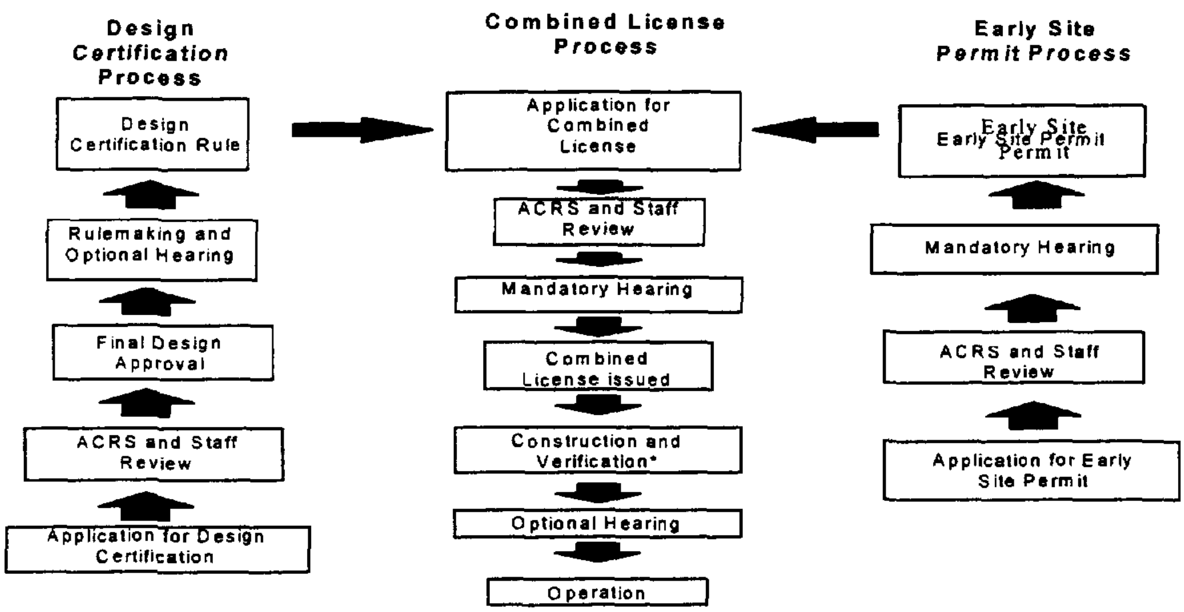
## 5. NUCLEAR LAWS AND REGULATIONS

### 5.1. Regulatory Framework

Regulation of the nuclear power industry is exercised by the U.S. Nuclear Regulatory Commission (NRC). Its mission is to ensure adequate protection of the public health and safety, the common defence and security, and the environment. The NRC's scope of responsibility includes regulation of commercial nuclear power plants; non-power research, test and training reactors; fuel cycle facilities; medical, academic, and industrial uses of nuclear materials, and disposal of nuclear materials and waste.

The NRC accomplishes its purpose by the licensing and regulatory oversight of nuclear reactors operations and other activities involving the possession and use of nuclear materials and waste; by the safe guarding of nuclear materials and facilities from theft and/or sabotage; by the issuance of rules and standards; and by inspection and enforcement actions.

Of particular importance to the future of the nuclear industry is NRC's nuclear power plant licensing process. The Energy Policy Act of 1992 (EPACT) specified a new nuclear power plant licensing process which the NRC can use for any new applicant for a nuclear plant. Under the new licensing procedure outlined in the EPACT (see Figure 5 for a schematic of the new license procedure), the applicant (i.e., an entity that seeks to build a new reactor), will use off-the shelf reactor designs that will have been approved and certified by the NRC. After reviewing the application and holding one or more public hearings, the NRC may issue a combined construction and operating license (the previous process was to issue a construction permit and a full power operating license separately and at different times). Because the applicant is using an NRC-certified design, safety issues related to the design will have been resolved, and the main concern will be the quality of the construction of the reactor.




* Finding issued after construction to determine whether the conditions of the combined operating license were met.
ACRS - Advisory Committee on Reactor Safegurads
Source: 10 CFR Part 52 Nuclear Regulatory Commission

*FIG.5. Reactor Licensing Process*

Before authorising power operation, the NRC will perform comprehensive testing and acceptance procedures on the reactor. Codified in part 52 of Title 10, Code of Federal Regulations, the new licensing process is in place and ready to be used when certification of the new designs is completed. The new license procedure is said to be a more predictable process with less uncertainty, and less financial risk to the applicant.

## 5.2. Main National Laws and Regulations

The U.S. Congress has enacted several laws which together create a comprehensive regulatory program governing the design, construction, and operation of nuclear energy plants. Transportation and disposal of radioactive waste is a major concern of the industry and the public, and there is specific legislation to address these activities as well.

The nuclear industry in the U.S. is affected by the legislation outlined in Table 8, which covers the entire electric power industry, and the major legislation outlined in Table 9, which affects the nuclear power industry specifically. These laws are by no means exhaustive of the national legislation affecting the nuclear industry. It should also be noted that, although the Federal Government has an extensive role in the nuclear industry, there is also an appropriate regulatory role for the individual states.

TABLE 8. IMPORTANT LEGISLATION COVERING THE ELECTRIC POWER INDUSTRY

| |
|---|
| **The Public Utility Holding Company Act of 1935 (PUHCA)** (Public Law 74-333) |
| PUHCA was enacted to break up the large and powerful trusts that controlled the Nation's electric and gas distribution networks. PUHCA gave the Securities and Exchange Commission the authority to break up the trusts and to regulate the reorganized industry in order to prevent their return. PUHCA was recently overhauled since many argued that PUHCA's regulations were impediments to the development of an efficient electricity market. |
| **The Federal Power Act of 1935** (Title II of PUHCA) |
| This act was passed at the same time as the Public Utilities Holding Company Act. It was passed to provide for a Federal mechanism, as required by the Commerce Clause of the Constitution, for interstate electricity regulation. Prior to this, electricity generation, transmission and distribution were almost always a series of intrastate transactions. |
| **The Public Utility Regulatory Policies Act of 1978 (PURPA)** (Public Law 95-617) |
| PURPA was passed in response to the unstable energy climate of the late 1970's. PURPA sought to promote conservation of electric energy. Additionally, PURPA created a new class of non-utility generators, small power producers, from which, along with qualified co-generators, utilities are required to buy power. |
| **The Energy Tax Act of 1978 (ETA)** (Public Law 95-618) |
| This act, like PURPA, was passed in response to the unstable energy climate of the 1970's. The ETA encouraged conversion of boilers to coal and investment in cogeneration equipment and solar and wind technologies by allowing a tax credit on top of the investment tax credit. It was later expanded to include other renewable technologies. However, the incentives were curtailed as a result of tax reform legislation in the mid-1980's. |
| **The Clean Air Act Amendments of 1990** (Public Law 101-549) |
| These amendments established a new emissions-reduction programme. The goal of the legislation was to reduce annual sulphur dioxide emissions by 10 million tons and annual nitrogen oxide emission by 2 million tons from 1980 levels for all man-made sources. Generators of electricity will be responsible for large portions of the sulphur dioxide and nitrogen oxide reductions. The programme instituted under the Clean Air Act Amendments of 1990 employs a unique, market-based approach to sulphur dioxide emission reductions, while relying on more traditional methods for nitrogen oxide reductions. |
| **The Energy Policy Act of 1992 (ENACT)** (Public Law 102-486) |
| This law created a new category of electricity producer, the exempt wholesale generator, which circumvented PUHCA's impediments to the development of non-utility electricity generation. The law also allowed FERC to open up the national electricity transmission system to wholesale suppliers. |

TABLE 9. IMPORTANT LEGISLATION AFFECTING THE NUCLEAR POWER INDUSTRY

| |
|---|
| **Atomic Energy Act of 1954, as amended** |
| (Public Law 83-703) |
| The Atomic Energy Act of 1954 was enacted to encourage private enterprise in the development and utilisation of nuclear energy for peaceful purposes. This act amended the AEA of 1946 to allow non-federal ownership of nuclear production and utilisation facilities if an operating license was obtained from the Atomic Energy Commission (AEC). This act enabled the development of the commercial nuclear power industry in the U.S.. |
| **Energy Reorganization Act of 1974** |
| (Public Law 93-438) |
| This Act separated the licensing and related functions of the AEC from energy development and related functions. The Nuclear Regulatory Commission (NRC) was established as an independent regulatory authority to assure the safety and licensing of nuclear reactors and other facilities associated with processing, transport and handling of nuclear materials. The NRC is still today the main regulatory agency of the US nuclear power industry. |
| **Low-level Radioactive Waste Policy Act of 1980, as amended** |
| (Public Law 96-573) |
| This Act was an important step toward the development of new disposal capacity for low-level radioactive waste. Each state was made responsible for providing, either by itself or in co-operation with other states, for the disposal of low-level radioactive waste generated within the state. To carry out this policy, the Act authorises the states to enter into compacts to provide for the establishment and operation of regional disposal facilities for low-level waste, subject to NRC licensing approval. |
| **Nuclear Waste Policy Act of 1982, as amended** |
| (Public Law 97-425) |
| This Act established Federal responsibility for the development of repositories for the disposal of high-level radioactive waste and spent nuclear fuel. This Act was amended in 1987 requiring the US Department of Energy to begin evaluating the suitability of Yucca Mountain in Nevada as the nation's permanent high-level waste repository. This activity is currently in progress |
| **Energy Policy Act of 1992** |
| (Public Law 102-486) |
| The Energy Policy Act (ENACT) includes many new initiatives dealing with energy over a broad range of issues. Seven of EPACT's 30 Titles contain provision related to nuclear power and/or uranium |

Two important issues of national concern are the disposal of spent fuel and decommissioning of retired nuclear plants. Because the costs of these activities is high, the funding of them is an important issue. People who use electricity generated at nuclear powerplants are paying for the disposal of spent fuel. Under a general contract with nuclear-generating utilities, the Federal Government collects a fee of one mill (one-tenth of a cent) per kilowatt-hour from utility companies for nuclear-generated electricity. This money goes into the Nuclear Waste Fund, which is used to pay for all aspects of nuclear waste disposal, including the geologic repository, the Monitored Retrieval Storage facility (this will be an interim storage facility used until the final repository is completed), transportation of the waste, and support of State and local government involvement in the project. On an annual basis, DOE evaluates the adequacy of the fees collected for nuclear waste disposal. Expenditures of all waste fund monies are subject to Congressional oversight and authorisation.

Accumulating adequate funds to cover decommissioning costs is a challenge. The NRC has established minimum funding levels to plan for decommissioning, however State utility commissions have the major role in determining the actual timing, amounts, and other conditions of decommissioning financing. Under NRC rules, the minimum financial assurance that licensees must provide to decommission each reactor is determined by a sliding scale that considers primarily the type and size (as measured in megawatts-thermal) of a reactor. In 1986 dollars, the minimum financial assurance for decommissioning a PWR ranges from roughly $86 million for the smallest reactors to $105 million for the largest, and the minimum financial assurance for a BWR ranges from roughly $115 million to $135 million. These regulations contain additional requirements to adjust annually the escalations in labour, energy, and low-level-waste burial costs (the most significant components of decommissioning expenses).

### 5.3. International, Multilateral and Bilateral Agreements

Agreements for co-operation provide the legal framework of US trade with other countries in the peaceful uses of nuclear energy. Agreements establish binding national commitments enforceable under international law, and set the ground rules for civilian nuclear commerce between nations. The guiding principal is that the U.S. will co-operate in peaceful nuclear trade as long as the other signatory abides by the agreement's conditions governing the safeguarding and continued peaceful use of nuclear material and technology transferred from the U.S., and grants the U.S. certain consent rights over such material's use, alteration and retransfer.

The U.S. has entered into agreements with 29 countries for peaceful nuclear co-operation. Similar agreements have been entered with international organizations including the European Atomic Energy Agency (EURATOM), and the International Atomic Energy Agency (IAEA). In addition, the U.S. has entered into numerous trilateral agreements with IAEA and other countries for the application of safeguards by the IAEA to equipment, devices, and materials supplied under bilateral agreements for co-operation in the use of commercial nuclear power.

*AGREEMENTS WITH THE IAEA*

| | | |
|---|---|---|
| • Safeguards agreement with the IAEA INFCIRC/288x | Entry into force: | 9 December 1980 |
| • Tlatelolco related agreement INFCIRC/366 | Entry into force: | 6 April 1989 |
| • Improved procedures for designation of safeguards inspectors | Accepted: | 14 September 1988 |

*OTHER RELEVANT INTERNATIONAL TREATIES etc.*

| | | |
|---|---|---|
| • NPT | Entry into force: | 5 March 1970 |
| • Agreement on privileges and immunities | Entry into force: | Non-Party |
| • Convention on physical protection of nuclear material | Entry into force: | 8 February 1987 |
| • Convention on early notification of a nuclear accident | Entry into force: | 20 October 1988 |
| • Convention on assistance in the case of a nuclear accident or radiological emergency | Entry into force: | 20 October 1988 |
| • Conventions on civil liability for nuclear damage and joint protocol | Non-Party | |
| • Convention on nuclear safety | Signature: | 20 September 1994 |
| • ZANGGER Committee | Member | |

- Nuclear Export Guidelines — Adopted
  Acceptance of NUSS Codes
  Summary: Codes are appropriate safety standards in Agency assisted projects; valuable guidance for national regulatory requirements; useful reference in safety assessment. Use of codes for above purposes supported. Generally consistent with requirements.

- Nuclear Suppliers Group — Member

*BILATERAL AGREEMENTS*

The bilateral agreements are listed in Table 10.

TABLE 10. LIST OF AGREEMENTS FOR PEACEFUL NUCLEAR COOPERATION

| Agreement | Date Signed | Effective Date | Termination Date | Citation |
|---|---|---|---|---|
| Argentina | June 25, 1969 | July 25, 1969 | July 24, 1999 | TIAS No. 6721, 20 UST 2587 |
| Australia | July 5, 1979 | January 16, 1981 | January 15, 2011 | TIAS No. 9893, 32 UST 3227 |
| Austria<br>-amendment | July 11, 1969<br>June 14, 1974 | January 24, 1970<br>October 8, 1974 | January 23, 2014<br>January 23, 2014 | TIAS No. 6815, 21 UST 10<br>TIAS No. 7912, 25 UST 2337 |
| Bangladesh | September 17, 1981 | June 24, 1982 | June 23, 1992 | TIAS No. 10339, —UST— |
| Brazil | July 19, 1972 | September 20, 1972 | September 19, 2002 | TIAS No. 7439, 23 UST 2477 |
| Canada<br>-amendment<br>-amendment<br>-amendment<br>-amendment | June 15, 1955<br>June 26, 1956<br>June 11, 1960<br>May 25, 1962<br>April 23, 1980 | July 21, 1955<br>March 4, 1957<br>July 14, 1960<br>July 12, 1962<br>July 9, 1980 | January 1, 2000<br>-<br>-<br>-<br>- | TIAS No. 3304, 6 UST 2598<br>TIAS No. 3771, 8 UST 275<br>TIAS No. 4518, 11 UST 1780<br>TIAS No. 5102, 13 UST 1400<br>TIAS No. 9759, 32 UST 1079 |
| Czech Republic | | February 13, 1992 | February 12, 2022 | |
| China | July 23, 1985 | December 30, 1985 | December 29, 2015 | TIAS No. —, —UST—[1] |
| Colombia | January 9, 1981 | December 30, 1985 | September 6, 2013 | TIAS No. 10722, —UST— |
| Egypt | June 29, 1981 | December 29, 1981 | December 28, 2021 | TIAS No. 10208, 33 UST 2915 |
| EURATOM[2]<br>-Additional<br>Agreement[3]<br>-amendment<br>-amendment<br>-amendment | May 29/June 18, 1958<br>June 11, 1960<br>May 21 & 22, 1962<br>August 22 & 27, 1963<br>September 20, 1972 | August 27, 1958<br><br>July 25, 1960<br>July 9, 1962<br>October 15, 1963<br>February 28, 1973 | -<br><br>December 31, 1995<br>-<br>December 31, 1995<br>- | TIAS No. 4091, 9 UST 1116<br><br>TIAS No. 4650, 11 UST 2589<br>TIAS No. 5104, 13 UST 1439<br>TIAS No. 5444, 14 UST 1459<br>TIAS No. 7566, 24 UST 472 |
| Finland[4] | April 8, 1970 | July 7, 1970 | December 6, 2000 | TIAS No. 5446, 14 UST 1484 |
| Hungary | | February 13, 1992 | February 12, 2022 | |
| India<br>-waiver of certain obligations | August 8, 1963<br>November 30, 1982 | October 25, 1963<br>November 30, 1982 | October 24, 1993<br>December 29, 1991[8] | TIAS No. 5446, 14 UST 1484<br>TIAS No. 10614, —UST— |
| Indonesia | June 30, 1980 | December 30, 1981 | December 29, 1991[8] | TIAS No. 10219, 33 UST 3194 |
| IAEA[5]<br>-amendment<br>-amendment | May 11, 1959<br>February 12, 1974<br>January 14, 1980 | August 7, 1959<br>May 31, 1974<br>May 6, 1980 | -<br>August 6, 2014<br>- | TIAS No. 4291, 10 UST 1424<br>TIAS No. 7852, 25 UST 1199<br>TIAS No. 9762, 32 UST 1424 |
| Japan<br>-amendment<br>-amendment | February 26, 1968<br>February 24, 1972<br>March 28, 1973 | July 17, 1988<br>April 26, 1972<br>December 21, 1973<br>July 17, 1988[9] | July 17, 2018<br>-<br>July 9, 2003 | TIAS No. 6517, 19 UST 5214<br>TIAS No. 7306, 23 UST 275<br>TIAS No. 7758, 24 UST 1102 |
| Korea<br>-amendment | November 24, 1972<br>May 15, 1974 | March 19, 1973<br>June 26, 1974 | March 18, 2014<br>March 18, 2014 | TIAS No. 7583, 24 UST 775<br>TIAS No. 7842, 25 UST 1102 |
| Morocco | May 30, 1980 | May 16, 1981 | May 15, 2001 | TIAS No. 10018, 32 UST 5823 |
| Norway | January 12, 1984 | July 2, 1984 | July 1, 2014 | TIAS No. —,—UST—[6] |
| Peru | June 26, 1980 | April 15, 1982 | April 14, 200 | TIAS No. 10300, —UST— |
| Philippines | June 13, 1968 | July 19, 1968 | July 18, 1998 | TIAS No. 6522, 19 UST 5389 |
| Poland | | August 3, 1992 | September 2, 2022 | |

TABLE 10. LIST OF AGREEMENTS FOR PEACEFUL NUCLEAR COOPERATION

| Agreement | Date Signed | Effective Date | Termination Date | Citation |
|---|---|---|---|---|
| Portugal | May 16, 1974 | June 26, 1974 | June 25, 2014 | TIAS No. 7844, 25 UST 1125 |
| Slovakia | | February 23, 1992 | February 12, 2022 | |
| South Africa | July 8, 1957 | August 22, 1957 | August 21, 2007 | TIAS No. 3885, 8 UST 1367 |
| -amendment | June 12, 1962 | August 23, 1962 | - | TIAS No. 5129, 13 UST 1812 |
| -amendment | July 17, 1967 | August 17, 1967 | - | TIAS No. 6312, 18 UST 1671 |
| -amendment | May 22, 1974 | June 28, 1974 | August 21, 2007 | TIAS No. 7845, 25 UST 1158 |
| Spain | March 20, 1974 | June 28, 1974 | June 27, 2014 | TIAS No. 7841, 25 UST 1063 |
| Sweden | December 19, 1983 | April 11, 1984 | April 10, 2014 | TIAS No. —, —UST—[7] |
| Switzerland | December 30, 1965 | August 8, 1966 | August 7, 1996 | TIAS No. 6059, 17 UST 1004 |
| -amendment | November 2, 1973 | January 29, 1974 | - | TIAS No. 7773, 25 UST 913 |
| Taiwan[8] | April 4, 1972 | June 22, 1972 | June 21, 2014 | TIAS No. 7364, 23 UST 945 |
| -amendment | March 15, 1974 | June 14, 1974 | June 21, 2014 | TIAS No. 7834, 25 UST 913 |
| Thailand | May 14, 1974 | June 27, 1974 | June 26, 2014 | TIAS No. 7850, 25 UST 1181 |

[1]Text of agreement available in House Document 99-86, 99th Congress, 1st Session (July 24, 1985).

[2]The members of EURATOM are Belgium, Denmark, Germany, France, Greece, Italy, Ireland, Luxembourg, Netherlands, Portugal, Spain and the United Kingdom.

[3]This agreement incorporates by reference certain provision of the expired "Joint Program" Agreement, signed November 8, 1958, TIAS No. 4173, 10 UST 75, amended TIAS No. 5103, 13 UST 1403. By exchange of notes of December 16 and 17, 1985, TIAS No. —, —UST—, the U.S. and EURATOM agreed for administrative convenience that material, equipment or devices that had been subject to the Joint Program Agreement would be held subject to the Additional Agreement.

[4]A new agreement with Finland was signed on May 2, 1985. The text of this agreement is available in House Document 99-71, 99th Congress, 1st Session (May 21, 1985); expires March 26, 2022.

[5]A separate table lists U.S. supply agreements concluded pursuant to the U.S.-IAEA co-operation agreement.

[6]Text of agreement available in House Document 98-164, 98th Congress, 2nd Session (January 26, 1984).

[7]Expired June 23, 1992; agreement on extension has been concluded and is being processed internally by the respective Governments.

[8]Agreement on extension has been concluded and is being processed internally by the respective Governments.

[9]30 year term, with provision for continuation thereafter unless terminated by either party.

## REFERENCES


[1] Energy Information Administration, *World Nuclear Outlook 1994*, DOE/EIA-0436(94), Washington DC, (December 1994).

[2] Congressional Research Service, Library of Congress, *State Regulation of Nuclear Power: An Overview of Current State Regulatory Activities*, Prepared for the Committee on Interior and Insular Affairs U.S. House of Representatives, Washington DC, (1992) and *Compilation of Selected Energy Related Legislation, Nuclear Energy and Radioactive Waste*, Prepared for the Committee on Energy and Commerce, House of Representatives, Washington DC, (January 1994).

## ANNEX I. DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

*NATIONAL ATOMIC ENERGY AUTHORITY*

| | |
|---|---|
| United States Department of Energy<br>(USDOE)<br>Washington DC 20585 | Tel.: 202-586-6210<br>Fax: 202-586-6789<br>Telex: 230-622-99870 |
| United States Nuclear Regulatory Commission<br>Washington DC 20555 NRC-BHD WSH<br>United States of America<br>NRC-BHD WSH | Tel.: 301-415-1759<br>Fax: 301-415-2395<br>Telex:908142<br>Cable:710-824-0412 |

*OTHER ORGANIZATIONS*

The following pages contain a list of companies for selected specialties in the nuclear power industry. The categories of specialties represent broad major areas within the nuclear industry. They are many other specialties and companies supporting the nuclear industry in the United States. A more complete listing can be found in a buyers guide. Following the listing of company names for each category is an alphabetical listing of the companies with identifying information for each company.

**Architect/Engineers**

B&W Nuclear Technologies
Bechtel Power Company
Black & Veatch (FL)
Black & Veatch (MO)
Computech Engineering Services
Davy International
Ebasco Services Inc.
Energy Research Group Inc.
Fluor Daniel
Gibbs & Hill Inc.
Gilbert/Commonwealth International
Hill International Inc.
JBF Associates Inc.
Morrison Knudsen
MPR Associates Inc.
Nuclear Energy Service Inc.
NUS
Nutech Engineer Inc.
Pacific Nuclear Services
Raytheon Engineers & Constructors
Sargent & Lundy
Science Applications (STOW)
SE Technologies Inc.
UE&C Nuclear Inc.
Volt Technical Services
Roy F. Weston Inc.

**Reactors, NSSS, Main Components, and Power Plants**

**Balance of Plant Engineering and Systems**

ABB Impell Corporation
Black & Veatch (MO)
Ebasco Services Inc.
Gasser Associates Inc.
MPR Associates Inc.
Siemens Power Corporation
UE&C Nuclear Inc.
Y-E-P Industries Inc.

**Control Rod Drives**

ABB Combustion Engineering Nuclear Power
General Atomics
B&W Nuclear Technologies
GE Nuclear Energy
Nuclear Energy Services Inc.
Peerless Nuclear Corporation
Westinghouse Electric Corporation

**Control Rods**

ABB Combustion Engineering Nuclear Power
General Atomics
B&W Fuel Company
B&W Nuclear Technologies
GE Nuclear Energy
Peerless Nuclear Corporation
Westinghouse Commercial Nuclear Fuel Div.
Westinghouse Electric Corporation
ABB Combustion Engineering Nuclear Power
B&W Fuel Company
B&W Nuclear Technologies
Herbert Boyer Company
General Atomics
Siemens Power Corporation
Westinghouse Commercial Nuclear Fuel Div.
Westinghouse Electric Corporation

**Reactor Cores**

**Fuel Handling Equipment**

ABB Combustion Engineering Nuclear Power
Nuclear Energy Services Inc.
B&W Nuclear Technologies
Pacific Nuclear Systems Inc.
Bartholomew Company Inc. (Industrial Crane Division)
Rockwell International Corporation
Cimcorp Inc. P2R Systems
Ederer
GE Nuclear Energy
Holtec International
Sulzer Bingham Pumps Inc.
US Tool & Die Inc.
Westinghouse Electric Corporation

**Fueling Machines**

ABB Combustion Engineering Nuclear Power
Nuclear Energy Services Inc.
Cimcorp Inc. P2R Systems
Rockwell International Corporation

**Main Coolant Pumps, Liquid Metal**

ABB Combustion Engineering Nuclear Power
Westinghouse Electric Corp. (Energy Systems)

**Main Coolant Pumps, Water**

ABB Combustion Engineering Nuclear Power
Sulzer Bingham Pumps Inc.
Divesco Inc.
BW/IP International Inc.
Westinghouse Electric Corporation

**Motors, Main Coolant Pumps**

ABB Combustion Engineering Nuclear Power
Divesco Inc.
Westinghouse Electric Corp. (Energy Systems)

**Nuclear Steam Supply Systems, Fast Reactors**

ABB Combustion Engineering Nuclear Power
Rockwell International Corporation
Westinghouse Electric Corporation
Westinghouse Electric Corporation
GE Nuclear Energy

**Nuclear Steam Supply Systems, Thermal Reactors**

ABB Combustion Engineering Nuclear Power
B&W Nuclear Technologies
GE Nuclear Energy
Westinghouse Electric Corporation

**Power Plants, Turnkey**

ABB Combustion Engineering Nuclear Power
Morrison Knudsen
ABB Impell Corporation
Raytheon Engineers & Constructors
Fluor Daniel
UE&C Nuclear Inc.

**Pressure Tube Fuel Channels**

Carpenter Technology Corporation (Spec. Prod)

**Pressurizer Heaters**

B&W Nuclear Technologies
Westinghouse Electric Corporation

**Pressurizes**

ABB Combustion Engineering Nuclear Power
Sulzer Bingham Pumps Inc.
B&W Nuclear Technologies
Westinghouse Electric Corporation
IMPSA International Inc.

**Boiling Water Reactor Design**

ABB Combustion Engineering Nuclear Power
S.M. Stoller Corporation (Eastern Division)
GE Nuclear Energy

**Fast Breeder Reactor Design**

ABB Combustion Engineering Nuclear Power
Westinghouse Electric Corporation
GE Nuclear Energy
Rockwell International Corporation

**Gas Cooled Reactor Design**

ABB Combustion Engineering Nuclear Power
S.M. Stoller Corporation (Eastern Division)
General Atomics
Westinghouse Electric Corporation

**Heavy Water Reactor Design**

ABB Combustion Engineering Nuclear Power
Westinghouse Electric Corporation

**High Temperature Reactor Design**

ABB Combustion Engineering Nuclear Power
S.M. Stoller Corporation (Eastern Division)
General Atomics
Westinghouse Electric Corporation

**Pressurised Water Reactor Design**

ABB Combustion Engineering Nuclear Power
Westinghouse Commercial Nuclear Fuel Div.
B&W Nuclear Technologies
Westinghouse Electric
S.M. Stoller (Eastern Division)

**Reactor Internals**

ABB Combustion Engineering Nuclear Power
Sulzer Bingham Pumps Inc.
B&W Nuclear Technologies
Westinghouse Electric Corporation
GE Nuclear Energy
General Atomics

**Reactor Pressure Vessels**

ABB Combustion Engineering Nuclear Power
IMPSA International Inc.
AEA O'Donnell Inc.
Walker Stainless Equipment Company Inc.
AMER Industrial Technologies Inc.
Westinghouse Electric Corporation
B&W Nuclear Technologies
General Atomics

**Steel Reactor Pressure Vessels**

ABB Combustion Engineering Nuclear Power
Materials Engineering Associates Inc.
AMER Industrial Technologies Inc.
Walker Stainless Equipment Company Inc.
B&W Nuclear Technologies
Westinghouse Electric Corporation
IMPSA International Inc.

**Research, Test and Training Reactors**

B&W Nuclear Technologies
General Atomics

**Steam Generators**

ABB Combustion Engineering Nuclear Power
Scientific Technologies Inc.
B&W Nuclear Technologies
Henry Vogt Machine Company
Foster Wheeler Energy
Westinghouse Electric Corporation
General Atomics
IMPSA International Inc.

**Nuclear Fuel Cycle**

**Fuel and Fuel Cycle Management and Services**

ABB Combustion Engineering Nuclear Power
B & W Fuel
Black & Veatch (FL)
Chem.-Nuclear Systems
CKA Associates
Dufrane
Edlow International
Energy Resources International
ERC Environmental and Energy Services
GE Nuclear Energy
General Atomics
Nuclear Assurance Corporation
NUS
Pacific Nuclear Systems
Scandpower
Science Application (STOW)
Siemens Power
Stoller S.M. (Eastern Division)
Uranium Exchange
WasteChem
Westinghouse Commercial Nuclear Fuel
Westinghouse Electric

**Uranium Production**

Power Resources (Converse County Mining)
Fertiliser Inc. (IMC-Agrio Company)
Crow Butte Resources (Ferret Exploration)
Cogema Mining Inc.
Malipai Resources
Rio Algom Mining Corporation
Uranium Resources Inc.

**Uranium Hexaflouride Conversion**

Allied Signal

**Uranium Enrichment**

United States Enrichment Corporation

**Uranium Fuel Fabrication**

B&W Nuclear Technologies
Siemens Nuclear Power Corporation
ABB Combustion Engineering Nuclear Power
Westinghouse Electric Corporation
General Electric (Fuel Fabrication)

**Radioactive Waste Handling and Management Services**

ABB Combustion Engineering Nuclear Power
AMM Impell
ADCO Services
Allied Ecology Services
Allied Technology Group
ARD
Chem.-Nuclear Services
Consolidated Baling
Controls for Environmental Pollution
Decon
Dufrane
Duke Engineering Services
Duratek Corp.
Future Research Associates
General Atomics
General Electric
Gilbert Commonwealth International
Grove Engineering
HPD
Inet Corp.
International Technology
KLM
Little Author D
Lockheed Environmental Systems
MediPhysics
The NDL Organization Inc.
NFS/RPS (Nuclear Fuels Services/Radiation Protection)
NPS Products
Nuclear Consulting Services
Nuclear Energy Services
Nuclear Filter Technology
Nuclear Metals
NUS
Nutech Engineer
Pacific Nuclear Services
Pacific Nuclear Systems
Quadrex Recycle Centre
Refuelling Services
RLD Consulting
RSO
Sargent and Lundy
Science Applications (STOW)
Services First
Stoller S.M. (Western Division)
Suntrac Services
TTI Engineering
UE&C Engineering
UNC
WasteChem
Westinghouse Electric
Westinghouse Radiological Services
Roy F. Weston Inc

**Power Plant Owners**

Alabama Power Company
Arizona Public Service Company
Arkansas Power & Light Company
Baltimore Gas & Electric Company
Boston Edison Company
Carolina Power & Light Company
Cleveland Electric Illuminating Company
Commonwealth Edison Company
Connecticut Yankee Atomic Company
Consolidated Edison Company of New York
Consumers Power Company
Detroit Edison Company
Duquesne Light Company
Entergy Services Inc.
Florida Power & Light Company
Florida Power Corporation
GPU Nuclear Corporation
Georgia Power Company
Gulf States Utilities Company
Houston Lighting & Power Company
IES Utilities Company
Illinois Power Company
Indiana/Michigan Power Company
Louisiana Power & Light Company
Maine Yankee Atomic Power Company
Nebraska Public Power District
Niagara Mohawk Power Corporation
Northeast Nuclear Energy Co.
Northern States Power Co.
Omaha Public Power District
Pacific Gas & Electric Company
Pennsylvania Power & Light Company
Philadelphia Electric Company
Power Authority of the State of New York
Public Service Company of New Hampshire
Public Service Electric & Gas Company
Rochester Gas & Electric Corporation
South Carolina Electric & Gas Company
Southern California Edison Company
Tennessee Valley Authority
Toledo Edison Company
Union Electric Company
Virginia Electric & Power Company
Vermont Yankee Nuclear Power Company

Washington Public Power Supply Systems
Wisconsin Electric Power Company
Texas Utilities Electric Company
Wisconsin Public Service Corporation
Wolf Creek Nuclear Oper. Corporation

**Nuclear Plant Operator Training**

ABB Combustion Engineering Nuclear Power
ABB Power Plant Controls
Action Systems
ASTA
B&W Nuclear Technologies
Bently Nevada
Computer Aided Training
Design Assistance
Devar
Extech
General Atomics
HMMM Associates
Nuclear Filter Technology
NUS
NUS-Idaho Centre
Raytheon Engineers and Constructors
S3 Technologies
SE Technologies
Services First
Start Up Nuclear/Sun Technical Services
Tarus Technologies
United States Crane Certification
Vantage Training Services
Victoreen
Volt Technical Services
Western Space and Marine
Westinghouse Electric

**Maintenance Suppliers**

ABB Combustion Engineering Nuclear Power
ARD
AVO Multi-Amp Services
B & W Nuclear Technologies
Bechtel Power
BW/IP International (Nuclear Values)
CBI Services
Central Research Laboratories
Chesterton International
Climax Portable Machine Tools
Ebasco Services
Federal Industrial Services
Fluor Daniel
Foster Wheeler Energy
Gasser Associates
GE Nuclear Energy
Holtec International
Kinemetrics
Morrison Knudsen
Nuclear Energy Services
NUS
NUS-Idaho Centre
Ogden CISCO
PCI
Refuelling Services
Reliability Technology
Resource Technical Services
Science Applications (STOW)
Start UpNuclear Inc.
Stone & Webster
Townsend and Bottum Services
UE & C Nuclear
Undersea Systems
Vantage Training Services
Wachs EH
Westinghouse Electric (Energy Systems)

**Research and Development**

Argonne National Laboratory
Electric Power Research Institute
Idaho National Engineering Laboratory
Institute of Nuclear Power Operation
Lawrence Berkely Laboratory
Lawrence Livermore National Laboratory
Nuclear Energy Institute
Oak Ridge National Laboratory

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**Consultants Meetings**

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18-22 November 1996 (5)

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21-23 June 1995 (4)