INTERNATIONAL DATA COLLECTION AND ANALYSIS

Prepared for
U.S. Department of Energy
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Task 1

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NUCLEAR ASSURANCE CORPORATION

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AND

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MEXICO

18.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

INDIGENOUS RESOURCES

Mexico is a country rich in energy resources. It has oil, coal, gas, uranium, hydro and geothermal energy and sunshine!

Coal, which is mined and utilized basically by the steel industry, is expected to increase its share of the energy demand. Economically recoverable reserves are put at 698 million tonnes (ref. 1.2) and have been stated at that value also in reference 1.1. However, the figure for total indigenous resources has changed radically. In 1973 it was put at 5,316 million tonnes. In 1975 the estimate was 997.0 million tonnes. The World Energy Conference paper "Energy Resources Availability in Mexico to Satisfy Its Demand" (ref. 1.8) states that the Consejo de Recursos Minerales is undertaking a serious exploration program that will permit a better definition of the coal potential of the Country.

For crude oil the proved recoverable quantity has increased from 414.3 million tonnes in 1973 (ref. 1.1) to 481.0 million tonnes in 1975 (ref. 1.2). No figure for the total resource is available. The International Petroleum Encyclopedia notes reserves at 1507 million tonnes in 1977. Recently discovered are several oilfields under one locating name: Chicontepec Field, estimated to contain 100 billion barrels of oil and 40 trillion cubic feet of natural gas. Studies are now underway to determine what percentage of deposits are feasibly recoverable.

No figures for shale oil are obtainable.

Economically recoverable gas quantities have increased from 309.5 km^3 in 1973 to 337 km^3 in 1975 (refs. 1.1 and 1.2). Further increases are occurring.

In 1976 total hydro-electric energy was 44 TWh. The economically recoverable energy is estimated at 80.9 TWh and maximum theoretical capacity 99.4 TWh (from ref. 1.2).

Extensive work is in progress to exploit geothermal energy using steam for electricity production. There are 310 thermal zones and 20 geothermal fields in Mexico. Ultimate capacity is expected to be 500 MW by 1980. It is hoped by the end of the century, 7% of Mexico's power will be produced by geothermal sources. Several additional studies are in progress along the 20° N latitude. The figure given in Table 18.1.1 is the actual energy produced in 1975.

Uranium reserves are estimated at about 5,500 tonnes U_3O_8, with an additional 2,800 tonnes inferred. Extensive exploration may raise these figures in the future. None of the deposits have been subjected to economic or viability analyses.

At the Second Pacific Basin Conference (September 25-29, 1978), Mexico speakers provided the following tabulation of national resources:

Hydrocarbons (Oil and Gas)	
Proven	$23,250(10^6)m^3$
Potential	$18,600(10^6)m^3$
Hydro Power	
Installed	6,000 MW
Potential	25,000 MW
Coal	
Proven	2,400 million tonnes
Potential	8,000 million tonnes
Geothermal	
Pessimistic	2,000 MW
Potential	13,000 MW
Uranium	
Proven	10,000 MT
Potential	150,000 MT

ENERGY SUPPLY

Production of hard coal was 5.128 million tonnes (ref. 1.5). This compares with the value given in reference 1.33 of 5.17 million tonnes.

Crude oil production was at the rate of 39.7 million tonnes (ref. 1.5), 42.1 million tonnes (ref. 1.33) and 36.6 million tonnes (ref. 1.2). In 1976, Mexico exported 140,000 b/d oil, increasing to 200,000 b/d in 1977, 280,000 b/d in early 1978, and possibly increasing to 500,000 b/d by the end of 1978. The U. S., according to Energy Daily (12/14/78), is getting more than 80% of it. Other countries exported to are: Israel, Spain, Sweden and U.K., with other likely customers: Italy, Brazil, and Japan.

Natural gas production has been steadily increasing and stands at 14.99 km^3 (ref. 1.5) 23.05 km^3 (ref. 1.33). The small imported quantity is supplied entirely by the United States.

Uranium production has been very modest.

PATTERNS OF ENERGY USE

No coal consumption occurs in the household or transport sectors.

Petroleum is consumed in all sectors with transportation making the highest demand.

Though industry is the major consumer of natural gas, a significant quantity is used for electrical generation.

All figures for Table 18.1.3 come from Paper 1.4-7, reference 1.8.

FORECASTS OF ENERGY SUPPLY AND DEMAND

Energy demand in Mexico is expected to increase at a rate of between 3.5% and 6.0% per year over the period 1975-2000. In the same period, electricity demand is expected to grow at a somewhat faster annual rate of between 4.4% and 9.6%. As a result of this difference in growth rates, electricity production will account for some 40% of the total primary energy demand in 2000 compared with only 25% in 1975. These forecasts are presented in Table 18.1.4.

The United Nations Economic Commission for Latin America forecasts a total primary energy demand of 11,350 x 10^{12} Btu (285.1 million tonnes oil equivalent) for Mexico in 2000 (ref. 1.33) which is considerably higher than the figures presented in Table 18.1.4. However, the United Nations forecasts represents a continuation of the 7% per year growth in energy demand experienced from 1971 to 1975 (ref. 1.5) and therefore appear somewhat optimistic. The United Nations forecast of electricity demand for the year 2000 is 404 TWh which is considerably greater than the medium growth scenario forecast of 235 TWh and again appears to be a rather optimistic projection of the recent historic growth in demand.

Table 18.1.5 shows that the importance of nuclear electricity as a source of energy is expected to increase significantly during the period 1975 to 2000 reducing the contribution of oil and gas to the primary energy supply from 84% in 1975 to only 61% in 2000. It can also be seen that geothermal energy is expected to be providing some 2.5 TWh of electricity by 2000. This will derive from a number of plants with a total capacity in excess of 500 MW (ref. 1.33).

Projections of installed nuclear capacity indicate a total of 14,500 MW in 2000. The Comision Economica para America Latina (CEPAL) projected a capacity of 46,000 MWe in 2000. However, an increase to this level would result in an extremely low average capacity factor (approximately 35%).

A sharp increase in the activity level of the Mexican nuclear energy program will be needed even to meet the lower 14,500 MW projection. At present, there are no official plans for further nuclear power plants after the current two reactors under construction. This position appears to be caused by a combination of the massive fossil fuel resources and the unfavorable experience in constructing the first reactors.

INDIGENOUS ENERGY RESOURCES

Table 18.1.1

	Economically Recoverable Reserves	Total Indigenous Resources	Location of Identified Reserves
Hard Coal (million tonnes)	698	997	Altiplanicie Mexicana
Soft Coal (million tonnes)	0	0	
Crude Oil (million tonnes)	481	Not Available	Litoral + Istmica Chicontepec, Reforma, Samaria
Shale Oil (million tonnes)	Not Available	Not Available	
Natural Gas (cubic km)	337	Not Available	Litoral + Istmica Coahuila, Nuevo Leon
Uranium (thousand tonnes U_3O_8)	5.5	8.3	Chihauhua
Hydro Power (TWh/year)	80.9	99.4	Isthmus, Sierra Madre
Geothermal (TWh/year)	(0.491)*	Not Available	Hidalgo, Mexicali, Pathe, Ahuachapan

* Energy produced in 1975

ENERGY SUPPLY 1975

Table 18.1.2

Resource	Indigenous Supply	Imports		Exports	
		Total	% from US	Total	% to US
Hard Coal (million tonnes)	5.128	0.580	100	0	0
Soft Coal (million tonnes)	0	0	0	0	0
Crude Oil (million tonnes)	39.729	0	0	5.50	0
Shale Oil (million tonnes)	Not Available	0	0	0	0
Natural Gas (cubic km)	14.99	0.267	100	0	0
Uranium (thousand tonnes U_3O_8)	Not Available	0	0	0	0
Electricity (TWh)	43.29	0.38	100	0.10	100

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 13.1.3

Resource	Consuming Sector				
	Household and Commercial	Industrial	Transportation	Electrical Generation	Total
Coal (million tonnes)	0	4.89	0	0.079	4.97
Petroleum (million tonnes)	3.34	8.02	20.42	7.08	38.86
Natural Gas (cubic km)	0.49	8.4	0	2.6	11.5
Nuclear Power (TWh)	0	0	0	0	0
Hydro Power (TWh)	0	0	0	15.14	15.14
Geothermal Power (TWh)	0	0	0	0.491	0.491*
Utility Electricity Distributed (TWh)	6.1	27.5	0	–	33.6

* In 1974

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 18.1.4

Year	Low Economic Growth 3.0%		Medium Economic Growth 5.0%		High Economic Growth 7.0%	
	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)
1975	2,164	43.30	2,164	43.3	2,164	43.3
1985	3,812	71.6	4,316	91.7	4,875	116.9
2000	5,075	126.7	6,924	235.3	9,390	431.8

CONSUMPTION OF ENERGY RESOURCES

Table 18.1.5

Resource	Standard Unit	Annual Consumption of Standard Units			Energy Consumption (10^{12} BtU)		
		1975	1985	2000	1975	1985	2000
Coal	Million Tonnes	5.71	10.9	19.2	158.5	302	534
Crude Oil	Million Tonnes	30.31	60.8	65.6	1307.3	2590	2830
Natural Gas	Cubic km	14.49	26.4	38.5	520.7	950	1385
Hydro Power	TWh	15.14	30.3	48.7	172.2	345	554
Other Renewables	TWh	0.49	1.1	2.5	5.6	13	28
Nuclear Power	TWh	–	10.2	140.0	–	116	1593
Uranium	Thousand Tonnes U_3O_8	0	0.25	2.88	–	–	–

18.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

COMMERCIAL NUCLEAR POWER PLANTS

Table 18.2.1

Facility Name	Utility	Vendor	Facility Type	Capacity (MWe net)	Status*	COD
Laguna Verde-1	Comision Federal de Electricidad	GE	BWR	645	U	Mar 1982
Laguna Verde-2	Mexico	GE	BWR	645	U	May 1983

* O-Operational; U-Under Construction; P-Planned

PROJECTED NUCLEAR GENERATING CAPACITY
MWe (net)

Table 18.2.2

Year	PWR	BWR	Magnox	AGR	CANDU	Other	FBR	Firm + Planned Cumulative Total	NAC Cumulative Projection
Pre-1978									
1978									
1979									
1980									
1981									
1982		645						645	645
1983		645						1290	1290
1984								1290	1290
1985								1290	1290
1986								1290	1290
1987								1290	1290
1988								1290	1290
1989	600	600						1290	2490
1990					1200			1290	3690
1991	600	600						1290	4890
1992					1200			1290	6090
1993	600	600						1290	7290
1994					1200			1290	7290
1995	600	600						1290	8490
1996					1200			1290	9690
1997	600	600						1290	10890
1998	600	600						1290	12090
1999	600	600						1290	13290
2000					1200			1290	14490

All reactors projected after Laguna Verde 1 and 2 must be considered highly speculative.

NUCLEAR REACTOR VENDORS

Overview

Mexico has no domestic nuclear reactor vendors.

Nuclear Reactor Vendor Support Industries

There are currently no heavy component reactor support industries in Mexico. Extensive training in all aspects of power engineering (including those needed to support nuclear power plant construction) is underway. Based upon Mexico's nuclear growth plans, support industries could be expected to develop in the late 1980's.

NUCLEAR FUEL CYCLE FACILITIES

Overview

The sole current Mexican fuel cycle activity is in uranium exploration, mining, and milling. Presently Mexico has only modest uranium reserves and resources, but only small portions of the nation have been explored.

A small pilot plant (~ 88 tons of ore per day) at Villa Aldama has previously produced about 40 MTU. The plant, which had been idle, resumed operation in 1978. A major mine/mill complex is planned for operation at Pena Blanca in Tamaulipos with a capacity of 2200 TPD. When complete in 1982 it should yield approximately 380 MTU per year. A possible mill may be operational in the late 1980s in the La Coma, Buena Vista area of Nueva Leon. The capacity will be about 2200 TPD.

Some research is carried out in fuel fabrication; eventually this could lead to indigenous fuel fabrication capability.

CURRENT AND PLANNED FACILITIES

Table 18.2.3

Facility Name	Location	Facility Type	Capacity MT/YR	Status	Year	Shareholdings
Sierra Pena Blanca	Tamaulipos, Chihualua	Uranium Mine		Construction	1982	Mexican Government
La Coma Ranch	Nueva Leon	Uranium Mine		Planned	1988	Mexican Government
Sierra Pena Blanca	Tamaulipos, Chihualua	Uranium Mill	385	Construction	1982	Mexican Government

NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

Vested Interests in Current Reactor Technologies and Fuel Cycles

Currently Mexico has no vested interest in specific nuclear reactor technology or fuel cycles. Such interests might develop as Mexico's nuclear program matures and vendor support industries or fuel cycle industries emerge.

Current Trends in Nuclear Development Programs

Mexico's primary emphasis is now upon development of knowledge concerning its uranium resources.

18.3 NUCLEAR TECHNOLOGY CAPACITY AND RESOURCES

PROFESSIONAL LABOR FORCE PROFILE

Table 18.3.1

Available information presents the following data for 1971:

4,064 Engineers and Scientists engaged in R&D

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 18.3.2

Institution	Location
Universidad Alexander von Humboldt	Mexico City
Universidad Anahuac	Mexico City
Universidad Autonoma de Baja California	Mexicali
Universidad Autonoma Metropolitan	Mexico City
Universidad Autonoma de San Luis Potosi	San Luis Potosi
Universidad Autonoma de Chihuahua	Chihuahua
Universidad de Guadalajara	Guadalajara
Universidad La Salle	Mexico City
Universidad Nacional Autonoma de Mexico	Mexico City
Universidad Regiomontana	Monterrey
Universidad de Sonora	Hermosillo
Universidad del Sudeste	Campeche
Universidad Veracruzana	Xalapa
Instituto Politecnico Nacional	Mexico City
Instituto Techologico regional de Tlalnepantla	Tlalnepantla
Centro de Estudios Universitarios de Monterrey	Monterrey
Instituto de Ciencias y Artes de Chiapas	Tuxtla Gutierrez
Instituto Tecnologico y de Estudios Superiores de Occidente	Guadalajara

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 18.3.3

Name	Location	Main Activities
Instituto de Investigaciones Electricas (IIE)	Cuernavaca	1. Research in advanced technologies for generation of electric power. 2. Develop technique for manufacture in Mexico of generative and transmission equipment. 3. Train technicians. 4. Consultants to CFE.
National Institute of Nuclear Energy (INEN) 1. National Institute of Nuclear Research 2. URAMEX 3. National Commission on Nuclear Security and Safeguards	Mexico City	Nuclear power development.
Nuclear Energy Center	Salazar	Basic nuclear physics research and utilization of radioisotopes.

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 18.3.4

Name	Owner	Location	Main Activities

Not Applicable

RESEARCH AND TEST REACTORS
List of Reactors

Table 18.3.5

Facility Name	Location	Owner	Constructor	Facility Type	Facility Status		
					MW(th)	Status*	COD
RCN	Salazar	--	--	U-Zr hydride	1	0	1968
Sur-Mexico	Mexico City	--	--	Solid homog.	0	0	1972

* 0-Operational; U-Under Construction; P-Planned; S-Shutdown

INDIGENOUS CAPABILITY TO DESIGN AND SUPPLY RESEARCH AND TEST REACTORS AND FUEL SERVICES
Summary of Reactor Orders by Vendor and Country

Table 18.3.6

Vendor	Country	Facility Name	Facility Type	Facility Status: MW(th)	Facility Status: Status*	Facility Status: COD	Scope of Services

Not Applicable

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 18.3.7

Facility Name	Location	Facility Type	Capacity Status MT/YR	Status*	Year	Shareholdings

Not Applicable

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

18.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

ECONOMIC DATA PROFILE

Table 18.4.1

GDP (Current million $)	- 72,277 (1977)	Inflation Rate	- 20% (1977)
Exports (million $)	- 4,093 (1977)	Imports (million $)	- 5,486 (1977)
Per Capita Income ($)	- 1,119 (1977)	Disposable Income ($)	- 386 (1963)
Monetary Unit	- Peso	Exchange Rate (/US$)	- 22.6 (4/77)
Population (million)	- 64.59 (1977)		

18.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

NATIONAL INSTITUTE OF NUCLEAR ENERGY (INEN)	FY 75 ($ MILLION)
Research	4.0
Exploration	4.0
Development	2.4
Other including radiation applications	5.6
TOTAL	16.0

Energy R&D budgets of all other government agencies are very small.

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 18.4.3

Industry University or Laboratory	Program Area	Budget $ (Millions)	Key Personnel
Mexican Institute of Electrical Research (IIE)	Power research in general	--	Dr. Carlos Valez-Ocon, Director General
National Polytechnic Institute	Training, subcritical assembly	--	--
National Institute of Nuclear Energy (INEN)	Nuclear power development	--	Vizcano Murray Director General
National Autonomous University of Mexico (UNAM)	Nuclear power research	--	--

18.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

There is essentially no energy R&D in the private sector. All energy R&D is carried out in government laboratories or in universities funded by the government.

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 18.4.5

Name	Share Capital	Assets	Sales

Not Applicable

18.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Capital investments in nuclear power plants are expected to reach $171 million in 1980 and $240 million in 1985. Trade sources report CFE favors making future nuclear power equipment purchases from a single source, as a package which includes long-term financing.

In 1973, the arrangements for financing Laguna Verde I, were made with Wells Fargo Bank and U.S. Export-Import Bank. A $54.2 million loan agreement was signed to support a $60.2 million sale of U.S. equipment, materials and services for construction. These two companies each committed to half of the loan. The terms were for repayment of $37.6 million in 30 equal semi-annual installments, beginning 5/10/78. In addition, $16.6 million will be repaid in ten semi-annual installments also beginning 5/10/78. The borrower was Comision Federal de Electridad which will make a 10% cash payment, or $6 million, on the total U.S. costs.

18.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR DEVELOPMENT

18.5.1 ENERGY POLICY - BASIC LEGISLATION

1. Article 27 of the Mexican Constitution reserves for the National Government all energy responsibilities.

2. Created Federal Electricity Commission (CFE) 1939.

3. National Nuclear Energy Commission (CNEN) established 1955.

4. Established the National Institute of Nuclear Energy 1972.

5. Instituto Nacional de Energia Nuclear (INEN) replaced CNEN in 1972.

6. Institute of Electrical Research (IIE) created 1976.

7. INEN split into three separate entities (1978):

    a. National Institute Nuclear Research

    b. URAMEX

    c. National Nuclear Safety Commission

18.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

LEGISLATIVE

Congress consists of the Chamber of Deputies (213 members) and the Senate (60 members). Other than acting positively on Presidential initiatives, Congress plays virtually no role in the energy area.

EXECUTIVE

The executive branch is dominant. Executive power is vested in the President (Lopez Portillo) who promulgates and executes the laws of Congress and, by delegation from the Congress, legislates by executive decree in certain areas. The President heads a Cabinet composed of 15 Ministries.

Other organizations with energy responsibility include:

ORGANIZATION	RESPONSIBILITY	KEY INDIVIDUALS
Comision Federal de Electricidad	Autonomous government department with primary responsibility for all energy activities.	Hugo Cervantes del Rio, Director General
National Energetics Commission (NEC)	Coordinates national energy policy. Reports directly to the powerful Minister of Patrimony (over natural resources) (policy making, advises on future energy policy and carries out energy studies).	Juan Eibenschutz, Executive Secretary
National Council of Science and Technology (CONACYT)	Funds research in universities and government laboratories.	
Institute for Electricity Research (IIE)	Coordinates general research in electricity and power, advisory function, in nuclear power program, particularly in preparation of regulatory standards.	Guillermo Fernandez de la Garza

The National Institute of Nuclear Energy has been replaced by three organizations:

National Institute of Nuclear Research	Concentrates on nuclear research and development programs.
URAMEX - Uranio de Mexico	Uranium exploration and exploitation.
National Commission on Nuclear Security and Safeguards	Investigates and establishes standards for safety of nuclear power facilities.

18.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

Ultimate responsibility for policy is President of the Republic at present. Lopez Portillo, inaugurated 1976 for six years.

National Energetics Commission - advises the Administration on future energy policy. Chairman is also Secretary of Patrimony and Industrial Development - Jose Andris Oteyza.

National Institute of Nuclear Research - concentrates on nuclear research and development programs.

URAMEX - Uranio de Mexico - uranium exploration and exploitation.

National Commission on Nuclear Security and Safeguards.

IIE - coordinates general research in electricity and power and has no advisory function in preparation of standards. Engr. Guillermo Fernandez de la Garza - Executive Director.

Primary responsibility for energy activities is CFE - Hugo Cervantes del Rio - Director.

18.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

According to Mexico's current 6-year plan (1977-82), the emphasis will be on development of petroleum and gas resources although developments will also go ahead on coal, hydro, geothermal, and nuclear inputs.

Laguna Verde 1 and 2 are not expected to be completed until 1982 and 83. The feeling is that nuclear energy can be utilized on a large scale as soon as breeder reactors, which permit utilization of nuclear wastes, are available internationally, and at a national level, when operational experience of the Laguna Verde plants are achieved. No new nuclear energy installations are seen to be built in Mexico, so it will not be a basis for their energy development in the near future.

The energy policy objectives are to:

a) promote the diversification of our primary sources of energy in order to diminish the dependency in oil and gas.

b) promote the coordination of planning in the energy sector as a whole.

c) promote a more efficient utilization of energy.

d) develop the local manufacture of capital goods associated to the energy sector.

e) promote research and development activities in the energy field.

18.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

The nuclear program during the Echeverria administration was quite ambitious - 40 million kw of electric power produced by 40 nuclear reactors by year 2000. This has been scaled down sharply by the incumbent Administration. The program is being approached with caution, with priority in research given to hydroelectric and geothermal projects. There is consideration given now to a yellowcake concentrating plant to process proven resources of 8,000 tons of uranium located in the border states of Chihauhau Tamaulipas.

18.5.6 NUCLEAR ENERGY R&D - PRIORITIES

The main priority for an energy R&D program is total energy self-sufficiency. Though emphasis is placed primarily on other fuel resources at present, much effort is being directed toward development of nuclear capability. The recognized need for a more defined governmental structure to regulate nuclear R&D efforts is being implemented in establishing within the INEN a National Institute for Nuclear Research.

Though reliance on international assistance in the areas of engineering design, construction and maintenance of power plant systems will continue, there is a gradual increase in Mexican contribution in all phases of the fuel cycle. Reduction of this kind of foreign dependence is very attractive to Mexico, economically.

18.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

The Mexican government controls virtually all energy related activities. The CFE is responsible for the construction and operation of nuclear facilities. The INEN is responsible for licensing activities and with INEN is the Naitonal Nuclear Safety Commission which will establish safety standards. The IIE coordinates preparation of all regulatory standards.

18.6.1 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 18.6.1

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Tijuana	Tijuana	CFDE		Steam	307	0	
Malpaso	Teepatan	CFDE		Hydro	720	0	
Nonoalco	Colonia Guerrero	Cia de Luz y Fuerza del Centro		Steam Int. Comb. TG	92.5 77.4	0	
La Laguna	Gomez Palacio	CFDE		Steam TG	99 60.9	0	
Salamanca	Salamanca	CFDE	HI	Steam TG	308 14 + 300	0	1969, 1970, 1979
Infiernillo	La Union	CFDE		Steam	672	0	
Valle de Mexico	Acolman	CFDE	HI	Steam TG	750 105 150	0	1969,1970,1979
Jorque Luque	Guatitlan	Cia. de Luz y Fuerza del Centro		Steam TG	231 116	0	
Tingambato	Otzoluapan	CFDE		Hydro	135	0	
Ixtapantongo	Valle de Bravo	CFDE		Hydro	106	0	
Jose Ma Morelos	Lazaro Gardenas	CFDE		Hydro	300	0	

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 18.6.1 (Continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Monterrey	San Nicolas de la Gorza	CFDE		Steam	477	0	
San Jeronimo	Monterrey	CFDE		Steam	105	0	
		Grupo Ind. de Monterrey		Steam	152	0	
		Grupo Ind. de Monterrey		Steam	127	0	
Temascal	San Miguel	CFDE		Hydro	154	0	
Mazatepec	Tlatlauqui- tepec	CFDE		Hydro	209	0	
Necaxa	Juan Galindo	Cia. de Luz y Fuerza del Centro		Hydro	115	0	
Guaymas I	Sonora	CFDE	Bechtel (A-E)	Steam	150	U	7/79
Guaymas II	Sonora	CFDE	Bechtel (A-E)	Steam	150	U	1/80
El Novillo	Sayapa	CFDE		Hydro	90	0	
Poza Rica	Molocan	CFDE		Steam	117	0	

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 18.6.1 (Continued)

Facility Name	Location	Utility/ Owner	Vendor	Type of Fuel	Capacity (MWe net)	Commissioning Date	Status*
Manzanilla	Colima	CFDE	Bechtel (A-E)	Steam	1200	1981, 1982, 1984, 1985	U
Rio Escondido		CFDE		Coal	1500	1982, 1983, 1984	U
Desemboque	Gulf of California	CFDE		Steam	600	1983, 1984, 1985, 1986	U
Penitas		CFDE		Hydro	400	1985	U
Carbon II		CFDE		Coal	900	1985, 1986	U
Caracol		CFDE		Hydro	570	1985	U
Aguamilpa		CFDE		Hydro	540	1986	U
Merida II	Yucatan		Comec-Displan (A-E)	Steam	336	1981, 1982, 1984, 1986	U
Tula	Estado de Mexico			Steam	300	1978	O
Tampico	Vera Cruz	CFDE	WY/To	Gas/Oil	566 600	1972,1973,1974,1975, 1978	O/U

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 18.6.1 (Continued)

Facility Name	Location	Utility/ Owner	Vendor	Type of Fuel	Capacity (MWe net)	Commissioning Date	Status*
Mazatlan	Sinaloa	CFDE	HI Bechtel (A-E)	Steam	316 300	1974 1981	O/U
Cerro Prieto		CFDE	To		148	1969, 1976, 1977	O
Angostura		CFDE		Hydro	360	1978	U
Chicoasen		CFDE		Hydro	1500	1980, 1981	U

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 18.6.2

Year	Capacity - MWe(net)
1975	11,052
1980	
1985	
1990	
1995	
2000	

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
	Barrancas, Oaxaca, Coahuila			3.7	0
Fco. Cano	North Zone, N.E. District		Oil Field	208	0
Monterrey	North Zone, N.E. District		Oil Field	698	0
Tigrillo	North Zone, N.E. District		Oil Field	101	0
Other	North Zone, N.E. District		Oil Field	220	0
Arenque	North Zone, N. District		Oil Field	20,858	0
Barcodon	North Zone, N. District		Oil Field	283	0
Constituciones	North Zone, N. District		Oil Field	6,176	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil-barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
Ebano-Panuco	North Zone, N. District		Oil Field	6,328	0
Tamaulipas	North Zone, N. District		Oil Field	6,837	0
Other	North Zone, N. District		Oil Field	239	0
Cabo Neuvo	North Zone, S. District		Oil Field	447	0
Isla de Lobos	North Zone, S. District		Oil Field	1,233	0
Marsopa	North Zone, S. District		Oil Field	5,114	0
Naranjos-C Azul	North Zone, S. District		Oil Field	8,473	0
Soledad Norte	North Zone, S. District		Oil Field	1,276	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown
** Oil - barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
Tiburon	North Zone, S. District		Oil Field	365	0
Tres Hnos	North Zone, S. District		Oil Field	3,787	0
Other	North Zone, S. District		Oil Field	1,698	0
Atun	Central Zone, Poza Rica		Oil Field	1,076	0
Bagre	Central Zone, Poza Rica		Oil Field	11,945	0
M.A. Camacho	Central Zone, Poza Rica		Oil Field	377	0
C. del Carbon	Central Zone, Poza Rica		Oil Field	629	0
Escualo	Central Zone, Poza Rica		Oil Field	239	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil - barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
Hallazgo	Central Zone, Poza Rica		Oil Field	4,749	0
Ciliapa	Central Zone, Poza Rica		Oil Field	1,497	0
Miquetla	Central Zone, Poza Rica		Oil Field	2,258	0
Morsa	Central Zone, Poza Rica		Oil Field	459	0
Nvo. Progreso	Central Zone, Poza Rica		Oil Field	352	0
Papantla	Central Zone, Poza Rica		Oil Field	258	0
Poza Rica	Central Zone, Poza Rica		Oil Field	47,187	0
Remolino	Central Zone, Poza Rica		Oil Field	1,887	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil - barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
Riachuelo	Central Zone, Poza Rica		Oil Field	484	0
San Andres	Central Zone, Poza Rica		Oil Field	29,223	0
Other	Central Zone, Poza Rica		Oil Field	6,852	0
Acuatempa	Central Zone, Nueva Faja, de Oro		Oil Field	1,541	0
Alamo Jardin	Central Zone, Nueva Faja, de Oro		Oil Field	472	0
Copal	Central Zone, Nueva Faja, de Oro		Oil Field	333	0
El Muro	Central Zone, Nueva Faja, de Oro		Oil Field	4,730	0
E. Ordonez	Central Zone, Nueva Faja, de Oro		Oil Field	1,912	0
Meya Cerrada	Central Zone, Nueva Faia, de Oro		Oil Field	440	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil-barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
Ocotepec	Central Zone, Zeuva Faja, de Oro		Oil Field	572	0
Santa Agueda	Central Zone, Zeuva Faja, de Oro		Oil Field	3,824	0
Others	Central Zone, Zeuva Faja, de Oro		Oil Field	744	0
Angostura	Central Zone, Vera Cruz		Oil Field	346	0
Matapionche	Central Zone, Vera Cruz		Oil Field	623	0
Other	Central Zone, Vera Cruz		Oil Field	100	0
Agata	Southern Zone, Isthmus of Tehuantepec		Oil Field	673	0
Cuichapa	Southern Zone, Isthmus of Tehuantepec		Oil Field	18,794	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil-barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
El Burro	Southern Zone, Isthmus of Tehuantepec		Oil Field	1,050	0
El Plan	Southern Zone, Isthmus of Tehuantepec		Oil Field	3,460	0
Ixhatlan Ote	Southern Zone, Isthmus of Tehuantepec		Oil Field	1,667	0
Los Soldados	Southern Zone, Isthmus of Tehuantepec		Oil Field	1,378	0
Mecoacan	Southern Zone, Isthmus of Tehuantepec		Oil Field	5,120	0
Santa Rosa	Southern Zone, Isthmus of Tehuantepec		Oil Field	170	0
Tacuilolapa	Southern Zone, Isthmus of Tehuantepec		Oil Field	277	0
Tonala	Southern Zone, Isthmus of Tehuantepec		Oil Field	1,384	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil-barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
Lucamango	Southern Zone, Isthmus of Tenuantepec		Oil Field	3,736	0
Concepcion	Southern Zone, Isthmus of Tenuantepec		Oil Field	1,799	0
Other	Southern Zone, Isthmus of Tenuantepec		Oil Field	528	0
Ayapa			Oil Field	1,604	0
Blasillo			Oil Field	5,396	0
Cactus			Oil Field	87,142	0
Caracolillo			Oil Field	698	0
Carrizo			Oil Field	1,050	0
Castarrical			Oil Field	4,585	0
Cinco Presidentes			Oil Field	17,625	0
Cunduacan			Oil Field	141,468	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil-barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
El Gope			Oil Field	9,498	0
Iride			Oil Field	15,171	0
La Venta			Oil Field	4,523	0
Magallenes			Oil Field	8,297	0
Mecoacan			Oil Field	3,705	0
Nispero			Oil Field	20,788	0
Ogarrio			Oil Field	14,259	0
Otates			Oil Field	2,944	0
Rio Nuevo			Oil Field	4,051	0
Rodador			Oil Field	1,174	0
Samaria			Oil Field	287,515	0
San Ramon			Oil Field	8,290	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil-barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 18.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
Santa Ana			Oil Field	120	0
Santuario			Oil Field	7,781	0
Sitio Grande			Oil Field	42,262	0
Tintal			Oil Field	472	0
Tupilco			Oil Field	7,296	0
Other			Oil Field	506	0
Poza Rica	Gulf of Mexico	Petroleus Mexicanos	Gas Field	7.08	0
Zona Norte Reynosa	Gulf of Mexico	Petroleus Mexicanos	Gas Field	7.08	0
Zona San Jose Colomo	Chiapas	Petroleus Mexicanos	Gas Field	5.66	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Oil-barrels/day; Natural gas-km^3/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 18.6.4

RESOURCE	1985	2000
COAL (million tonnes)		
Indigenous Supply	13.69	48.57
Imports	--	--
Exports	2.79	29.37
CRUDE OIL (million tonnes)		
Indigenous Supply	49.30	62.98
Imports	11.42	2.62
Exports	--	--
SHALE OIL (million tonnes)		
Indigenous Supply	0	0
Imports		
Exports		
NATURAL GAS (cubic kilometers)		
Indigenous Supply	32.29	35.98
Imports	--	2.52
Exports	5.89	--
URANIUM (kilotonnes U_3O_8)		
Indigenous Supply	0.38	15.4
Imports	0	0
Exports	0.13	12.5

SECTION 19

NETHERLANDS

19.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

INDIGENOUS RESOURCES

No indigenous resources of coal were reported in reference 1.2. Reference 1.1 gave a total resource of 3,705 million tonnes of which 1,843 million tonnes are economically recoverable.

A small quantity of oil is available, however there are no figures for the total resource and the economically recoverable amount has been downrated from 37.0 million tonnes in 1972 to 13.0 million tonnes in 1975 (see refs. 1.1 and 1.2).

There are no known reserves of oil shale or bituminous sands.

The Netherlands has a considerable quantity of natural gas located principally at Groningen. Figures for economically recoverable reserves of 1,753 km^3 are given in ref. 1.1 and 1.2 and have been constant over the period 1971-1975. No figure for the total indigenous resource quantity is available from references 1.1 or 1.2. Total recoverable reserves are given as 2,404 km^3 (ref. 1.26); however no definition of the term is given and this figure has not been included in the tables.

The Netherlands has no sources of hydro or geothermal power and no sources of uranium or thorium.

ENERGY SUPPLY

No solid fuel production has taken place in the Netherlands since 1974, though it has an indigenous source. Imports are put at 4.609 million tonnes (ref. 1.5) and 4.67 million tonnes (ref. 1.6). Approximately 20 % of imports come from the United States.

Crude oil production is minimal, reserves being very small. Comparative figures are 1.573 million tonnes (ref. 1.5), 1.60 million tonnes (ref. 1.6) and 1.4 million tonnes (ref. 1.2). Imports are considerable at 55.225 million tonnes (55.61, ref. 1.6) but none of this is supplied by the United States.

Natural gas is the Netherlands' chief indigenous resource (approximately 20 years' supply from current economic reserves at the present rate of extraction). Production stands at 90.14 km^3 (90.0 km^3, ref. 1.2) of which 48.9 km^3 is exported. None of this export goes to the United States.

PATTERNS OF ENERGY USE

The majority of imported coal goes to industry. The remainder is used mainly for electrical generation with only a small demand in the household sector (0.22 million tonnes, ref. 1.6).

A large percentage of the Netherlands' crude oil imports are re-exported as petroleum products (approximately 34 million tonnes of imported crude oil). The remainder is used throughout all sectors.

Natural gas is used in all sectors except transportation and is particularly significant with regard to electrical generation, supplying almost 83 % of energy input to the power stations.

FORECASTS OF ENERGY SUPPLY AND DEMAND

The forecasts of energy and electricity demand in the Netherlands presented in Table 19.1.4 show an average annual rate of growth over the period 1975 to 2000 of between 2.8 % and 5.8 % for total primary energy, and of 4.5 % to 9.0 % for electricity demand.

The Commission of the European Communities (ref. 1.16) forecasts a 1985 total energy demand in the Netherlands of 4,088 x 10^{12} Btu (102.7 million tonnes oil equivalent) which is higher than any of the forecasts shown in Table 19.1.4. The Workshop on Alternative Energy Strategies (ref. 1.14) produced forecasts of primary energy demand in the Netherlands in 1985 ranging from 2,870 x 10^{12} Btu to 4,460 x 10^{12} Btu dependent mainly upon the economic growth rate and the price of oil and also affected by the expected response to energy conservation measures. These are more in accord with the forecasts shown in Table 19.1.4.

The relative importance of oil and natural gas as a source of energy is expected to decline in the period 1975-1985 (ref. 1.16) as nuclear energy becomes available, and the breakdown given in Table 19.1.5 shows the effects of a continuation of this trend through to 2000. By 2000 the demand for nuclear electricity is expected to reach 83 TWh which will be supplied by a forecast 5,400 MW total installed capacity.

INDIGENOUS ENERGY RESOURCES

Table 19.1.1

	Economically Recoverable Reserves	Total Indigenous Resources	Location of Identified Reserves
Hard Coal (million tonnes)	1,843	3,705	Eastern Gelderland
Soft Coal (million tonnes)	0	0	-
Crude Oil (million tonnes)	13	Not Available	Onshore (S. Holland)
Shale Oil (million tonnes)	0	0	-
Natural Gas (cubic km)	1,753	Not Available	Groningen
Uranium (thousand tonnes U_3O_8)	0	0	-
Hydro Power (TWh/year)	0	0	-
Geothermal (TWh/year)	0	0	-

ENERGY SUPPLY 1975

Table 19.1.2

Resource	Indigenous Supply	Imports		Exports	
		Total	% from US	Total	% to US
Hard Coal (million tonnes)	0.758[1]	4.609	20.39*	0.876	0
Soft Coal (million tonnes)	0	0	0	0	0
Crude Oil (million tonnes)	1.573	55.225	0	0	0
Shale Oil (million tonnes)	0	0	0	0	0
Natural Gas (cubic km)	90.14	0	0	48.92	0
Uranium (thousand tonnes U_3O_8)	0	.113	0	0	0
Electricity (TWh)	54.26	0.05	0	0.31	0

1) For 1974
* UN Statistical Office Estimate

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 19.1.3

Resource	Consuming Sector				Total
	Household and Commercial	Industrial	Transportation	Electrical Generation	
Coal (million tonnes)	0.22	2.18	0	0.87	3.27
Petroleum (million tonnes)	4.43	6.56	7.36	0.75	19.10
Natural Gas (cubic km)	16.2	10.8	0	10.9	37.9
Nuclear Power (TWh)	-	-	-	3.87	3.87
Hydro Power (TWh)	-	-	-	0	0
Geothermal Power (TWh)	-	-	-	0	0
Utility Electricity Distributed (TWh)	23.82	23.12	0.93	6.04	53.91

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 19.1.4

Year	Low Economic Growth 3.0%		Medium Economic Growth 4.5%		High Economic Growth 6.0%	
	Total Primary Energy (10^{12} BtU)	Electricity (TWh)	Total Primary Energy (10^{12} BtU)	Electricity (TWh)	Total Primary Energy (10^{12} BtU)	Electricity (TWh)
1975	2,225	54.3	2,225	54.3	2,225	54.3
1985	2,845	85.4	3,285	105.4	3,789	129.8
2000	4,432	162.9	6,325	275.8	9,071	463.5

CONSUMPTION OF ENERGY RESOURCES

Table 19.1.5

Resource	Standard Unit	Annual Consumption of Standard Units			Energy Consumption (10^{12} BtU)		
		1975	1985	2000	1975	1985	2000
Coal	Million Tonnes	3.39	6.9	15.9	94.1	192	441
Crude Oil	Million Tonnes	16.52	42.0	100.5	703.5	1,788	4,282
Natural Gas	Cubic km	38.66	35.3	31.6	1,389.1	1,267	1,137
Hydro Power	TWh	0	0	0	0	0	0
Other Renewables	TWh	-	-	-	-	-	-
Nuclear Power	TWh	3.33	3.4	83.0	37.9	38	465
Uranium	Thousand tonnes U_3O_8	0	0.53	1.20	-	-	-

19.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

COMMERCIAL NUCLEAR POWER PLANTS

Table 19.2.1

Facility Name	Utility	Vendor	Facility Type	Capacity (MWe net)	Status*	COD
Dodewaard	GKN	GE	BWR	52	O	Jan 1969
Borssele	PZEM	KWU	PWR	445	O	Nov 1973
Netherlands-3	GKN	-	PWR	960	P	1987

* O-Operational; U-Under Construction; P-Planned

PROJECTED NUCLEAR GENERATING CAPACITY
MWe (net)

Table 19.2.2

Year	PWR	BWR	Magnox	AGR	CANDU	Other	FBR	Firm + Planned Cumulative Total	NAC Cumulative Projection
pre-1978	445	52						497	497
1978								497	497
1979								497	497
1980								497	497
1981								497	497
1982								497	497
1983								497	497
1984								497	497
1985								497	497
1986								497	497
1987	960							1457	1457
1988								1457	1457
1989								1457	1457
1990								1457	1457
1991								1457	1457
1992								1457	1457
1993	650	650						1457	2757
1994								1457	2757
1995								1457	2757
1996	650	650						1457	4057
1997								1457	4057
1998								1457	4057
1999	650	650						1457	5357
2000								1457	5357

NUCLEAR REACTOR VENDORS

Overview

Although there is no reactor vendor per se in the Netherlands, Dutch industry is closely involved in several nuclear power plant supply groups. The most long established group consists of Comprimo N.V. (an architect engineer), Rijn-Schelde-Verolme (RSV) (supplier of heavy equipment) and General Electric Co. (reactor technology). It was set up both for the anticipated domestic Dutch market and other markets, primarily in Europe. The LWR interests of Comprimo and RSV were later integrated into a group called Nucon (1/3 Comprimo, 2/3 RSV). The Nucon group has a major involvement in the nuclear portion of the Leibstadt nuclear power station under construction in Switzerland. The Nucon group, together with GE and Brown-Boveri of Switzerland, made bids to South Africa for the two Koeberg units in South Africa.

A second LWR group which was set up by Verenigde Machinefabrieken (VMF)/Stork-Werkspoor, Hollandse Beton Groep, Siemens Nederland and KWU no longer exists.

The Netherlands is closely involved in the financing, research and development and the supply of equipment for the joint Dutch-Belgium-German demonstration fast breeder reactor SNR-300 now under construction in Germany. The Dutch Government provides about 15% of the cost of the project via the multinational utility Schnell-Bruter-Kernkraftwerkgesellschaft, SBK (SEP, Netherlands 14.8%; Synatom, Belgium 14.8%; RWE, Germany 68.8%; CEGB;UK 1.6%). The Dutch equipment supply partner is Neratoom which consists of the major elements of the Dutch nuclear industry (RSV, VNF/Stork, Comprimo, Philips, etc.) and which is involved in coordinating and performing fast breeder industrial development and engineering for the member companies and awarding subcontracts for equipment for SNR-300. The Energieonderzock Centrum Nederland (ECN), formerly Reaktor Centrum Nederland, and TNO are involved in basic fast reactor research and development work and there is close collaboration between industrial groups and research centers in the three countries.

Nuclear Reactor Vendor Support Industries

As can be anticipated from the above, Dutch industry is able to supply a wide range of components and equipment for LWR's and is making rapid progress in the same direction for FBR's. For the main components the most important of these companies is Rotterdam Nuclear, RN (50% RSV, 50% Dutch Government) which supplies pressure vessels. RN has the capability to produce about five large vessels per year. Facilities exist for the the forming of all sizes of plates; the only parts which must be purchased are the heavy ring forgings. Vessels are shop assembled since transport from the factory is not limited (except where parts of vessels are supplied to other vessel manufacturers e.g., to Sulzer for Leibstadt). Some 25 vessels have been delivered so far.

In view of the depressed nuclear market and extensive competition, in 1977, RN concluded negotiations with the government of Netherlands for 50% participation and a large interest-free loan. RN also expanded its activities to include the petro-chemical, chemical and coal conversion markets. The plan is to devote 50% of its activities to nuclear and the other half to the other areas. To acknowledge these changes, the company's name was changed to Rotterdam Heavy Equipment (RSV-A).

NUCLEAR FUEL CYCLE FACILITIES

Overview

The Netherlands has had a fairly wide involvement in the nuclear fuel cycle.

In 1967/68 Philips fabricated the first core of the Dodewaard BWR. However, because of the lack of a market they withdrew from the business. In 1972 a new fuel fabrication company, Interfuel, was set up by Dutch industry with the aim of taking advantage of processes developed at the ECN for the production of either pelletized or vibrocompacted oxide fuel (including mixed oxides) obtained from the sol-gel process. In 1975, the lack of both a domestic and foreign market also led to the withdrawal of Interfuel from the market.

Gas centrifuge enrichment has been under study and development at ECN since the late 1950's. In 1969, Ultra Centrifuge Nederland N.V. (UCN) was set up to represent Dutch interests in the tripartite agreement with Germany and the UK for centrifuge enrichment activities. UCN is owned 55% by the Dutch Government through ECN and 45% by Dutch industry (10% Philips Gloeilampenfabrieken NV; 10% Shell Kernenergie NV; 10% Staatsmijen; 7.5% Rijn-Schelde NF; 7.5% Verenigde Machinefabrieken NV). UCN, BNFL (UK) and Uranit (Germany) each have a one-third share in Urenco Ltd. with headquarters in the UK which has the responsibility to purchase and operate centrifuge enrichment plants and market the output. Pilot and production facilities exist both at Capenhurst (UK) and Almelo (Netherlands). UCN, BNFL and GnV (Germany) also each have a one-third share in CENTEC (Gesellschaft fur Zentrifugentechnik mbH) with headquarters in Germany which has the responsibility for the design, development and manufacture of plants.

Recently, Dutch industry has expressed concern about continuing involvement in UCN due to uncertain market conditions. Although there has been no firm announcement by the Government, it is believed that the Netherlands intends to remain a full partner in Urenco and CENTEC. Current enrichment facilities in the Netherlands are summarized in Table 19.2.3. The details of operation, capacity and capacity expansion plans, marketing strategy, market shares and production are given under Urenco, United Kingdom.

RCN also has a small shareholding in the international Eurochemic reprocessing plant in Belgium which was closed down in 1974.

CURRENT FACILITIES

Table 19.2.3

Facility Name	Location	Facility Type	Capacity Status		Year	Shareholdings
			MT/YR	Status*		
Almelo Pilot Plant SP1	Almelo	Centrifuge Enrichment	20 (25 nominal)	O	1974	100% Urenco
Almelo Pilot Plant SP2	Almelo	Centrifuge Enrichment	25	O	1974	100% Urenco
Almelo Production Plant SP3	Almelo	Centrifuge Enrichment	60 140 400	O O P	1976 1978 1982	100% Urenco
Centrifuge Manufacturing Facility	Almelo	-	-	O		100% UCN

* O-Operational; U-Under Construction; P-Planned

NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

Vested Interests in Current Fuel Cycles and Reactor Technologies

The Netherlands has a significant vested interest in both current and future reactor technologies and fuel cycles.

Both the Government and industrial companies are deeply involved in the continuing development of know-how and the supply of equipment and components for both LWR's and FBR's. Rotterdam Nuclear in particular possesses extensive pressure vessel manufacturing capabilities.

There also exists a major national vested interest in centrifuge uranium enrichment through the participation of industry and Government in Urenco and CENTEC. Urenco is anticipated to become one of the important future suppliers of enrichment since centrifuge plants unlike diffusion plants can be step-wise expanded to meet market requirements.

Current Trends in Nuclear Development Programs

Despite the uncertainty in both domestic and export nuclear markets, the Netherlands is continuing to maintain and develop through industry and Governmental actions an active LWR support industry including both the supply of components and equipment and enrichment services. There are, however, some doubts at this time as to the future position, particularly of Dutch industry in enrichment. Further, FBR development and supply is being actively pursued.

19.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

PROFESSIONAL LABOR FORCE PROFILE

Table 19.3.1

Information available shows that in 1973, there were 22,554 Scientists and Engineers engaged in R & D.

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 19.3.2

Institution	Location
Universiteit van Amsterdam	Amsterdam
Vrije Universiteit te Amsterdam	Amsterdam
Technische Hogeschool te Delft	Delft
Technische Hogeschool te Eindhouen	Eindhouen
Technische Hogeschool Twente	Enschede
Rijksuniversiteit te Groningen	Groningen
Rijksuniversiteit te Leiden	Leiden
Katholieke Universiteit te Nijmegen	Nijmegen
Erasmus Universiteit Rotterdam	Rotterdam
Katholieke Hogeschool te Tilburg	Tilburg
Rijksuniversiteit te Utrecht	Utrecht

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 19.3.3

Name	Location	Main Activities
Netherlands Organization of Technical and Scientific Research (TNO)	The Hague	implements along with ECN national energy R&D programs
Netherlands Energy Development Company (NEDM)	--	helps to improve country's energy position by undertaking or assisting industry to undertake new energy development progress
Foundation for Fundamental Research (ZWO)	--	responsible for management of fundamental research
Netherlands Energy Center (ECN)	The Hague	nuclear research and development. Took over responsibilities of the Reactor Centrum Nederland (RCN) and the Central Organization for Applied Research (NND)
National Energy Research Steering Group (LSED)	--	makes recommendations for energy research including nuclear energy

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 19.3.4

Name	Owner	Location	Main Activities
Neratoom	(cooperative with Dutch Philips Company)	The Hague	breeder reactor research
AKZO B.U.	--	Arnhem	waste storage & disposal
Verenigde Machini Fabrieken	--	Amsterdam	ultracentrifuge, LMFBR design
Rhine Schelde Verolme Engineers & Shipbuilders	--	Rotterdam	fuel rod development LMFBR design waste storage & disposal
Ultra-Centrifuge Nederland N.V.	--	The Hague	uranium enrichment

Much of laboratory scale research is carried out by government sponsored research organizations as ECN & TNO. Industry is represented on the boards and in the advisory councils of these institutions, where the research programs and projects are discussed and decided. In the nuclear field, where most of the work is in the development and even demonstration phase, much work has been carried out by industry in close cooperation with ECN and TNO.

RESEARCH AND TEST REACTORS
List of Reactors

Table 19.3.5

Facility Name	Location	Owner	Constructor	Facility Type	Facility Status		
					MW(th)	Status*	COD
SUSPOP	Kema-Arnhem	Kema	Kema, RCN	Aqu. homog.	0	0	1959
LFR	Reactor Center, Petten	RCN	Hawker Siddeley Nuclear Power Co.Ltd.	Argonaut	0	0	1960
HFR	Reactor Center, Petten	RCN	Allis Chalmers	Research tank	45	0	1961
BARN	Wageningen	Institute for Atomic Science in Agriculture	--	Research pool	0.1	0	1963
HOR	Delft	Delft Technical University	AMF	Research pool	2	0	1963
KSTR	Kema Arnhem	Kema	Kema	aqu. homogeneous	1	0	1974
ATHENE**	Eindhoven	Eindhoven Technical University	RCN & N.V. Neratom	Argonaut	0	S	1969-1973
KRITO	Petten	RCN	RCN & various Dutch industries	Research pool	0	S	1963-1969
SIEK	Petten	RCN	RCN. various Dutch industries	Research pool	0	--	1969

* O-Operational; U-Under Construction; P-Planned; S-Shutdown
** Decommissioned

INDIGENOUS CAPABILITY TO DESIGN AND SUPPLY RESEARCH AND TEST REACTORS AND FUEL SERVICES

Summary of Reactor Orders by Vendor and Country

Table 19.3.6

Vendor	Country	Facility Name	Facility Type	Facility Status			Scope of Services
				MW(th)	Status*	COD	
N. V. Neratoom	Italy	ECO	tank, nat. U, D_2O, organic	0	S	1965-1972	Constructor
Kema	Netherlands	SUSPOP	Aqu. Homog.	0	0	1959	Constructor
Kema	Netherlands	KSTR	Aqu. Homog.	1	0	1974	Constructor
RCN + N. V. Neratoom	Netherlands	Athene**	Argonaut	0	S	1969-1973	Constructor
RCN	Netherlands	KRITO	Pool	0	S	1963-1969	Constructor
RCN	Netherlands	SIEK	Pool	0	-	1969	Constructor

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Decommissioned

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 19.3.7

Facility Name	Location	Facility Type	Capacity Status MR/YR	Status*	Year	Shareholdings

CERCA and NUKEM are fabricating the fuel elements for nuclear research reactors and MTR'S. The reactors are owned by EURATOM and there is an agreement for the fabrication of the fuel.

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

19.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

ECONOMIC DATA PROFILE

Table 19.4.1

GNP (Current million $)	- 105,600 (1977)	Inflation Rate	- 4.8% (1978)
Exports (million $)	- 40,200 (1977)	Imports (million $)	- 39,500 (1977)
Per Capita Income ($)	- 7,597 (1977)	Disposable Income ($)	- 5,303 (1975)
Monetary Unit	- Guilders	Exchange Rate (/US$)	- 2.45 (4/77)
Population (million)	- 13.9 (1978)		

19.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

	MILLIONS $US 1977
NUCLEAR FISSION	48.5
LWR	(12.6)
HTR	(2.3)
Other Converter Reactors	(2.3)
Fuel Cycle	(30.2)
FAST BREEDER	30.2
NUCLEAR FUSION	12.9
SUPPORTING TECHNOLOGIES	15.4
Electric Power Conversion	(4.6)
Transmission and Distribution	(0.9)
Energy Storage	(1.6)
Energy Systems Analysis	(4.6)
Others	(4.3)

Exchange rate used: 1 U.S. dollar = 2.482 guilders

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 19.4.3

Industry University or Laboratory	Program Area	Budget $ (Millions)	Key Personnel
Netherlands Energy Center (ECN)	Nuclear marine propulsion, reactor kinetic experiments, fast breeder research	--	Dr. E. Kramer
Central Technical Institute	Sodium coolant in fast reactors	--	--
Foundation for Fundamental Research on Matter (FOM)	Nuclear physics, mass separation and analysis, thermonuclear reactions research and high energy physics	8.3	--
Central Laboratory	Isotope research	--	--
Electronic Materials Testing Company (KEMA)	Aqueous homogeneous suspension reactors with circulating liquid fuel	--	W. K. Wierchers
ERASMUS University	LMFBR design	--	Dr. J. A. Bourdrez
Institute for Nuclear Physics Research (IKO)	Nuclear reactions, nuclear spectroscopy, radiochemistry	--	--
University of Amsterdam	Ultra-Centrifuge	--	--
Institute for the Application of Nuclear Energy in Agriculture (ITAL)	Radiation-caused mutations in plants, preservation of foodstuffs by irradiation, behavior of isotopes and labeled compounds in the nutrition cycle in the soil as well as plants and animals, use of radioactive substances in biological research	--	--
Delft Reactor Institute (RID)	Dynamic behavior of a pressurized system for a high-pressure water reactor	--	--
Tilburg University	Fuel rod production and development	--	--

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 19.4.3 (Cont.)

Industry University or Laboratory	Program Area	Budget $ (Millions)	Key Personnel
Institute of Radiopathology and Radiation Shielding	Radioactive isotopes and ionizing radiation	--	--
Laboratory for Heat Technology and Reactor Engineering	Heat transfer and hydraulics of gas-cooled reactors	--	--

19.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

Energy R&D expenditures for industry in 1977 are expected to be $54.1 million, as compared to the Government energy R&D budget of $137.5 million. Over the last four years industrial investment in energy R, D&D has increased five to six fold and expanded its share to technology to 60% of the total industrial investment in 1977, while that of nuclear fission continued to decline slightly in absolute terms. Future prospects of industrial investment up to 1985 are expected to be very slow with relatively high increases in renewable resources and conservation technologies.

Dutch industry plays an increasingly important role in demonstration projects. The Netherlands Energy Development Company (NEOM) was created in 1976 to assist industry in bringing new energy technologies to commercial use.

The major impediments in the way of enhancing industrial R, D&D activities and commercial application are:

1. a general shortage of funds;
2. uncertainty about the energy policy of the Government;
3. a general shortage of qualified staff.

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 19.4.5

Name	Share Capital	Assets	Sales
Ultra Centrifuge Nederland N. V. (UCN)	(Owned 55% Government and 45% industry)		

19.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Dutch reactors were obtained from G.E. and KWU.

19.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

19.5.1 ENERGY POLICY - BASIC LEGISLATION

1. Netherlands Oil Company (NAM) established in 1947.

2. Nuclear Energy Act 1963.

3. Gasonie, the sole natural gas distributing company in the Netherlands, established 1963.

4. Interdepartmental Commission for Nuclear Energy founded in 1964 to coordinate policies regarding peaceful nuclear application.

5. Surface Water Pollution Act 1970.

6. Air Pollution Act 1972.

7. The National Steering Committee for Energy Research (LSEO) established 1974.

8. Netherlands Energy Center (ECN) established 1976, taking over the responsibilities of the Reactor Centrum Nederland (RCN) and the Central Organization for Applied Research (NND). The Center will handle nuclear R&D, as well as more exotic energy research projects.

9. In 1976, Parliament approved the principles of the government's energy White Paper published in 1974.

10. Netherlands Energy Development Company (NEOM) established 1976.

11. Fast Breeder Act.

In the area of energy conservation, legislation is in preparation which may lead to increased efforts to develop energy saving technologies.

19.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

LEGISLATIVE - a bicameral Parliament called the States General consists of the First Chamber (upper house composed of 75 members) and the Second Chamber (lower house composed of 150 members). The two chambers meet separately, except for ceremonial occasions. In addition to their legislative authority, both chambers exercise a check on the Council of Ministers through questioning and investigation. The First Chamber mainly reviews legislation passed by the Second Chamber. The Second Chamber, however, is far more important, for it alone has the right to initiate legislation and amend bills submitted by the Council of Ministers. Both chambers have committees that consider energy matters. For example, the Second Chamber has a standing committee on nuclear energy, however, most energy questions are brought up in the Economics Committee.

EXECUTIVE - the Council of Ministers (or Cabinet) has collective responsibility. The President of the Council (Prime Minister Andreas A. M. van Agt) cannot over-ride the majority of his colleagues, although he exercises significant influence on decisions.

The Minister of Economic Affairs (Gijsbert M. V. van Aardenne) is responsible for the establishment and implementation of energy policy and energy R&D policy.

OTHER PARTS OF THE ENERGY STRUCTURE

1. Minister for Science Policy (Rinus W. J. M. Peijnenburg) deliberates with the Minister of Economic Affairs to ensure that the energy R&D policy, envisioned by the latter, fits in general science policy of the Government.

2. General Energy Council (AER),which is broad in scope, advises the Minister of Economic Affairs on matters regarding energy policy.

3. National Energy Research Steering Committee (LSEO) is constituted of recognized experts with mainly a research background and advises both the Minister of Science Policy and Minister of Economic Affairs on matters regarding energy R&D policy.

4. Netherlands Energy Research Foundation (ECN) and, to a lesser extent, the Netherlands Organization of Technical and Scientific Research (TNO) are the agencies through which the energy R&D program is implemented.

5. Energy Research Council (REO) is expected to replace LSEO by the end of 1977.

6. Netherlands Energy Development Company (NEOM) is state-owned with an objective of helping to improve the national energy position by undertaking or by assisting industry to undertake new energy development projects that are not yet commercially attractive.

7. While nuclear activities are conducted cooperatively by various organizations and institutions (Government-subsidized to varying degrees), as well as the universities and energy producers, the Interdepartmental Commission for Nuclear Energy is responsible for coordinating policies regarding peaceful nuclear application.

19.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

MINISTRY OF ECONOMIC AFFAIRS (Minister, Gijsbert M. V. van Aardenne)

DIRECTORATE GENERAL FOR ENERGY SUPPLY - divided into five directorates of which four provide advice on energy policy and legislation in the specific fields of:

1. natural gas supply
2. electricity and nuclear energy
3. mining
4. coal and oil

The fifth directorate advises the Cabinet on international energy affairs, in particular, those related to EEC and OECD, and on matters related to energy R&D policies.

Scenarios and other relevant policy information are supplied by:

1. Energy Study Center (technological information)
2. Central Planning Bureau (for economic data)

19.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

A coalition government was formed in December 1977, and is not yet in a position to take firm control of the nuclear siting and disposal waste debate now underway. The country is resting on its still adequate sources of gas and oil, but is dependant on imports of 90% of its energy demands. The present government is not showing signs of being anti-nuclear as it decided to allow the expansion of the Urenco enrichment plant at Almelo and is considering how best to develop the nuclear industry (not whether to develop it).

19.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

The Netherlands has two nuclear power reactors with a total output of 500 MWe, and an enrichment contract for an additional reactor of 960 MWe. However, owing to various difficulties including political opposition, completion of this reactor before 1990 is questionable. There are three main areas of research in process: reactor safety, the disposal of radioactive material and enrichment. The Netherlands is participating in several international programs on uranium and plutonium analyses for safeguarding purposes. Cooperation was set up with UK and FRG to develop the ultra-centrifuge technology. Three pilot plants with a capacity of 20 tonnes SWU per annum are in operation, and under construction are two demonstrating plants of 200 tonnes SWU/year, one at Almelo. The Netherlands is cooperating with FRG and Belgium on the development of a 300 MWe sodium cooled fast breeder reactor, the SNR-300). The Dutch effort is the development of the large components in the heat-exchange system as well as the building and operation of a 50MW testbed for sodium components. For the time being, the Dutch Government has decided not to participate in the construction of a commercial scale fast breeder reactor, SNR-2. The Dutch participate in thermonuclear fusion research within the framework of EURATOM.

19.5.6 NUCLEAR ENERGY R&D - PRIORITIES

The following areas of R&D priority have been established:

CATEGORIES	AREA OF R & D
Proven Reactors	. Reactor studies and calculations . Fuel behavior experiments . Steam boilers . Pressure vessel
HTGR	. Assessment . Graphite irradiation and research . Coated particle fuel behavior research
Breeders	. Sodium Cooled FBR . Components . Fuel behavior and safety . Prototype kalkar
Fuel Cycle	. Fabrication experiments . Pilot plant . Ultra centrifuge technology
Waste Treatment & Disposal	. Assessment in salt formation
Safety	. Pressure vessel fracture . Mechanics . Reactor building response analysis . Risk analysis
Transportation	. Radioisotope toxicity and neutron radiation experiments

19.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

The government seeks approval from National Assembly for construction of power plants, and once granted, these plants are operated by the utilities. However, the state governments exercise control over normal operations of the plants.

19.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 19.6.1

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Eems	Groningen	EGD		Gas	597	O	1977
Harculo	Ijssel	IJSSEL		Coal/Oil	320	U	1979
Gelderland	Gelder	PGEM		Coal/Oil	596	U	1980
Merwede-Kanal	Utrecht	PEGUS		Gas	100	U	1978
Hemweg	Amsterdam	GEB		Oil/Gas	506	U	1978
Amer	North Brabant	PNEM		Coal/Oil	627	U	1979
Maasbracht	Limburg	PLEM		Oil/Gas	316	O	1977
Maasbracht	Limburg	PLEM		Oil/Gas	633	U	1978
Helpman	Groningen	EGD		Gas	139	O	
Hunze	Groningen	EGD		Gas	643	O	1966/1970
Leenwarden	Friesland	PEB		Gas	150	O	
Bergum	Friesland	PEB		Gas	646	O	1974
Harculo	Ijssel	Ijssel-Centrala		Coal/Oil	697	O	1972
Hengelo	Ijssel	IJssel-Centrala		Coal/Oil	187	O	

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 19.6.1 (Continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Flevo	Gelderland	PGEM		Gas/Oil	860	O	1968/69 1974
Gelderland	Gelderland	PGEM		Gas/Oil	541	O	
Lage Weide	Utrecht	PEGUS		Gas	639	O	1966/69 1976
Velsen	North Holland	PEN		Gas	1068	O	1966/74
Driemen	North Holland	PEN		Gas	370	O	1970
Hemweg	Amsterdam	GEB		Gas	479	O	1966/68
S'Gravenhage	S'Gravenhage	GE		Gas	179	O	
Norwedehaven	Dordrecht	GEB (EZH)		Gas	507	O	1968
Delft	Delft	GB		Gas	100	O	
Galileistraat	Rotterdam	GEB		Gas	161	O	
Schiehaven	Rotterdam	GEB		Gas	180	O	
Waalhaven	Rotterdam	GEB		Gas	944	O	1971/72
Maasvlakte	Rotterdam	GEB		Gas/Oil	1052	O	1975

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 19.6.1

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Maascentrale	Buggenum (Limburg)	PLEM		Oil/Gas	719	0	1966/69
Vlissingen	Zeeland	PZEM		Gas	262	0	
Borssele	Zeeland	PZEM		384 MW Oil/Gas 443 MW Nuclear	827	0	1971/73 1975
Amer	North Brabant	PNEM		Coal/Oil	1690	0	1966/71 1972
Donge	North Brabant	PNEM		Oil/Gas (Combined cycle)	116	0	

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 19.6.2

Year	Capacity - MWe(net)
1975	13,982
1980	18,045
1985	
1990	
1995	
2000	

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 19.6.3

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
	Limberg			0.76	O
Delier-Munster	Rotterdam	NAM	Oil Field	989	O
Lisselmonde/Ridderkerk	Rotterdam	NAM	Oil Field	4,655	O
Pijnacker	Emmen	NAM	Oil Field	382	O
Schoonebeck	Emmen	NAM	Oil Field	15,818	O
Wassenaar-Meyendel	Rotterdam	NAM	Oil Field	3,515	O
Zoetemeer	Rotterdam	NAM	Oil Field	673	O
Other			Oil Field	76	O
Groningen	Groningen	NAM	Gas Field	96	O
L10/L11	Offshore North Sea	Placid Group	Gas Field	2.0	O
K14	Offshore North Sea	NAM	Gas Field	--	P
K11	Offshore North Sea	NAM	Gas Field	--	P

* O-Operational; U-Under Construction; P-Planned; S-Shutdown
** Oil-barrels/day; Natural gas-km^3/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 19.6.4

RESOURCE	1985	2000
COAL (million tonnes)		
Indigenous Supply	0.72	0.38
Imports	6.18	15.52
Exports	--	--
CRUDE OIL (million tonnes)		
Indigenous Supply	1.10	0.09
Imports	40.90	100.41
Exports	--	--
SHALE OIL (million tonnes)	0	0
Indigenous Supply		
Imports		
Exports		
NATURAL GAS (cubic kilometers)		
Indigenous Supply	86.42	23.48
Imports	--	8.12
Exports	51.12	--
URANIUM (kilotonnes U_3O_8)		
Indigenous Supply	0	0
Imports	.53	1.20
Exports	0	0

SECTION 20

PAKISTAN

20.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

INDIGENOUS RESOURCES

The coal reserves of Pakistan are lignites, have high moisture, ash and sulphur content and are usually non-coking and susceptible to spontaneous combustion. There are also sub-bituminous deposits of very poor quality. Neither can be transported over long distances. Indigenous resources are put at 653 million tonnes (ref. 1.2), 482 million tonnes (ref. 1.9) and 476 million tonnes (ref. 1.27). Previous estimates (ref. 1.13) put total resources as high as 1,941 million tonnes in 1966.

Pakistan has a small amount of oil, estimated at 24.5 million tonnes of which 5.3 million tonnes is economically recoverable at present. The International Encyclopedia listed oil reserves as 10 million tonnes. Despite a considerable investment sum (762 million Rs) during 1955-1965 no new oil deposits had been discovered until Dhodak in December 1976. Studies have put the total recoverable potential for oil as high as 4,930 million tonnes (ref. 1.27) but no confirmation of this figure has been obtained.

No figures are available for shale oil deposits.

Some good reserves of natural gas are available and the fields are almost entirely located within an 80-mile radius of Sukkur, in the Upper Sind region. Total resources are given as 445 km^3 (ref. 1.2), 521 km^3 (ref. 1.9) and 419 km^3 (ref. 1.27).

All the hydro-electric power is connected with the River Indus and its tributaries. High seasonal variation of flow occurs together with high siltation rates. More importantly, use of water from the reservoirs for irrigation has absolute priority over the use of power. Most potential sites are situated in inaccessible regions far from load centers and therefore are not favorable for early development. The figures for hydro-power have been taken from the World Energy Conference Survey (ref. 1.2).

Small deposits of uranium are known to exist, but the magnitude is not known.

ENERGY SUPPLY

Production figures for solid fuels in Pakistan vary from 1.1 million tonnes (ref. 1.5), 1.29 million tonnes (ref. 1.2) to 1.5 million tonnes (Paper XXXV, ref. 1.23) though the latter was for 1972. Reference 1.27 gives 0.921 million tonnes based on an average calorific value for coal of 10,000 Btu/lb. Imports of hard coal are small at 0.074 million tonnes.

Crude oil production is estimated at 0.385 million tonnes (ref. 1.5). Reference 1.2 gives 0.5 million tonnes for 1972. Reference 1.25 gives 0.39 million tonnes for 1974.

Natural gas production is estimated at 5 km^3 (ref. 1.5). Reference 1.2 gives 3.97 km^3 for 1972 and reference 1.25 4.66 km^3 for 1974.

Small quantities of uranium are believed to be produced.

PATTERNS OF ENERGY USE

Reliable data on end uses of energy are not available according to the Government of Pakistan (see Paper XXXV, ref. 1.23). Figures for Table 20.1.3 were supplied by private communication.

FORECASTS OF ENERGY SUPPLY AND DEMAND

Total primary energy demand in Pakistan is expected to increase from its 1975 level of 399 x 10^{12} Btu to between 1,000 x 10^{12} Btu and 5,100 x 10^{12} Btu by 2000, an average annual rate of growth of 3.9% to 10.7%. Electricity demand is expected to grow at an average annual rate of 4.6% to 11.8% during the same period increasing to as much as 155 TWh by 2000. These forecasts are presented in Table 20.1.4. In the period 1965 to 1974 economic growth averaged 5.4% (ref. 1.43) while energy and electricity consumption increased by 5.3% and 8.3% per year respectively (refs. 1.5 and 1.44).

An energy and electricity demand forecast made by the International Atomic Energy Agency (ref. 1.19) estimated demands by 2000 of approximately 3,700 x 10^{12} Btu of primary energy and 117 TWh of electricity. These forecasts, which are based on an economic growth of 4.3% per year, compare favorably with the figures shown in Table 20.1.4.

The future breakdown of energy demand into sources of supply shown in Table 20.1.5 is based on a projection of current trends such as the increasing importance of nuclear power and the reduction in the relative contribution of oil and gas. These figures are corroborated by similar values in the breakdown presented in the IAEA report (ref. 1.9).

INDIGENOUS ENERGY RESOURCES

Table 20.1.1

	Economically Recoverable Reserves	Total Indigenous Resources	Location of Identified Reserves
Hard Coal (million tonnes)	403	410	Punjab, Sinol, Baluchistan
Soft Coal (million tonnes)	243	243	
Crude Oil (million tonnes)	5.3	24.5	Punjab, Potwar Plateau
Shale Oil (million tonnes)	Not Available	Not Available	
Natural Gas (cubic km)	337	445	Baluchistan, Dhulian, Mari, Sui
Uranium (thousand tonnes U_3O_8)	Not Available	Not Available	Dera Ghazi Khan
Hydro Power (TWh/year)	20.4	156.8	Indus River (Mangla Dam, Tarbela Dam)
Geothermal (TWh/year)	0	0	

ENERGY SUPPLY 1975

Table 20.1.2

Resource	Indigenous Supply	Imports		Exports	
		Total	% from US	Total	% to US
Hard Coal (million tonnes)	1.2	0.074	0	0	0
Soft Coal (million tonnes)	0.09	0	0	0	0
Crude Oil (million tonnes)	0.385*	3.200*	0	0	0
Shale Oil (million tonnes)	0	0	0	0	0
Natural Gas (cubic km)	5.00*	0	0	0	0
Uranium (thousand tonnes U_3O_8)	0	0.18	0	0	0
Electricity (TWh)	9.45	0	0	0	0

* UN Statistical Office estimate

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 20.1.3

Resource	Consuming Sector				Total
	Household and Commercial	Industrial	Transportation	Electrical Generation	
Coal (million tonnes)	0.092	0.833	Not Available	0.6	1.014
Petroleum (million tonnes)	0.479	0.187	1.403	0.151	2.22
Natural Gas (cubic km)	0.295	2.745	0	1.401	4.441
Nuclear Power (TWh)	-	-	-	0.55	0.55
Hydro Power (TWh)	-	-	-	4.85	4.85
Geothermal Power (TWh)	-	-	-	0	0
Utility Electricity Distributed (TWh)	1.69	3.113	Not Available	-	9.45*

* UN Statistical Office estimate

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 20.1.4

Year	Low Economic Growth 2.0%		Medium Economic Growth 3.5%		High Economic Growth 5.0%	
	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)
1975	399	9.5	399	9.5	399	9.5
1985	547	14.9	752	20.8	1,029	28.9
2000	1,037	29.4	2,316	67.9	5,111	154.9

CONSUMPTION OF ENERGY RESOURCES

Table 20.1.5

Resource	Standard Unit	Annual Consumption of Standard Units			Energy Consumption (10^{12} BtU)		
		1975	1985	2000	1975	1985	2000
Coal	Million Tonnes	0.84	2.5	8.4	23.3	68	232
Crude Oil	Million Tonnes	3.35	6.8	12.0	142.1	290	510
Natural Gas	Cubic km	4.81	7.2	21.3	172.2	260	764
Hydro Power	TWh	4.85	6.5	22.3	55.2	74	254
Other Renewables	TWh	-	-	-	-	-	-
Nuclear Power	TWh	0.55	5.3	48.9	6.3	60	556
Uranium	Thousand Tonnes U_3O_8	0.182	0.13	2.0	-	-	-

20.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

COMMERCIAL NUCLEAR POWER PLANTS

Table 20.2.1

Facility Name	Utility	Vendor	Facility Type	Capacity (MWe net)	Status*	COD
Kanupp	Pakistan Atomic Energy	Canada	CANDU	125	O	Apr 1972

* O-Operational

PROJECTED NUCLEAR GENERATING CAPACITY
MWe (net)

Table 20.2.2

Year	PWR	BWR	Magnox	AGR	CANDU	Other	FBR	Firm + Planned Cumulative Total	NAC Cumulative Projection
pre-1977					125			125	125
1977								125	125
1978								125	125
1979								125	125
1980								125	125
1981								125	125
1982								125	125
1983								125	125
1984	600							125	725
1985								125	725
1986	600							125	1325
1987	0							125	1325
1988	300	300						125	1925
1989	0							125	1925
1990	300	300						125	2525
1991	0							125	2525
1992	450	450						125	3425
1993	0							125	3425
1994	450	450						125	4325
1995	0							125	4325
1996	450	450						125	5225
1997	450	450						125	6125
1998	450	450						125	7025
1999	450	450						125	7925
2000	450	450						125	8825

NUCLEAR REACTOR VENDORS

Overview

Pakistan has no domestic reactor vendors. In view of the technological status of Pakistan, it is anticipated that the nation will depend upon reactor imports from foreign vendors.

Nuclear Reactor Vendor Support Industries

No substantial reactor vendor support industries currently exist. Pakistan is endeavoring to develop domestic skill and manufacturing industries; however lack of trained personnel, technology and financing limit this effort.

NUCLEAR FUEL CYCLE FACILITIES

Overview

Pakistan is concentrating its efforts in two areas - uranium exploration, mining and milling; and reprocessing.

Uranium deposits do exist in Pakistan and it is believed that indigenous uranium resources are sufficient for the Kanupp Candu reactor. A pilot concentration plant is located at the Dera Ghazi Khan mining area.

Pakistan has contracted with France for a small reprocessing plant to be constructed at Chasma, on the Indes River. It is believed that most (reported to be 95%) of the plant plans have been delivered. Financing, technical manpower, and lack of Franch export credit guarantees may hinder Pakistan's ability to construct the plant. Some international pressure is being applied in order to attempt to convert the plant design to a coprocessing scheme where the uranium and plutonium streams remain combined. If Pakistan does not agree to the coprocessing arrangement, France prefers not to carry through with this contract.

It has been noted in recent literature that Pakistan may be building a gas centrifuge enrichment plant. Pakistan has denied this, saying that equipment they have ordered, which could be used for an enrichment plant, is being ordered for military purposes. There is no firm substantiation of this however.

Pakistan has no fabrication facilities.

NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

Vested Interests in Current Reactor Technologies and Fuel Cycles

The single Pakistan CANDU reactor and the need for Pakistan to develop trained personnel to operate and maintain that reactor can be considered to create some degree of vested interest in the CANDU. Conversely, the planned construction of a reprocessing plant and possible imports of Framatome PWRs in the future could create equal personnel interest in LWR and plutonium fuel cycles. Substantial time, commitments and actual reactor/reprocessing plant construction would have to occur before major technological vested interests would exist.

Current Trends in Nuclear Development Programs

Uranium exploration and attempts to assure continued operation of the Kanupp reactor are the two clear trends in Pakistan. Financial, political, and trained personnel matters appear to severely restrict activities towards either further reactors or the reprocessing plant.

20.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

PROFESSIONAL LABOR FORCE PROFILE

Table 20.3.1

Available information presents the following data for 1973:

111,000 Scientists and Engineers
4,164 Scientists and Engineers engaged in R&D

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 20.3.2

Institution	Location
University of Baluchistan	Quetta
Gomal University	Dera Ismail Khan
University of Islamabad	Islamabad
University of Karachi	Karachi
University of Peshawar	Peshawar
University of the Punjab	Lahore
University of Sind	Jamshoro-Sind
University of Engineering and Technology	Lahore

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 20.3.3

Name	Location	Main Activities
Pakistan Atomic Energy Communion	Islamabad	responsible for generation of electric power from nuclear energy and the developing of nuclcar energy.
Pakistani Science Foundation		(modelled after US National Science Foundation) overseas dissemination of a comprehensive scientific and technological information and dessemination center and administers a fund of money available for university research projects.

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 20.3.4

Name	Owner	Location	Main Activities

Not Applicable

RESEARCH AND TEST REACTORS
List of Reactors

Table 20.3.5

Facility Name	Location	Owner	Constructor	Facility Type	Facility Status		
					MW(th)	Status*	COD
PARR	Islamabad	PAEC	AMF Atomics	research pool	5	0	1965

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

INDIGENOUS CAPABILITY TO DESIGN AND SUPPLY RESEARCH AND TEST REACTORS AND FUEL SERVICES
Summary of Reactor Orders by Vendor and Country

Table 20.3.6

Vendor	Country	Facility Name	Facility Type	Facility Status			Scope of Services
				MW(th)	Status*	COD	

Not Applicable

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 20.3.7

Facility Name	Location	Facility Type	Capacity Status MT/YR	Status*	Year	Shareholdings

Not Applicable

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

20.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

ECONOMIC DATA PROFILE

Table 20.4.1

GNP (Current million $)	- 15,800 (1977)	Inflation Rate	- 9% (1977)
Exports (million $)	- 1,292 (1977)	Imports (million $)	- 2,770 (1977)
Per Capita Income ($)	- 192.6 (1977)	Disposable Income ($)	- --
Monetary Unit	- Rupee	Exchange Rate (/US$)	9.93 (4/77)
Population (million)	- 72.0 (1976)		

20.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

PAKISTAN ATOMIC ENERGY COMMISSION BUDGET

1975-76

DEVELOPMENT EXPENDITURE RESEARCH	Rupees ($x10^6$)
Pakistan Institute of Nuclear Science and Technology	4.296
Other projects:	
Federal Government	6.428
Provincial Governments	3.974
	14,698
NON-DEVELOPMENT EXPENDITURE	
Scientific Research	32.744

1976 Exchange Rate: 9.93 rupees/US$

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 20.4.3

Industry University or Laboratory	Program Area	1976-1977 Budget Rupees (Millions)	Key Personnel
Pakistan Institute of Nuclear Science and Technology (Pinstech)	Heat transfer Nuclear physics Radioisotope production	18	--
Atomic Energy Center, Lahore	Application of radioisotopes	--	--

1977 Exchange Rate: 9.93 rupees/US$

20.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

The private sector remains an insignificant factor in Pakistan's energy R&D program. The government of Pakistan, however, is looking for means to stimulate activities in the mineral field.

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 20.4.5

Name	Share Capital	Assets	Sales
	Not Applicable		

20.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Pakistan seeks collaboration from friendly countries, the World Bank and other agencies, as well as "harnessing internal sources."

20.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

20.5.1 ENERGY POLICY - BASIC LEGISLATION

There is no basic legislation dealing directly with energy R&D.

Pakistan law, however, will not permit any significant expansion of private interests into new deposits or new sectors of mineral development. Private enterprise is only minimally involved in nonpetroleum mineral development in Pakistan.

1. PAEC - established 1955.

2. Pakistan Atomic Energy Council est. 1958 - reports to Scientific and Technological Research Division of the President's Secretariat.

3. PAEC initiated uranium prospecting program - early 1960.

4. Karachi Nuclear Power Project (KANUPP) approved by GOP in 1964.

5. KANUPP power plant inaugurated in 1972.

6. Nuclear Safety & Radiation Protection Ordinance - 1973 (was scheduled to be in force in 1973)

20.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

LEGISLATIVE-PARLIAMENTARY consisting of two houses: The Senate and the National Assembly which must approve all major legislation.

EXECUTIVE-PRESIDENT is constitutional head of the government. The dominant government figure, however, is the PRIME MINISTER. Normally, legislation must be approved by the National Assembly, but important decisions are often made by executive fiat. The Prime Minister must approve all energy policies and actions, but this is largely delegated to the interagency Ministerial-level Executive Committee of the National Economic Council (ECNEC).

ADDITIONAL ENERGY STRUCTURE

THE PLANNING COMMISSION is responsible for the overall coordination of power planning in relation to the economic development of the Country.

PAKISTAN ATOMIC ENERGY COMMISSION (PAEC) formulates nuclear energy policy. Its jurisdiction includes:

1. Formulation of nuclear policy
2. Operation of nuclear installations
3. Representation of Pakistan at international meetings on nuclear energy matters
4. Research and application of nuclear technology
5. Exploration of radioactive materials
6. Manpower training

On July 5, 1977, the Pakistani military seized power and imposed martial law. The Martial Law Administration is headed by a four-man military council with General Zia ul-Haq as chief martial law administrator.

20.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

PAKISTAN ATOMIC ENERGY COMMISSION (PAEC) is controlled by a four-man commission, headed by a chairman (Munir Ahmed Khan). PAEC is in charge of all aspects of nuclear policy.

Executive Committee of National Economic Council approves nuclear power plant projects.

Directorate of Industrial Liaison promotes participation of local industries and technical capabilities in implementing nuclear power program.

PAEC, in collaboration with the Ministry of Fuel, Power & Natural Resources, the Planning Commission, Water & Power Development Authority (WAPDA) and Karachi Electric Supply Corporation (KESC), works to evolve long-term nuclear power development programs.

20.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

The objective of the Government of Pakistan is to lessen, and if possible, eliminate the Country's dependence on foreign energy sources. The major energy source is imported oil which contributes more than 40 per cent of the total commercial energy, followed by natural gas, hydroelectric, coal and nuclear power.

Pakistan has expressed interest in nuclear energy in view of:

1. limited indigenous natural resources
2. high cost of imported fuel
3. rapidly growing demand for energy
4. ambitious economic development targets

The Government of Pakistan, however, remains open to reconsider its options based on the cost of available alternatives.

In order to provide the supply of nuclear power needed for economic development, PAEC has established a plan for the construction of several nuclear plants. Because of limited financial resources, financing would be sought from friendly countries, the World Bank and other agencies.

20.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

Nuclear energy development in Pakistan is at very beginning stages.

Two nuclear power plants are now in operation:

1. Karachi Nuclear Power Plant (KANUPP) - 137 MWe heavy water moderated reactor established by the PAEC with Canadian help, became critical in August 1971.

2. Experimental reactor at Pakistan Institute of Science and Technology (PINSTECH) near Islamabad.

PAEC Chairman Munir Ahmed Khan has indicated that Pakistan does not intend to build any additional power plants that would require imported oil or domestic natural gas. The Government of Pakistan is planning to build several more nuclear reactors by 2000. The Chasma Nuclear Power Plant (CHASNUPP) is a proposed 600 MW nuclear plant to be built at Chasma Barrage to feed the northern grid. The reactor type is not yet decided. The Government of Pakistan has also arranged with France to purchase a 100 ton/year reprocessing plant in order to produce their own nuclear fuel. The deal is stymied and the plant may not be built.

20.5.6 NUCLEAR ENERGY R&D - PRIORITIES

The major Pakistan priorities are:

- Increase domestic nuclear technology to decrease dependence on foreign countries.
- Develop uranium resources.
- Construct fabrication plant for KANUPP.
- Acquire a reprocessing facility.

20.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

Pakistan Atomic Energy Commission

Administrative Ministry/Division

Planning Commission
(for circulating schemes for obtaining views of the Ministry of Finance and others concerned)

Central Development Working Party (CDWP)
(for consideration of schemes and projects)

Executive Committee of National Economic Council (ECNEC)
(for final approval of projects and schemes).
The President of Pakistan is Chairman of ECNEC.

After completing the above process, the Administrative Ministry/Division accords a formal sanction for execution of the schemes and projects.

PAEC's relationship to the utilities is that PAEC has constructed and is operating the KANUPP power plant and is selling power to KESC on a contract.

20.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 20.6.1

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Korangi	Karachi	KESC	Hitachi	Gas/Oil	257	O	1965/1969
Guddu I + II	Upper Sind	WAPDA		Thermal (Gas)	220	O	1974
Guddu III	Upper Sind	WAPDA		Thermal (Gas)	200	P	1977
Multan	Northern Sector	WAPDA		Thermal (Gas)	266	O	1960/1963
Multan	Northern Sector	WAPDA		Thermal (Gas)	200	P	1977
Lyallpur	Northern Sector	WAPDA		Thermal (Gas)	141	O	1967
Lyallpur	Northern Sector	WAPDA		Thermal (Gas)	200	P	1975
Mangla 1-4	Northern Sector	WAPDA		Hydro	400	O	1967-69
Mangla 5-6	Northern Sector	WAPDA		Hydro	200	O	1974
Mangla 7-8	Northern Sector	WAPDA		Hydro	200	P	1977
Warsak 1-4	Northern Sector	WAPDA		Hydro	160	O	1960

*O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 20.6.1 (cont.)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Warsak 5+6	Northern Sector	WAPDA		Hydro	80	P	1978
Tarbela	Northern Sector	WAPDA		Hydro	2,100	U	1975/1981
Kalabagh	Northern Sector	WAPDA		Hydro	1,125	P	1985

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 20.6.2

Year	Capacity - MWe(net)
1975	2,854
1980	5,384
1985	7,109
1990	11,500
1995	
2000	18,000

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 20.6.3

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
Sor Range	Baluchistan		Coal Field	1.5	0
Deghari	Baluchistan		Coal Field	1.5	0
Mach	Baluchistan		Coal Field	1.5	0
Sharigh	Baluchistan		Coal Field	1.5	0
Makarwal	Punjab		Coal Field	1.5	0
Salt Range	Punjab		Coal Field	1.5	0
Jhimpir	Sind		Coal Field	1.5	0
Lakhra	Sind		Coal Field	1.5	0
Balkassar	Punjab	OGDC	Oil Field	980	0
Dhulian	Punjab	OGDC	Oil Field	750	0
Joyamair	Punjab	OGDC	Oil Field	440	0
Meyal	Punjab	OGDC	Oil Field	4,500	0
Tut	Punjab	OGDC	Oil Field	2,800	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Coal - million tonnes/year; Oil - barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 20.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
Dhulian	Potwar Basin	Pakistan Oil Fields Ltd.	Gas Field	-	O
Mari	Indus Basin		Gas Field	-	O
Sui	Indus Basin		Gas Field	4.25	O
Zim	Indus Basin		Gas Field		P
Uch	Indus Basin		Gas Field		P
Khand Kot	Indus Basin		Gas Field		P
Mazaroni	Indus Basin		Gas Field		P
Khairpur	Indus Basin		Gas Field		P

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Natural gas - km^3/year

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 20.6.3 (Continued)

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
Sarising	Near Karachi		Gas Field		P

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Natural gas - km^3/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 20.6.4

RESOURCE	1985	2000
COAL (million tonnes)		
Indigenous Supply	2.11	3.10
Imports	.39	5.30
Exports	--	--
CRUDE OIL (million tonnes)		
Indigenous Supply	1.24	1.26
Imports	5.56	10.74
Exports	--	--
SHALE OIL (million tonnes)		
Indigenous Supply	0	0
Imports		
Exports		
NATURAL GAS (cubic kilometers)		
Indigenous Supply	9.43	11.05
Imports	--	10.25
Exports	2.23	--
URANIUM (kilotonnes U_3O_8)		
Indigenous Supply	0	0
Imports	.13	2.0
Exports	0	0

SECTION 21

PHILIPPINES

21.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

INDIGENOUS RESOURCES

Coal resources for the Philippines were unobtainable from the World Energy Conference Survey of 1976 (ref. 1.2). The earlier survey of 1974 (ref. 1.1) was also unable to obtain figures for the economically recoverable amount, but total resource was given as 91.12 million tonnes. Reference 1.28 gives estimates of 36-125 million tonnes, the wide range being due to inadequacy of geological data. The 1975 U. N. Statistical Year Book, N. Y., 1976, lists 211 million tonnes as total coal resources.

No figure for resources of crude oil and shale oil are available.

The total resource on natural gas is given as 0.071 km^3 (refs. 1.2). This is confirmed in reference 1.28, the assessment of which is based upon pilot surveys in Isabela. Natural gas is not included in the Philippine energy plan.

Hydro-power represents approximately 3% of total Asian output and the theoretical capacity is estimated at 19.6 TWh of which 7.6 TWh is economically recoverable.

Four studies to utilize geothermal hot water and steam resources for the generation of electric power are under progress. The first at Tiwi, Luzon, may lead to the installation of 9 units of 700 MW combined capacity. The second at Los Barnos, Luzon, may lead to an installed capacity of 400 MW. Two other studies are in progress for geothermal resources at Tongonan on Leyte Island and on Negros Island, but no details are available.

The government is spurring a nationwide search for recoverable uranium. There are surveys being conducted in the Larap-Paracale district, Camarines Norte. Other areas investigated in 1978 and currently are the Bagacay mines in Samar and the Magna Rosa prospect in the Caramoan peninsula.

ENERGY SUPPLY

A small quantity of coal is produced (0.105 million tonnes, ref. 1.5). No other resource is produced internally.

Oil imports are relatively large at 8.8 million tonnes (ref. 1.5) and have been reasonably constant over the last five years.

PATTERNS OF ENERGY USE

Figures for Table 21.1.3 were supplied by private communication.

Utility electricity distributed quantities are from an extract of information supplied by the Philippines in 1977 for "Electric Power in Asia and the Pacific 1975 and 1976" (ref. 1.50).

FORECASTS OF ENERGY SUPPLY AND DEMAND

The energy and electricity demand forecasts for the Philippines presented in Table 21.1.4 indicate an average annual rate of growth of 4.0% to 7.6% for total primary energy demand and 4.0% to 10.3% for electricity demand.

Forecasts of the growth of energy demand have been prepared by the Energy Development Board of the Philippines (ref. 1.28) and these indicate a total primary energy demand of 836×10^{12} Btu in 1985 increasing to $2,350 \times 10^{12}$ Btu by 2000. Electricity demand forecasts are implied in the forecast of energy requirement of the electricity generating sector and indicate a total electricity demand of 35 TWh in 1985 and 127 TWh in 2000.

The breakdown of energy demand to show the contribution from each source of supply is given in Table 21.1.5. These figures reflect the relative importance of each energy source as indicated in reference 1.28 which provided a breakdown of the EDB forecasts for 1985 and 2000. They show a decline in the relative importance of oil which contributed 88% in 1975, but is expected to contribute only 75% in 1985 and 51% in 2000.

Installed nuclear capacity in 2000 is projected to be 3,000 MW. The first reactor, PNPP-1, is now under construction with a second, similar reactor projected for operation in 1988-1989. There are no official plans yet for later reactors.

Geothermal energy is a major resource in the Philippines and at the moment it is expected that this renewable resource will account for approximately 10% of the total primary energy demand in the year 2000 (ref. 1.28).

It is also planned to develop the use of solar energy to the extent of meeting approximately 8% of total demand in 2000 from this source.

INDIGENOUS ENERGY RESOURCES

Table 21.1.1

	Economically Recoverable Reserves	Total Indigenous Resources	Location of Identified Reserves
Hard Coal (million tonnes)	0	0	
Soft Coal (million tonnes)	Not Available	91.12	Cebu, Malangas in Zomoanga del Sur, Somerara Island in Antigue
Crude Oil (million tonnes)	0	0	
Shale Oil (million tonnes)	0	0	
Natural Gas (cubic km)	Not Available	0.071	Isabela
Uranium (thousand tonnes U_3O_8)	0.4	0.4	Camarines Norte, Samar
Hydro Power (TWh/year)	7.6	19.6	Luzon, Mindanao, Binga
Geothermal (TWh/year)	See Text		Mindanao, Luzon

ENERGY SUPPLY 1975

Table 21.1.2

Resource	Indigenous Supply	Imports		Exports	
		Total	% from US	Total	% to US
Hard Coal (million tonnes)	0	0.023	0	0	0
Soft Coal (million tonnes)	0.105	0	0	0	0
Crude Oil (million tonnes)	0	8.80	0	0	0
Shale Oil (million tonnes)	0	0	0	0	0
Natural Gas (cubic km)	0	0	0	0	0
Uranium (thousand tonnes U_3O_8)	0	0	0	0	0
Electricity (TWh)	12.36	0	0	0	0

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 21.1.3

Resource	Consuming Sector: Household and Commercial	Industrial	Transportation	Electrical Generation	Total
Coal (million tonnes)				0	
Petroleum (million tonnes)	1.19	2.7	3.8	0.88	8.57
Natural Gas (cubic km)	0	0	0	0	
Nuclear Power (TWh)	0	0	0	0	0
Hydro Power (TWh)	0	0	0	3.719	3.719
Geothermal Power (TWh)	0	0	0	0	0
Utility Electricity Distributed (TWh)	4.55	6.16	0	1.58	12.29

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 21.1.4

Year	Low Economic Growth 3.0%		Medium Economic Growth 5.0%		High Economic Growth 7.0%	
	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)
1975	414	12.4	414	12.4	414	12.4
1985	661	16.4	783	22.1	902	29.7
2000	1,104	32.7	1,546	69.0	2,576	143.4

CONSUMPTION OF ENERGY RESOURCES

Table 21.1.5

Resource	Standard Unit	Annual Consumption of Standard Units			Energy Consumption (10^{12} Btu)		
		1975	1985	2000	1975	1985	2000
Coal	Million Tonnes	0.13	1.7	5.7	3.6	47	157
Crude Oil	Million Tonnes	8.64	13.4	19.6	368.3	570	837
Natural Gas	Cubic km	-	-	-	-	-	-
Hydro Power	TWh	3.72	6.2	11.1	42.3	71	126
Geothermal Power	TWh	-	4.8	14.1	-	55	160
Nuclear Power	TWh	-	3.5	23.4	-	40	266
Uranium	Thousand Tonnes U_3O_8	-	0.23	0.65	-	-	-

21.2 NUCLEAR HISTORY, CAPABILITY, COMMITTMENT AND TRENDS

COMMERCIAL NUCLEAR POWER PLANTS

Table 21.2.1

Facility Name	Utility	Vendor	Facility Type	Capacity (MWe net)	Status*	COD
PNPP-1	PNPP	Westinghouse	PWR	626	U	Jul 1983

* O-Operational; U-Under Construction; P-Planned

PROJECTED NUCLEAR GENERATING CAPACITY
MWe (net)

Table 21.2.2

Year	PWR	BWR	Magnox	AGR	CANDU	Other	FBR	Firm + Planned Cumulative Total	NAC Cumulative Projection
pre-1977								0	0
1977								0	0
1978								0	0
1979								0	0
1980								0	0
1981								0	0
1982								0	0
1983								0	0
1984	626							626	626
1985								626	626
1986								626	626
1987								626	626
1988								626	626
1989	626							626	1252
1990								626	1252
1991								626	1252
1992								626	1252
1993	450	450						626	2152
1994								626	2152
1995								626	2152
1996								626	2152
1997	450	450						626	3052
1998								626	3052
1999								626	3052
2000								626	3052

NUCLEAR REACTOR VENDORS

Overview

The Philippines have no indigenous reactor vendors. It is expected that future reactors will be obtained from foreign vendors. It is to be presumed that most future reactors would be imported from the United States.

Nuclear Reactor Vendor Support Industries

There are no major reactor vendor support industries in the Philippines.

NUCLEAR FUEL CYCLE FACILITIES

Overview

At present there are no commercial fuel cycle facilities in the Philippines. The nation has evidenced desire to develop some fuel cycle facilities in the future, and is in fact beginning a modest uranium exploration program. The Philippines note that such facilities would require regional partners, financing, technically trained personnel, and time.

NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

Vested Interests in Current Reactor Technologies and Fuel Cycles

There are no industrial vested interests in any reactor type or fuel cycles. As PNPP-1 operates and further reactor commitments become firm, such interests may develop.

Current Trends in Nuclear Development Programs

The Philippines are just beginning to obtain nuclear technology. A uranium exploration program is just being initiated.

21.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

PROFESSIONAL LABOR FORCE PROFILE

Table 21.3.1

Not Available

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 21.3.2

Institution	Location
Aquinas University	Legazpi City
Araneta University Foundation	Victoneta Park, Rizal
Bicol University	Regan Barracks, Regazpi City
Central Luzon State University	Munez, Nueva, Ecija
Central Philippine University	Iloilo City
De la Salle College	Manila
Divine Word University	Tacloban City
Feati University	Santa Cruz, Manila
Mindanao State University	Marawi City
National University	Sampaloc, Manila
Notre Dame University of Cotabato	Cotabato City
Silliman University	Dumaguete City
Southwestern University	Villaznar, Cebu City
University of Baguio	Baguio City
University of the East	Manila
University of Eastern Philippines	Catarman, Samar
University of Mindanao	Davao City
University of Negros Occidental - Recoletos	Bacolod City

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 21.3.3

Name	Location	Main Activities
Philippine Atomic Energy Commission	Quezon City	sole authority for promotion and regulation of Philippine nuclear activities. Research in areas of: -food supply -energy - U_3O_8 resources - U_3O_8 mine/mill -engineering -medicine -environmental studies -basic research

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 21.3.4

Name	Owner	Location	Main Activities

Not Applicable

RESEARCH AND TEST REACTORS
List of Reactors

Table 21.3.5

Facility Name	Location	Owner	Constructor	Facility Type	Facility Status MW(th)	Status*	COD
PRR-1	Quezon City	PAEC	G.E.	research pool	1	0	1963

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

INDIGENOUS CAPABILITY TO DESIGN AND SUPPLY RESEARCH AND TEST REACTORS AND FUEL SERVICES

Summary of Reactor Orders by Vendor and Country

Table 21.3.6

Vendor	Country	Facility Name	Facility Type	Facility Status MW(th)	Status*	COD	Scope of Services

Not Applicable

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 21.3.7

Facility Name	Location	Facility Type	Capacity Status MT/YR	Status*	Year	Shareholdings

Not Applicable

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

21.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

ECONOMIC DATA PROFILE

Table 21.4.1

GNP (Current million $)	- 20,600 (1977)	Inflation Rate	- 7% (1977)
Exports (million $)	- 3,150 (1977)	Imports (million $)	- 3,914 (1977)
Per Capita Income ($)	- 462 (1977)	Disposable Income ($)	- 333 (1975)
Monetary Unit	- Pesos	Exchange Rate (/US$)	- 7.36 (10/78)
Population (million)	- 45.0 (1977)		

21.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

Pesos (Thousands)

1977	1978 to 1980	1981 to 1986	1987 to 1990	1991 to 2000	Total 1977-2000
11,440	44,980	102,960	161,660	688,100	1,009,140

7.43 Pesos/US Dollar (1976)

Approximately 40% of Philippine Atomic Energy Commission (PAEC) funding is used for R&D, about 24% of the total PAEC expenditures is expected to come from external sources (such as the Energy Development Board and IAEA); all is to be used on R&D.

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 21.4.3

Industry University or Laboratory	Program Area	Budget $ (Millions)	Key Personnel
National University	Training in Nuclear Technology	--	--

The main bodies involved with the implementation of nuclear power studies are:

- PAEC - Philippine Atomic Energy Commission
- NPC - National Power Corporation
- Bureau of Mines
- MERALCO - Manila Electric Company
- Philippine Electric Plant Operators Association
- Philippine Chamber of Industries

21.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

Virtually all nuclear R&D is conducted by the government, specifically PAEC. Private efforts are encouraged only in the development of Philippine uranium resources and production capability.

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 21.4.5

Name	Share Capital	Assets	Sales

Not Applicable

21.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

The foreign investment is expected to come from loans from international financing organizations, while the domestic investment can be met either by outright government contribution or normal utility corporate financing.

PNPP-1 - $534 million loan from U. S. Eximbank and a consortium of commercial banks.

- $367 million bond issue guaranteed by U. S. Eximbank, floated in U. S. capital markets.

21.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

21.5.1 ENERGY POLICY - BASIC LEGISLATION

Commonwealth Act No. 120 (1936) - created the National Power Corporation, nationalized hydroelectric industry.

Republic Act 2067 (1958), amended by Republic Act 3589, and Presidential Decree No. 606 - created by Philippine Atomic Energy Commission (PAEC).

Republic Act 5207 (1968) - guiding policy on development and use of nuclear energy, liability for nuclear damage.

Presidential Decree No. 1200 (1977) - approves "Five-Year Philippine Development Plan, 1978-1982, including the Ten-Year Development Plan, 1978-1987," which includes National Energy Policy.

Presidential Decree No. 1206 (1977) - creates Department of Energy, brought NPC and PAEC into Department of Energy.

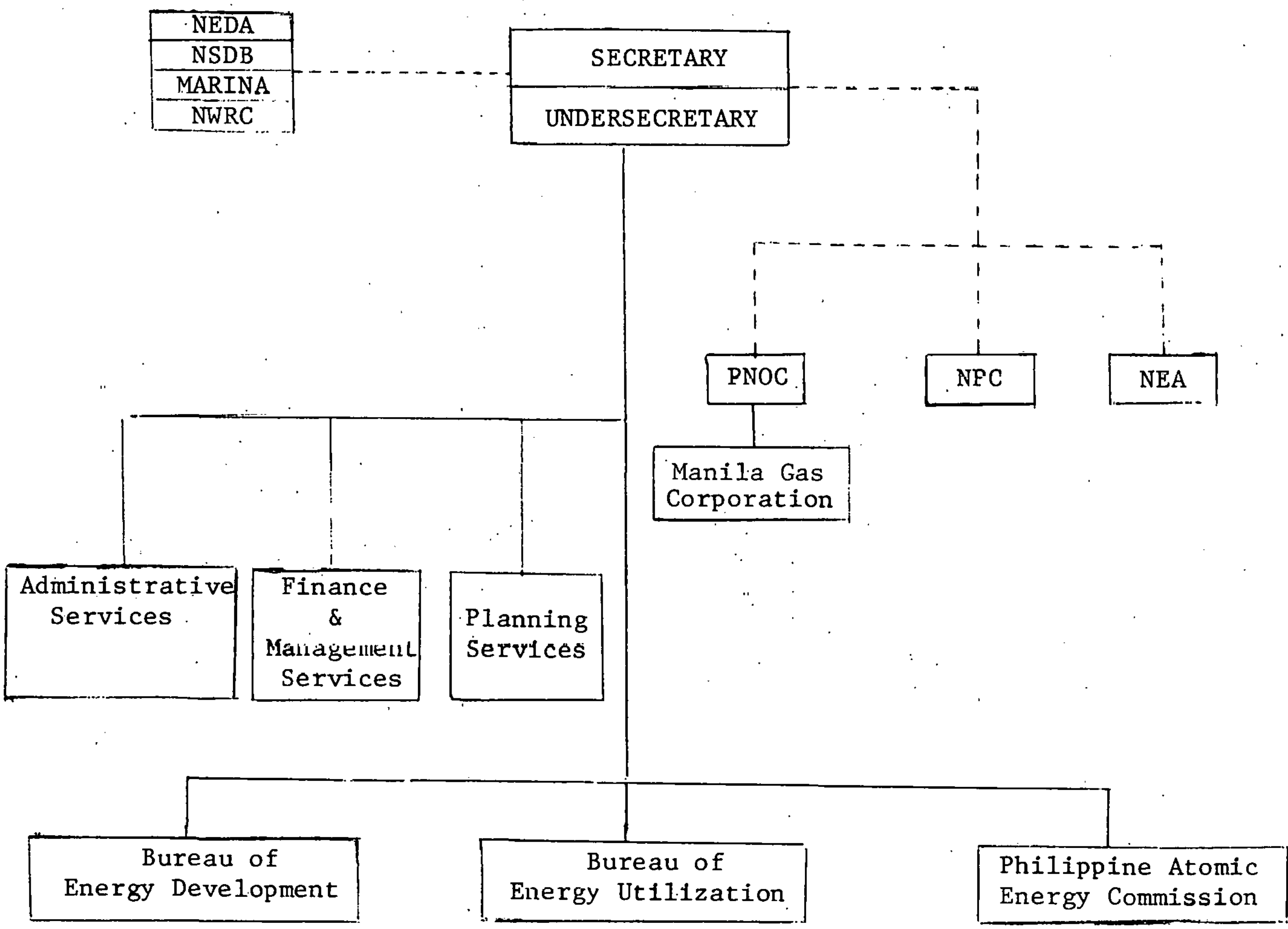
21.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

The government is a parliamentary republic headed by President and Prime Minister Ferdinand E. Marcos. Martial law was imposed by Marcos in 1972, and a new constitution went into effect in 1973. A general election was held in April 1978, and in June 1978, a National Assembly consisting of 200 members was formed. Martial law has remained in effect.

Nuclear Energy Policy and R&D is established and operated within the Department of Energy and specifically by the Philippine Atomic Energy Commission

ORGANIZATIONAL CHART

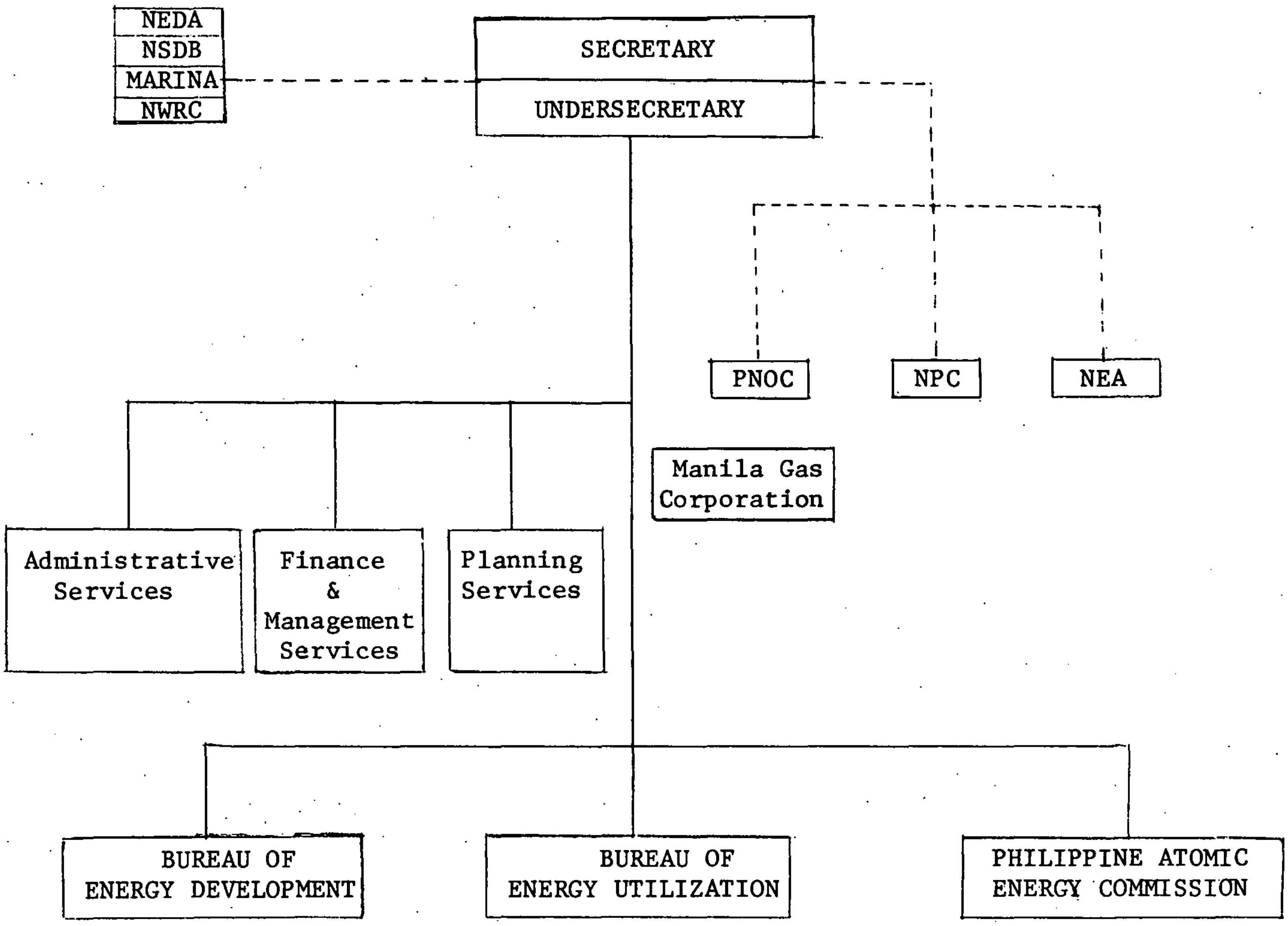
DEPARTMENT OF ENERGY



21.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

ORGANIZATIONAL CHART

DEPARTMENT OF ENERGY



21.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

Nuclear energy policy and objectives are contained within the broad outlines of the National Energy Policy. As discussed at the earlier 1976 Pacific Basic Conference, the Plan calls for installation of up to eleven nuclear units during this century, development of indigenous uranium resources, uranium production capability, and training of needed technical personnel.

21.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

Of the six nuclear R&D sub-programs, only one - Energy and Water Resources - is specifically directed towards nuclear energy. This effort has successfully produced lab scale quantities of U_3O_8 from Philippine ore, and carried out various activities directed towards delineating the indigenous uranium resources. It is expected that these efforts will result in partial indigenous ($\sim$ 300 ST U_3O_8) supply of uranium during the early to mid-1980's.

21.5.6 NUCLEAR ENERGY R&D - PRIORITIES

Established nuclear energy priorities are:

Initiate and undertake R&D using radiation, radioisotopes and nuclear techniques.

Train technical manpower for present and projected nuclear activities.

Establishment of necessary laboratories and pilot plants.

Local manufacture of nuclear instruments.

21.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

Construction - The government provides basic energy planning, financing, regulation, and personal training.

Operation - The government provides regulation (PAEC) and direct operation (NPC).

21.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 21.6.1

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Rockwell 1-5		Meralco		Oil	125	0	1958
Rockwell 6-8		Meralco		Oil	180	0	1963
Tegon 1-2		Meralco		Oil	200	0	1966
Gardnor 1-2		Meralco		Oil	350	0	1970
Snyder 1-2		Meralco		Oil	500	0	1972
Bataem 2		Meralco		Oil	150	0	1977
Binga		Meralco		Hydro	100	0	1960
Angat		Meralco		Hydro	212	0	1968
Montelibano I		Meralco		Oil	300	0	1974
Montelibano II		Meralco		Oil	300	0	1977
Patabanyan		Meralco		Hydro	100	0	1977
Malaya 2		Meralco		Oil	294	U	1979
Kalayaan 1+2		Meralco		Hydro	300	U	1981

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 21.6.1 (Continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Tabu		Meralco		Hydro	400	U	1984
Tiwi 1-4				Geothermal	220	P	1978-1983
Mak-Ban 1-4				Geothermal	220	U	1979-1983
Abulog I 1-4				Hydro	200	P	1985
Abulog I 5-8				Hydro	200	P	1987
Abulog I Geo 9-10				Geothermal	110	P	1985
Abulog I Geo 11-12				Geothermal	110	P	1986
Chico 4				Hydro	300	P	1987
Chico 2				Hydro	360	P	1989
Abulog II				Hydro	300	P	1989
Cebu Diesel 1+2	Visayas Region	Cebu Grid		Oil	140	O-U	1977-79
Cebu Thermal 1+2				Thermal	100	U	1980-83

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 21.6.1 (Continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Sipalay D 1-9		Negros Grid		Oil	162	U	1979-80
Dauin 1+2				Geothermal	110	P	1981-84
Tongonan 1-4		Leyte-Samar Grid		Geothermal	220	P	1981-84
Agus 1	Mindanao Region	Mindanao Grid			100	U	1980
Agus 2	Mindanao Region	Mindanao Grid			180	U	1978
Agus 3	Mindanao Region	Mindanao Grid			150	P	1982
Agus 4	Mindanao Region	Mindanao Grid			50	O	1977
Agus 5	Mindanao Region	Mindanao Grid			150	P	1984
Agus 7	Mindanao Region	Mindanao Grid			45	U	1980
Agus-Diesel Plant 1-6	Mindanao Region	Mindanao Grid			108	U	1978

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 21.6.1 (Continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Agus-Geo-thermal 1+2	Mindanao Region	Mindanao Grid			110	U	1980
Agus - Geo-thermal 3	Mindanao Region	Mindanao Grid			55	P	1985
Agus - Geo-thermal 4	Mindanao Region	Mindanao Grid			55	P	Beyond 1985
Agus - Thermal Plant 1	Mindanao Region	Mindanao Grid			150	P	1982
Pulangui 2	Mindanao Region	Mindanao Grid			250	P	Beyond 1985
Pulangui 3	Mindanao Region	Mindanao Grid			200	P	1985
Pulangui 5	Mindanao Region	Mindanao Grid			40		Beyond 1985

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 21.6.2

Year	Capacity - MWe(net)
1975	3,019
1980	4,769
1985	7,573
1990	9,005
1995	
2000	

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 21.6.3

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
	Mindanao		Coal Field	0.5	0
	Cebu		Coal Field		0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Coal - million tonnes/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 21.6.4

RESOURCE	1985	2000
COAL (million tonnes)		
Indigenous Supply	0.07	0.08
Imports	1.63	5.62
Exports	--	--
CRUDE OIL (million tonnes)		
Indigenous Supply	0	0
Imports	13.4	19.6
Exports	--	--
SHALE OIL (million tonnes)		
Indigenous Supply	0	0
Imports		
Exports		
NATURAL GAS (cubic kilometers)		
Indigenous Supply	0	0
Imports	--	--
Exports	--	--
URANIUM (kilotonnes U_3O_8)		
Indigenous Supply	0	0
Imports	.23	.65
Exports	0	0

SECTION 22

SOUTH AFRICA

22.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

INDIGENOUS RESOURCES

South Africa possesses 75 % of all African coal resources, and these are principally high-ranking. Total resources have increased from the 1969 survey value (ref. 1.1) of 44,339 million tonnes to 82,018 million tonnes (ref. 1.2). The economically recoverable amount is now put at 13,060 million tonnes (ref. 1.2) compared with 10,584 million tonnes (ref. 1.1).

No resources of crude or shale oil have been reported in Ref. 1.1 or 1.2. However, the 1977 World Energy Conference (Ref. 1.8) reported 20.2 million tonnes as reserves.

A small quantity of offshore natural gas has been identified on the continental shelf but no production has taken place and the economically recoverable amount is unknown.

Africa produces less than 0.1 % of world hydro-power output but this is almost exclusively South African. Economically recoverable reserves are put at 2.4 TWh annually and major developments are planned for both the Orange and Tugela Rivers. No data is available for theoretical hydro-power output for South Africa.

South Africa has one of the free-world's larger resources of uranium, 495.3 thousand tonnes. Most is found as a by-product of gold mining.

No geothermal plants have been reported.

ENERGY SUPPLY

Figures for supply, import and export are not generally available.

Export quantities of coal (2.8 million tonnes) were obtained by private communication.

Figures for oil movement are classified though reference 1.5 gives an estimated figure for oil imports.

All uranium produced in 1975 was stockpiled or exported.

PATTERNS OF ENERGY USE

Coal is consumed in all sectors, though its principal use is for electrical generation.

Petroleum is not used for electrical generation (Paper 1.2-14, ref. 1.7).

All sectoral data for Table 22.1.3 come from Paper 1.2-14, reference 1.17, and are for 1972. The figures given cannot therefore be compared directly with those of any other table.

The figures for utility electricity distributed come from reference 1.41 with an allowance for private generation and are for the year 1975.

FORECASTS OF ENERGY SUPPLY AND DEMAND

The primary energy and electricity demand forecasts for South Africa presented in Table 22.1.4 indicate an average demand growth rate from 1976 to 2000 of between 1.5 % and 3.2 % for total energy and 2.4 % to 4.6 % for electricity. During the period 1965 to 1974, economic growth averaged 5.2 % (ref. 1.43) while energy and electricity consumption increased by an average 6.6 % and 8.6 % per year respectively (refs. 1.5 and 1.44).

A forecast of energy demand in South Africa presented at the 1974 World Energy Conference (Paper 1.2-14, ref. 1.7) estimated a total primary energy in 2000 of approximately 4,900 x 10^{12} Btu (total useful energy consumption 1.9 x 10^{18} J and an average conversion efficiency of 37 %). The electricity demand forecast for 2000 was 232 TWh.

The breakdown of energy demand into the various sources of supply presented in Table 22.1.5 shows that the relative contribution of each source of energy remains virtually unchanged throughout the period 1985 to 2000 except for the expansion of nuclear power which slightly reduces the importance of coal. The increase in demand between 1975 and 1985 is met mainly by an increase in oil imports and nuclear power.

INDIGENOUS ENERGY RESOURCES

Table 22.1.1

	Economically Recoverable Reserves	Total Indigenous Resources	Location of Identified Reserves
Hard Coal (million tonnes)	13,060	82,018	Natal, Transvaal, Sasolburg
Soft Coal (million tonnes)	0	0	-
Crude Oil (million tonnes)	0	0	-
Shale Oil (million tonnes)	20.2	Not available	-
Natural Gas (cubic km)	Not available	14	Pattenburg Bay
Uranium (thousand tonnes U_3O_8)	410.4	495.3	East Rand, Orange Free State, Transvaal, Swakopmund
Hydro Power (TWh/year)	2.4	Not available	Orange and Tugela River
Geothermal (TWh/year)	0	0	-

ENERGY SUPPLY 1975

Table 22.1.2

Resource	Indigenous Supply	Imports		Exports	
		Total	% from US	Total	% to US
Hard Coal (million tonnes)	66.05	0	0	2.804	12.13
Soft Coal (million tonnes)	0	0	0	0	0
Crude Oil (million tonnes)	0	12.835*		0	0
Shale Oil (million tonnes)	0	0	0	0	0
Natural Gas (cubic km)	0	0	0	0	0
Uranium (thousand tonnes U_3O_8)	0	0	0	1.72	13.2
Electricity (TWh)	74.3	0	0	0.287	0

* UN Statistical Office estimate

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 22.1.3

Resource	Consuming Sector: Household and Commercial	Industrial	Transportation	Electrical Generation	Total
Coal (million tonnes)	3.77	5.3	4.33	32.7	46.1
Petroleum (million tonnes)	1.25	1.28	5.69	0	8.22
Natural Gas (cubic km)	0	0	0	0	0
Nuclear Power (TWh)	0	0	0	0	0
Hydro Power (TWh)	0	0	0	1.1	1.1
Geothermal Power (TWh)	0	0	0	0	0
Utility Electricity Distributed (TWh)	10.14	28.2	3.3	-	41.64

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 22.1.4

Year	Low Economic Growth 2.0 %		Medium Economic Growth 3.0 %		High Economic Growth 4.0 %	
	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)
1975	2,720	74.3	2,720	74.3	2,720	74.3
1985	3.116	99.3	3,377	110.1	3,656	122.0
2000	3,979	136.0	4,864	176.0	5,935	227.3

CONSUMPTION OF ENERGY RESOURCES

Table 22.1.5

Resource	Standard Unit	Annual Consumption of Standard Units			Energy Consumption (10^{12} BtU)		
		1975	1985	2000	1975	1985	2000
Coal	Million Tonnes	70.9	74.1	87.8	1,963	2,052	2,432
Crude Oil	Million Tonnes	15.0	25.7	42.1	592	1,013	1,663
Natural Gas	Cubic km	4.4	3.9	3.7	153	135	128
Hydro Power	TWh	1.1	3.0	8.5	12	34	97
Other Renewables	TWh	0	0	0	0	0	0
Nuclear Power	TWh	0	12.6	55.5	0	143	632
Uranium	Thousand Tonnes U_3O_8	0	0.34	2.42	-	-	-

22.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

COMMERCIAL NUCLEAR POWER PLANTS

Table 22.2.1

Facility Name	Utility	Vendor	Facility Type	Capacity (MWe net)	Status*	COD
Koeberg-1	Electricity Supply Commission of South Africa	Framatome	PWR	922	U	Jan 1983
Koeberg-2	Electricity Supply Commission of South Africa	Framatome	PWR	922	U	Jan 1984

* O-Operational; U-Under Construction; P-Planned

PROJECTED NUCLEAR GENERATING CAPACITY
MWe (net)

Table 22.2.2

Year	PWR	BWR	Magnox	AGR	CANDU	SGHWR	Other	Firm + Planned Cumulative Total	NAC Cumulative Projection
pre-1978								0	0
1978								0	0
1979								0	0
1980								0	0
1981								0	0
1982								0	0
1983	922							922	922
1984	922							1844	1844
1985								1844	1844
1986								1844	1844
1987								1844	1844
1988								1844	1844
1989								1844	1844
1990								1844	1844
1991								1844	1844
1992	500	500						1844	2844
1993								1844	2844
1994	500	500						1844	3844
1995	500	500						1844	4844
1996	500	500						1844	5844
1997	500	500						1844	6844
1998	500	500						1844	7844
1999	500	500						1844	8844
2000	500	500						1844	9844

NUCLEAR REACTOR VENDORS

Overview

There are no nuclear reactor vendors in South Africa. The purchase of the Koeberg units from France was politically motivated; however, future purchases from international vendors are highly speculative with no current preference.

Nuclear Reactor Vendor Support Industries

Major components for South African reactors are purchased abroad, and no major support industry is currently in place. However, as the nuclear program accelerates, the possibility for domestic support capability increases due to the highly independent economic philosophy in South Africa.

NUCLEAR FUEL CYCLE FACILITIES

Overview

Uranium Production - South Africa has been and remains one of the largest uranium producers in the world. Uranium is produced, for the most part, as a by-product or co-product of gold production. Uranium production peaked in 1959, with 26 mines and 17 mills in operation, producing 6,000 tonnes of uranium per year. Production dropped during the 1960's and early 1970's as a result of the decline in demand and the resulting low prices. In 1976, there were only eight mines in operation with a total production of about 3,000 tonnes. The price increase from 1974-1977 coupled with a generally weak market for gold has renewed activity in uranium recovery. New mills are being constructed and placed into operation, recovery of uranium from tailing dumps is being attempted, and exploration for uranium is being conducted in areas outside of the gold fields.

The extraction process used at the individual uranium mills yields a product in the form of an ammonium diuranate slurry which contains about 20% uranium by weight. The slurry is then processed at a central facility operated by the Nuclear Fuels Corporation of South Africa (NUFCOR), a private company owned by the mining companies. The NUFCOR operation includes blending, filtering, drying, and calcining the ammonium diuranate to produce U_3O_8.

Uranium Enrichment - In 1970, the South African Atomic Energy Board (AEB) announced that it had developed a new uranium enrichment technique. The announcement was received with a great deal of scepticism, but the AEB has continued its development work which, to date, includes the construction of a 6 MTSWU/yr. pilot plant. A government corporation, the Uranium Enrichment Corporation of South Africa (UCOR), has been established and given responsibility for the development and commercialization of uranium enrichment. The pilot plant is located at Valindaba, a site which is adjacent to the AEB's National Nuclear Research Center at Pelindaba.

CURRENT AND PLANNED FACILITIES

Table 22.2.3

Facility Name	Location	Facility Type	MT/YR	Status*	Year	Shareholdings
Vaal Reefs	Klerksdorp Area, Orange Free State	Uranium Production	900**	O		Anglo American Corp. of South Africa
Western Deep Levels	Far West Rand, Transvaal	Uranium Production	160**	O		Anglo American Corp. of South Africa
President Brand	O.F.S. Gold-Field, Orange Free State	Uranium Production	100**	O		Anglo American Corp. of South Africa
Buffelsfontein	Klerksdorp Area, Orange Free State	Uranium Production	560**	O		General Mining and Finance Corp.
West Rand Consolidated	West Rand, Transvaal	Uranium Production	230**	O		General Mining and Finance Corp.
Blyvoorintzicht	Far West Rand, Transvaal	Uranium Production	150**	O		Rand mines
Harmony	O.F.S. Gold-Field, Orange Free State	Uranium Production	450**	O		Rand mines
Hartebeestfontein	Klerksdorp Area, Orange Free State	Uranium Production	370**	O		Anglo-Transvaal Consolidated Investments Co.
West Driefontein	Far West Rand, Transvaal	Uranium Production	300**	O		Gold Fields of South Africa
NUFCOR	Suurbekom	Uranium Processing	6,000	O	1952	Held by South African mining companies
UCOR	Valindaba	Uranium Enrichment	6 MTSWU	O	1976	South African Government

* O-Operational; U-Under Construction; P-Planned
** Estimated from recent production figures

CURRENT AND PLANNED FACILITIES

Table 22.2.3 (cont.)

Facility Name	Location	Facility Type	MT/YR	Status*	Year	Shareholdings
Palabora	Phalaborwa, Transvaal	Uranium recovery from copper	200	O	1971	Rio-Tinto Zinc Corp.
East Rand Gold and Uranium Co. (ERGO)	East Witwatererand	Uranium Production	154	O	1978	Anglo American Corp. of South Africa
Randfontein	West Rand, Transvaal	Uranium Production	670	O	1978	Johannesburg Consolidated Investment Co.
Beisa Mines	Orange Free State		150	P	1982	Union Corp.

* O-Operational; U-Under Construction; P-Planned

Facilities: Gold/Uranium Mining

Description of Operation

Virtually all of South Africa's uranium is produced as a by-product or co-product of gold production (99.7 % of the total uranium produced to date has been in conjunction with gold mining operations, with the remaining 0.3% produced as a by-product of copper mining operations at Palabora).

The gold/uranium mining operations are massive; a typical mine employs 10,000-20,000 miners and operates around the clock, 365 days a year. All mines are underground, with shafts going as deep as two miles. The larger mines move more than 20,000 tons of ore and waste each day. The gold and uranium are found together in the Witwatersrand gold reefs in thin beds within a body of quartzite and shale. The uranium is mostly in the form of microscopic grains of uranimite. Both the gold and uranium are exposed by fine milling the ore. In the recovery operation, the gold is extracted first by treatment with cyanide. The residues go to a separate plant where uranium is extracted by sulfuric acid. To separate the uranium a solvent extraction process, known as the Purlex process, is used. The product from this recovery step is ammonium diuranate, or ADU. The ADU from the individual mills is transferred to a central processing plant in a ADU/water slurry. The central processing plant is operated by the Nuclear Fuels Corporation, or NUFCOR, which is owned by the mining companies. NUFCOR receives the slurries, blends them together to assure the contigency of the final product, filters and dries the ADU, then reduces the ADU to U_3O_8 in a coloring process.

Below is a discussion of the individual mining companies which are currently producing or may be producing uranium in the near future.

Africander Lease

A total of 495 ST U_3O_8 were produced from 1954 to 1961, at which time uranium production ceased although gold production continued until 1964. Currently, 9500 acres of mineral rights are held and drilling has indicated the existence of a potentially economic deposit. It is possible that the mine could re-open utilizing the original shafts and operating at a level of 0.55 - 1.1 million ST of ore per year by 1980. If new shafts are sunk, production before 1983 would be unlikely. The decision to reopen the mine will be based on results of the pilot plant tests and the probability of obtaining suitable contracts. A feasibility study is being conducted based on a uranium-only mill with a capacity of 630 MTU/year.

Buffelsfontein

The company is one of the larger uranium producers in South Africa. Approximately 5.5 million ST of uraniferous slimes have been accumulated and are ready for processing. Reserves are estimated to average 0.72 lb U_3O_8/ST ore. Estimated mine life is 16 years. Much of Buffelsfontein's future output is committed to contracts signed several years ago when lower prices prevailed. During 1976, modifications were made to the uranium plant and a new process introduced to improve the level of uranium recovery. Reserves at the Buffelsfontein mines are estimated to be on the order of 6.44 million tons.

Free State

The company has an entitlement to use the President Brand uranium plant which was put into operation in 1977. Production is expected to increase from the current level of 1.2 million ST ore/year to 2.6 million ST by 1981. Mine life is estimated to be 16 years. Uranium grades recovered are likely to be about 0.30 lb/ST.

Harmony

In 1974, the operations of Harmony, Virginia Gold Mining Co. Ltd., and Merriespruit Gold Mining Co. Ltd. were consolidated. Over the last three years, Harmony has processed over 50% of the total ore milled by the group. A stockpile of uraniferous slimes totaling 15.4 million tons has been accumulated and is ready for treatment. Mine life is estimated at 24 years and production is being increased from 5.7 million to 7.8 million tons per year by the end of 1977. This increase is being accomplished by the operation of an extension to the Virginia plant from a capacity of 130,000 tons/month to 160,000 tons/month. The expanded plant became operational in April 1977. Ore reserves are estimated at 17,445,000 tons of which 15,040,000 tons are available for mining at an average uranium value of 0.42 lb/ST. Uranium production since 1955 has totaled 12,520 ST U_3O_8 for the group. The Merriespruit uranium plant is expected to come on-line by mid-1980. When fully operational, the plant will increase the mine's U_3O_8 output by 16,500 ST/month.

Hartebeesfontein

A mine life of 19 years has been estimated. The mill rate is expected to rise eventually to 3.4 million tons/year. A stockpile of 4.1 million ST of uranium slimes is held by the company with an estimated value of 0.44 lb/ST.

The company has a three-year contract for the supply of uranium oxide which includes arrangements for a loan to the company. Recently, a long term contract has been signed which provides for a loan from the buyer for expansion. Capacity will be expanded from the current 275,000 ST/month to 325,000 ST/month by 1980.

Randfontein

Formerly one of the largest uranium producers in South Africa, the company is opening a new Cooke mining section and production has been increased to 1.9 million ST/year U_3O_8. Randfontein has among the highest uranium reserves and ore grades for South Africa. Total ore reserves at the three Cooke shaft areas are estimated to be 72 million ST of ore averaging from 0.44 lb/ST to 1.00 lb/ST. The Millsite uranium recovery plant (110,000 ST/month capacity) was commissioned in August 1977 and will treat ore from the Cooke No. 1 and the new Cooke No. 2 shafts. Shaft sinking at the Cooke No. 3 area is planned as a second part of the expansion program, along with the commissioning of the 275,000 ST/month Cooke recovery plant. A total production of 880-990 ST/year is anticipated. Randfontein has a 10-year contract with the French CEA which includes the funding of capital expenditures by the CEA. The production target for 1979 is 760 MTU/year with an eventual expansion to 1015 MTU/year. Full production is expected in early 1979.

Southvaal

Uranium reserves are reported to be large and rich, estimated at 110 million tons of ore. Mining was increased from a level of 1.65 million ST per year to 2.4 million ST at the end of 1976 and is slated to rise to 4.4 million by 1984, with further increases later. A uranium plant is to be installed in the near future for the production of uranium oxide.

Vaal Reefs

Vaal Reefs has the potential to become the largest uranium producer in South Africa. Vaal Reefs' own plant, along with its Western Reefs uranium mill has produced more U_3O_8 than any other mining company in South Africa. An accumulation of 20.2 million ST of uraniferous slimes will necessitate increased uranium capacity to handle the stockpile. Production is increasing from the current 1.65 million ST/yr. to 2.4 million by the end of 1977 and 4.4 million by 1984. This increase is due to an increase in capacity from 370,000 ST/month to 790,000 ST/month with the construction of a new

230,000 ST/month uranium plant at Vaal Reefs South. A long-term contract was signed in 1976 which is providing the front-end money for the production expansion. The annual capacity will be increased by 770 ST U_3O_8/year to 2050 ST U_3O_8/year by mid-1980. The expansion will allow treatment of current mine production, as well as uraniferous slimes.

West Rand

The uranium reserves are estimated at 1.54 million ST of uranium at 1.61 lb/ST. West Rand switched back to primarily producing gold following the sharp increase in gold prices in 1974. Uranium production was resumed in January 1976. Since operations began in 1952, the company has been the largest single producer of uranium in South Africa, although the combined output of Vaal Reefs and Western Reefs has been greater. A large stockpile of yellowcake is in the company's possession, but the material is already committed to contracts at relatively low prices. The mine currently produces ore with a grade of about 0.61 lb/ST and the plant is producing about 50,000 ST/month. Recently, West Rand increased its reserves by purchasing an adjoining inoperable mine from Luipaardsuiei Estates.

Bylvooruitzicht

Due to the favorable uranium market conditions, the company made a decision in 1975 to increase uranium production capacity. An expanded plant for the recovery of uranium was completed in July 1977 and is now in operation. The capacity of the new plant is 110,000 ST/month up from the previous figure of 60,000 ST/month for the existing facility. The additional uranium will be derived from the treatment of previously untreated gold tailings from slime dams. Ore reserves are estimated at 3,834,000 tons of ore at a value of 0.51 lb/ST uranium.

Beisa Mines

A new uranium-gold mine will be developed south of Welkom. It will be the first large scale uranium mine developed by a South African company with gold as a byproduct. A plant with a capacity of 110,000 ST/month is planned for operation in late 1982.

President Brand Consortium

President Brand built a uranium plant in 1971 which has a capacity of 2.4 million ST a year. Plant commissioning was delayed at the time due to unfavorable market conditions. The uranium plant was placed in operation in late 1976, and a recent contract will help finance further production expansions, which include a 30,000 ton/month expansion to the uranium plant. Free State Saaiplass, Welkom, President Steyn, Free State Geduld, Freddies Consolidated and Western Holdings will also use the plant. President Brand has 4.4 million ST, Free State Saaiplass 8.5 million ST and Welkom 4.4 million ST of accumulated slimes. The uranium plant will be used to treat both current residues and reclaimed slimes. An expansion to the existing leaching plant is due to be completed in late 1979.

Western Deep Levels

An extension to the existing plant is being added which will process an additional 220,000 ST/month to produce about 190 ST U_3O_8/year. The addition will process the remaining current tailings and reclaimed slimes. Production from the expansion will start in the second half of 1981.

Stillfontein

A new uranium plant is to be jointly built by Stillfontein and Buffelsfontein. The new facility will be sited at Stillfontein and, will have a capacity of 3.24 million tonnes/year of tailings. Operation is scheduled for 1980. About 85% of output attributed to Stillfontein.

West Driefontein

Underground uranium production and grade has declined over the last few years. Reduced production from underground activities has been supplemented with reclamation from the surface tailings dam on which uranium slime was stored. This required significant capital expenditures for the completion of extensions to the existing plant as well as providing facilities to pump the slime from the storage dam to the plant.

Palabora

The uranium recovery plant began operations in 1971. Current capacity is 125 ST U_3O_8/year with an expansion effective in 1979 to raise capacity to 260 ST U_3O_8/year. Reserves are estimated at 28,000,000 lbs. U_3O_8. Production is marketed by Rio Tinto.

East Rand Gold and Uranium Co.

The plant for treatment of slimes began trial runs in early 1978. Full production of 200 ST U_3O_8/year is expected in 1979. Uranium diuranate is the end product which is shipped to NUFCOR's processing plant. Reserves are estimated at 8,000,000 lbs. U_3O_8.

Capacity, Capacity Limiting Factors, Expansion Plans and New Facilities

The uranium production capacity of the individual mining companies will vary depending on the tonnage of ore processed and the grade of the ore. Each of the different mines have ores with different concentrations of uranium, and even at an individual mine, the grade can vary considerably. The grade of the ore processed is also influenced by the price of gold. At higher gold prices, the mines can process ores with lower concentrations of gold. Since uranium grades usually follow gold grades, higher gold prices generally mean lower production rates for uranium. In the past, this trend was more common, but with the high prices of uranium and relatively low prices of gold in the last 2-3 years, recovery of uranium has become more important. In a few mines, in fact, uranium production has made a greater contribution to profits than gold, an occurrence which will tend to stabilize uranium productions even with fluctations in gold prices.

In response to the higher uranium prices, several uranium mining companies have begun construction or announced plans for expansions or additions of new facilities. President Brand began operations in 1977 of a uranium plant that was constructed in 1971, but was not started at that time because of unfavorable price levels. In early 1977, Vaal Reefs announced the sale of uranium which included front money payments to expand its uranium production capacity. Randfontein has constructed a new gold and uranium plant and refurbished an old uranium plant. Blyvooruitzicht completed an expansion program in 1977. Harmony Gold Mine began an expansion program to its existing plant and announced plans to build a new plant. In addition, Anglo American Corp. has started a project to recover gold, sulphuric acid, and uranium from old slime dams.

Past and Present Marketing Strategy

NUFCOR now acts as the marketing agent for the individual mining companies. Contracts, however, are directly between the customer and the mining companies. The most recent contracts of this type typically involve front money to finance the construction of new production capacity. In early 1977, Vaal Reefs announced that it had sold uranium for delivery in the 1980's which included $69 million in front money to expand production. Randfontein reportedly will receive over $100 million in a similar arrangement, and President Brand announced a deal including about $40 million to expand its capacity. About half of all contracts in which NUFCOR has been involved are directly between the customer and the mining companies. All future contracts will be of this type.

Production History

Detailed production histories for each gold/uranium mine are not readily available. However, total historical production on a country basis is presented later under the discussion of NUFCOR which processes virtually all of the uranium for the South African mines.

Projection of Future Marketing Characteristics

The direct involvement of the mining companies in uranium sales and the arrangements for front money are departures from the previous marketing methods. It seems apparent that the mining companies have responded to the changes in the market and have taken full advantage of their leverage in the current sellers' market. It is likely that the mining companies will continue to look for front money as long as the market will bear it.

Facility: Nuclear Fuels Corporation of South Africa (NUFCOR)

Description of Operation

Nuclear Fuels Corporation of South Africa (NUFCOR) is a private company owned by South African gold/uranium mining companies. NUFCOR processes and markets the uranium produced as a by-product or co-product of the gold mining operations in South Africa. NUFCOR also coordinates research and development in the mining and processing of uranium, including the construction of a pilot plant for the conversion of U_3O_8 to UF_6. In its processing operation, NUFCOR receives uranium from the individual mine/mills in the form of an ammonium diuranate (ADU) slurry and processes the ADU to high purity U_3O_8 through a series of steps including blending, filtering, drying and calcining.

Capacity, Capacity Limiting Factors, Expansion Plans and New Facilities

NUFCOR's capacity is 7,800 ST U_3O_8/yr, although recent production has been around 4,400 ST U_3O_8/year. Production has been significantly below capacity since the late 1950's and early 1960's, which was the only time NUFCOR operated at full capacity. With the recent price increases and resulting expansions in the extraction plants of the individual mining companies, the processing load at NUFCOR will increase each year. However, with its large capacity NUFCOR will not need to expand before the mid-1980's, if at all.

Past and Present Marketing Strategy

Uranium production in South Africa began in 1952, and until the mid-1960's all production was sold to the Combined Development Agency, CDA, of the United States and United Kingdom. As the CDA cut back on its purchases in the 1960's, the only other market was the small but promising commercial power reactor market. NUFCOR served as the marketing agent for all uranium produced by the mining companies. Marketing in the late 1960's and early 1970's was difficult because of the abundance of suppliers (created as a result of the CDA's demand) and the scarcity of customers. NUFCOR was able to survive this period by a combination of factors: NUFCOR was a proven, reliable supplier with a high quality product; South African uranium prices could be held low since all production came as a by-product of gold operations; and NUFCOR participated in an organization with other major suppliers that attempted to stabilize the market by allocating market shares among the various suppliers.

Market Share Attained: NUFCOR

Table 22.2.4
($ST\ U_3O_8$)

Region: Domestic (S. Africa)

Year	NUFCOR Deliveries to S. Africa	Total Deliveries to S. Africa	Total S. Africa Requirements	Total S. Africa Uncommitted	NUFCOR Market Share of Committed Deliveries, %
pre-1978	0	0	0	0	0.0
1978	0	0	0	0	0.0
1979	0	0	0	0	0.0
1980	0	0	418	418	0.0
1981	0	0	418	418	0.0
1982	0	0	0	0	0.0
1983	0	0	189	189	0.0
1984	0	0	375	375	0.0
1985	0	0	372	372	0.0
1986	0	0	372	372	0.0
1987	0	0	372	372	0.0
1988	0	0	372	372	0.0
1989	0	0	372	372	0.0
1990	0	0	878	878	0.0

Market Share Attained: NUFCOR

Table 22.2.5 (cont.)

(ST U_3O_8)

Region: International (Non-S. Africa, non-US)

Year	NUFCOR Deliveries	Total Deliveries	Requirements	Uncommitted	NUFCOR Market Share of Committed Deliveries, %
pre-1978	12360	139899	102393	0	8.8
1978	3707	31155	20426	1913	11.9
1979	3655	29946	24827	3052	12.1
1980	3853	31563	26503	3163	12.1
1981	3858	34098	28903	2648	11.3
1982	4659	34918	30337	2834	13.3
1983	4974	36223	36792	4944	13.7
1984	4750	38585	40628	8816	12.3
1985	4183	37023	46585	13338	11.3
1986	3734	33425	52871	21103	11.2
1987	3539	32237	54842	23535	11.0
1988	2249	32645	64498	33647	6.9
1989	2249	30317	65703	33907	7.4
1990	2249	31172	76479	42697	7.2

Recent Production History

Year	MTU
1972	3070
1973	2617
1974	2600
1975	2377
1976	2707
1977	3396

Projection of Future Marketing Characteristics

NUFCOR has committed most of its output through the mid-1980's, so its marketing efforts will be limited in the near future. Recently NUFCOR has assisted some of the individual mining companies in their negotiations involving front money payments to finance new construction (see the section entitled "South African Gold/Uranium Mining Companies"). Marketing in the late 1980's may be linked to UCOR's marketing efforts (see the section entitled "Uranium Enrichment Corporation of South Africa").

Facility: Uranium Enrichment Corporation of South Africa (UCOR)

Description of Operation

The Uranium Enrichment Corporation of South Africa (UCOR) is a government corporation responsible for the research and development of uranium enrichment technology. UCOR has completed the construction of a pilot enrichment plant at Valindaba to demonstrate its technique on an industrial scale. The experience gained in the construction and operation of the pilot plant will provide technical foundation for the design and construction of a commercial size facility. The pilot facility is being converted into a small commercial operation. The UCOR enrichment process is an aerodynamic type, similar to the jet nozzle technique and uses UF_6 in hydrogen as the process fluid.

Capacity, Capacity Limiting Factors, Expansion Plans and New Facilities

The rated capacity of the UCOR pilot plant is 6 MTSWU/yr. The next stage in South Africa's development program is to construct a commercial scale facility. It is generally felt that the smallest economical size of an enrichment plant using the UCOR process would be 5,000 MTSWU/yr. However, given the clear world oversupply of SWU, considerable delay can be expected. Even the announced smaller plant ($\sim$ 250 MTSWU/year for S. African use) may be questionable.

Past and Present Marketing Strategy

Although they have not begun organized marketing efforts, UCOR representatives have stated that they are prepared to discuss supply arrangements with interested utilities. However, at this time, it is not likely that UCOR has a formal contract document or would be in a position to make a firm supply commitment.

Projection of Future Marketing Characteristics

UCOR's future marketing strategy is very simple; if someone wishes to purchase South African uranium, he must purchase it in the enriched form. It is believed that all new uranium supply contracts have a clause stipulating that if South African enrichment capability does exist, then uranium to be delivered after 1986 will be delivered as enriched UF_6.

NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

Vested Interest in Current Fuel Cycles and Reactor Technologies

South Africa has a vested interest in the enriched uranium fuel cycle (and therefore in light water reactor technology) because of the commitment by the South African government to develop commercial uranium enrichment capacity. South Africa is the only country in the world that is constructing enrichment capacity primarily for export, rather than assurance of supply for domestic reactors (although both Canada and Australia have conducted feasibility studies for developing enrichment capacity for the export market). South Africa's investment in its pilot enrichment plant is significant for a country its size and the investment in a commercial size plant will be far greater. A major shift in preference for fuel cycles such as the natural uranium fuel cycle in the Candu-type reactor or the natural uranium plutonium fuel cycle of the fast breeder reactor (such a shift could occur concurrently with the construction schedule of South Africa's commercial enrichment plant), would reduce the export market (since all light water reactors currently planned already have enrichment services contracts), and could have a very adverse effect on the government's financial position. Thus, South Africa has a strong vested interest in the continued acceptance and growth of reactor technologies that are based on enriched uranium fuel cycles.

Current Trends in Nuclear Development Programs

There are two contrasting trends in the South African government's nuclear development programs. In its power reactor program, the government (through the state-owned Electric Supply Commission, or ESCOM) has chosen a conservative route, purchasing proven reactor technology from an established foreign supplier. On the other hand, in its fuel cycle development programs, the government (through the Atomic Energy Board, AEB) has exhibited a very independent nature, embarking on an aggressive enrichment development program without any significant outside assistance. In fact, the program has been viewed with great skepticism outside of South Africa, with many experts questioning the technical and economic feasibility of the project. Criticism of the project, however, seems only to have increased the resolve of the South African government to prove it can be successful. It appears that this contrast will continue into the foreseeable future. ESCOM, when it adds new plants to its system, will look to experienced foreign suppliers, while another arm of the government, the AEB, will continue on its path to commercialize a novel enrichment technique.

22.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

PROFESSIONAL LABOR FORCE PROFILE

Table 22.3.1

Not Available

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 22.3.2

Institution	Location
University of Cape Town	Rondebosch
University of Pretoria	Hillcrest, Pretoria
University of Stellenbosch	Stellenbosch
University of the Witwaterstrand	Johannesburg
Potchefstroom University	Potchefstroom

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 22.3.3

Name	Location	Main Activities
National Nuclear Research Center	Pelindaba, near Pretoria	minerals prospecting and mining; mineral investigating; reactor and reactor fuel development; radiation and health physics; radioisotope production and application; basic and applied production; peaceful application of nuclear explosions; reactor safety and operation.
--	Vanindaba	pilot-scale uranium enrichment
--	Pelindaba	uranium metal and compounds for fuel
Southern Universities Institute	Faure, near Cape Town	basic nuclear research

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 22.3.4

Name	Owner	Location	Main Activities

Not Applicable

RESEARCH AND TEST REACTORS
List of Reactors

Table 22.3.5

Facility Name	Location	Owner	Constructor	Facility Type	Facility Status		
					MW(th)	Status*	COD
SAFARI-1	Pelindaba	NNRC	Allis Chalmers	ORR-tank 90% U^{235}	20	0	1965
Pelinduna Zero	Pelindaba	S. African Atomic Energy Board	S. African Atomic Energy Board	Critical exper.	0	0	1967

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

INDIGENOUS CAPABILITY TO DESIGN AND SUPPLY RESEARCH AND TEST REACTORS AND FUEL SERVICES

Summary of Reactor Orders by Vendor and Country

Table 22.3.6

Vendor	Country	Facility Name	Facility Type	Facility Status			Scope of Services
				MW(th)	Status*	COD	

Not Applicable

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 22.3.7

Facility Name	Location	Facility Type	Capacity Status MT/YR	Status*	Year	Shareholdings

None known, however, the SAAEB did complete a pilot plant to produce nuclear-grade uranium metal and compounds suitable for nuclear fuels in 1961.

It has been stated that the pilot enrichment plant can produce fuel suitable for the SAFARI-1 research reactor.

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

22.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

ECONOMIC DATA PROFILE

Table 22.4.1

GNP (Current million $)	- 37,189 (1977)	Inflation Rate	- 12.5% (1977)
Exports (million $)	- 7,282*(1977)	Imports (million $)	- 7,926 (1977)
Per Capita Income ($)	- 1,391*(1977)	Disposable Income ($)	- 1,178 (1975)
Monetary Unit	- South African Rand	Exchange Rate (/US$)	- 1.15 (1977)
Population (million)	- 26.1 (1976)		

* excluding gold. 1977 export value of gold output: $3,214 (million)

22.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

South African Atomic Energy Board (FY74) - $10.9 million

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 22.4.3

Industry University or Laboratory	Program Area	Budget $ (Millions)	Key Personnel
University of Stellenbosch	radioisotopes in plant biology, neutron meters for soil moisture	--	--
University of Pretoria	--	--	--
University General Hospital	irradiation of circulating blood	--	--
University of Capetown	nuclear medicine	--	--
South Africa Institute for Medical Research	nuclear physics training	--	--
Veterinary Station and School	metabolic disease	--	--
University of Witwatersrand	basic research	--	--

22.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

Not Applicable

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 22.4.5

Name	Share Capital	Assets	Sales
	Not Applicable		

22.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

The Koeberg reactors are supplied by Framatome. The billion-dollar contract went 40% to Framatome, 40% to Alsthom and 20% to Spie-Batignolles. Financing is supervised by the French bank Credit Lyonnais and guaranteed by CIE Francaise d' Assurance pour le Commerce Exterieur (COFACE), a government agency.

22.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

22.5.1 ENERGY POLICY - BASIC LEGISLATION

1. South African Atomic Energy Board (SAAEB) established in 1949.
2. Indigenous research and development nuclear program begin in 1957.
3. Act No. 90 of 1967 imposes severe sanctions on anyone guilty of publishing material relating to the prospecting, production, and pricing of uranium.
4. Third 5-year SAAEB program initiated in 1969.
5. Government passed a law stipulating that any application for a uranium enrichment patent by any company or organization other than South African Atomic Energy Board will be illegal.

22.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

Council for Scientific and Industrial Research - overall national program of scientific research.

South African Atomic Energy Board:

- Conducts the South African Atomic Energy Program
- Assisted by 10 technical and advisory committees
- Activities conducted under 5-year plan

22.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

South African Atomic Energy Board is the major force in implementing nuclear energy policy and R&D.

22.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

The specific nuclear energy policy is unknown, however, it can be inferred that nuclear power is to be used to further South Africa's policy of reducing dependence on foreign energy sources (chiefly, oil). Towards that end, objectives of the program are:

- minerals prospecting and mining
- extraction and sale of uranium
- development of uranium enriching capability
- reactor and reactor fuel development
- radiation and health physics
- radioisotope application and production

22.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

The most pertinent area of South African Nuclear Energy R&D is enrichment. In this area, the pilot plant at Vanindaba is operational, and in early 1978, it was announced that a commercial facility (200-300 MTSWU/year) would be constructed. This facility would be directed towards indigenous needs; participation in the world enrichment market is possible at a later date.

22.5.6 NUCLEAR ENERGY R&D - PRIORITIES

To further the fundamental objective of lessening dependence on foreign energy sources (or control), priorities are believed to be:

1. Enrichment
2. Uranium mining and milling technology

22.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

ESCOM (Electricity Supply Commission, a government agency) planned, negotiated for, and will operate the two commercial nuclear power plants - Koeberg I & II. The government will provide regulatory requirements.

22.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 22.6.1

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Arnot	Transvaal + OFS	Escom		Coal	1,980	O	
Hendrina	Transvaal + OFS	Escom		Coal	1,710	O	
Camden	Transvaal + OFS	Escom		Coal	1,520	O	
Grootvlei	Transvaal + OFS	Escom		Coal	1,150	O	1977
Komati	Transvaal + OFS	Escom		Coal	925	O	
Kriel	Transvaal + OFS	Escom		Coal	2,500	O/U	1976/1977
Highveld	Transvaal + OFS	Escom		Coal	440	O	
Taaibos	Transvaal + OFS	Escom		Coal	440	O	
Klip	Transvaal + OFS	Escom		Coal	372	O	
Vierfontein	Transvaal + OFS	Escom		Coal	336	O	
Vaal	Transvaal + OFS	Escom		Coal	282	O	
Wilge	Transvaal + OFS	Escom		Coal	221	O	
Ingagane	Natal	Escom		Coal	465	O	
Umgeni	Natal	Escom		Coal	222	O	

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 22.6.1 (Continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
West Bank 1+2	Eastern Cape	Escom		Coal	101	O	
Salt River 1+2	Western Cape	Escom		Coal	285	O	
Hex River	Western Cape	Escom		Coal	114	O	
Port Rex	Eastern Cape	Escom		Gas Turbine (Oil)	171	O	1976
Acacia	Western Cape	Escom		Gas Turbine (Oil)	171	O	1976
Hendrik Verwoerd	Orange River	Escom		Hydro	320	O	1976 (Sets 1+2)
Matla	Transvaal +OFS	Escom		Coal	3,600	U	1979 onwards
Duvha	Transvaal +OFS	Escom		Coal	3,600	U	1979 onwards
Vanderkloof	Orange River (PK le Roux Dam)	Escom		Hydro	220	O	1977
Drakensberg	Natal	Escom		Hydro (PS)	1,000	U	1980-81
Elandsberg	SW Cape	Escom		Hydro (PS)	1,000	P	Late 1980s

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 22.6.2

Year	Capacity - MWe(net)
1975	14,154
1980	24,474
1985	27,318
1990	
1995	
2000	

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 22.6.3

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
	Transvaal		Coal Field	51.5	O
	Orange Free State		Coal Field	12.4	O
	Natal		Coal Field (Bituminous)	9.3	O
	Natal		Coal Field (Anthracite)	2.2	O

* O-Operational; U-Under Construction; P-Planned; S-Shutdown
** Coal- Millicn tonnes/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 22.6.4

RESOURCE	1985	2000
COAL (million tonnes)		
Indigenous Supply	119	233
Imports	--	--
Exports	44.9	145.2
CRUDE OIL (million tonnes)		
Indigenous Supply	0	0
Imports	25.7	42.1
Exports	--	--
SHALE OIL (million tonnes)		
Indigenous Supply	0	0
Imports		
Exports		
NATURAL GAS (cubic kilometers)		
Indigenous Supply	0	0
Imports	3.9	3.7
Exports	--	--
URANIUM (kilotonnes U_3O_8)		
Indigenous Supply	14.7	15.4
Imports	0	0
Exports	14.4	13.0

SECTION 23

SOUTH KOREA

23.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

INDIGENOUS RESOURCES

South Korea has significant resources of coal and these are predominantly high ranking. Total resources are estimated at 1,434 million tonnes of which 327 million tonnes are economically recoverable (ref. 1.2). The latter figure has been reduced from that of 544 million tonnes stated in reference 1.1. The total resource figure is given as 1,450 million tonnes in reference 1.25 and can thus be considered firm.

No resources of crude oil, shale oil or natural gas have been reported.

A small amount of hydro-power is available. Generation (as at 1975) was 1.7 TWh with a further 2.3 TWh under construction or planned. The total theoretical capacity is estimated at approximately twice this amount, i.e. 7.7 TWh.

South Korea has only very small indigenous uranium resources.

ENERGY SUPPLY

Production of hard coal stood at 16.785 million tonnes (Paper XXVI, ref. 1.23). Reference 1.5 gives a value of 17.59 million tonnes and reference 1.2, 15.2 million tonnes for 1974. Reference 1.5 notes a very small amount of imports, one-third from the United States.

All crude oil is imported. The quantity in 1975 was put at 15.972 million tonnes (ref. 1.5). Reference 1.23, Paper XXVI gives imports of crude oil as 14.14 million tonnes in 1973.

No nuclear power was used in 1975.

PATTERNS OF ENERGY USE

The figures given in Table 23.1.3 were supplied by private communication.

FORECASTS OF ENERGY SUPPLY AND DEMAND

The total primary energy demand in South Korea increased at an average annual rate of 11.2% between 1965 and 1974 (refs. 1.5 and 1.44) while economic growth average 10.5% (ref. 1.43). In the same period, electricity demand increased by an average 19.8% per year. The energy and electricity demand forecasts presented in Table 23.1.4 indicate average rates of growth of demand from 1975 to 2000 ranging from 4.5% to 10.0% for primary energy and from 3.1% to 6.7% for electricity.

A forecast of energy demand presented to the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) in 1974 projected an annual rate of demand growth of 10.5% from 1973 to 1981 (ref. 1.23), but the continuing escalation of energy prices since that time is likely to have caused these projections to be revised downwards. Information provided at the Second Pacific Basin Conference indicated a projected GNP growth rate trending from 10.2% in 1978, to 9.0% by 2000. Coupled with that, peak electrical demand growth rates ranged from 15% in 1980, to 10% in 2000.

The energy demand breakdown shown in Table 23.1.5 shows the effects of the trends that were indicated in reference 1.23 continuing through to 2000. Oil consumption is expected to increase both in absolute and relative terms as the only means of meeting the growth in energy demand in this rapidly developing country. Longer term plans to reduce the rate of growth of oil demand include the exploitation of tidal power which it is expected will contribute 6 TWh in 2000. Nuclear power capacity is also expected to provide a significant proportion of future energy requirements and installed capacity should reach 4469 MW by 1985. In 1992, the nuclear electricity demand should be approximately 40 TWh. From 1993 to 2000, nuclear capacity is expected to increase by 1200 MWe every year. As ambitious as this may be, Korea has announced a plan to have 44 nuclear plants operating by 2000, approximately 51,000 MWe. Under this plan, 12 reactors would be operational by 1989 and the installation rate would grow to four 1200 MWe reactors per year after 1996.

INDIGENOUS ENERGY RESOURCES

Table 23.1.1

	Economically Recoverable Reserves	Total Indigenous Resources	Location of Identified Reserves
Hard Coal (million tonnes)	327	1,434	Dispersed; Samckoag, Danyang, Chungnum, Gangreung
Soft Coal (million tonnes)	0	0	-
Crude Oil (million tonnes)	0	0	-
Shale Oil (million tonnes)	0	0	-
Natural Gas (cubic km)	0	0	-
Uranium (thousand tonnes U_3O_8)	3.5	Not Available	Taeduck
Hydro Power (TWh/year)	4.0	7.7	North West, Han-gany
Geothermal (TWh/year)	0	0	-

ENERGY SUPPLY 1975

Table 23.1.2

Resource	Indigenous Supply	Imports Total	Imports % from US	Exports Total	Exports % to US
Hard Coal (million tonnes)	16.785	0.774	33	0	0
Soft Coal (million tonnes)	0	0	0	0	0
Crude Oil (million tonnes)	0	15.972	0	0	0
Shale Oil (million tonnes)	0	0	0	0	0
Natural Gas (cubic km)	0	0	0	0	0
Uranium (thousand tonnes U_3O_8)	0	0	0	0	0
Electricity (TWh)	20.8	0	0	0	0

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 23.1.3

Resource	Consuming Sector				Total
	Household and Commercial	Industrial	Transportation	Electrical Generation	
Coal (million tonnes)	13.911	1.653	0.042	1.349	16.96
Petroleum (million tonnes)	2.345	4.543	3.855	3.029	13.77
Natural Gas (cubic km)	0	0	0		
Nuclear Power (TWh)	0	0	0	0	0
Hydro Power (TWh)	0	0	0	1.683	1.683
Geothermal Power (TWh)	0	0	0	0	0
Utility Electricity Distributed (TWh)	3.027	13.586	0	0.017	16.63

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 23.1.4

Year	Low Economic Growth 5.0%		Medium Economic Growth 8.0%		High Economic Growth 11.0%	
	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)
1975	1,013	20.8	1,013	20.8	1,013	20.8
1985	1,525	28.2	2,006	33.6	2,926	39.9
2000	3,076	44.5	5,639	69.1	10,896	105.9

CONSUMPTION OF ENERGY RESOURCES

Table 23.1.5

Resource	Standard Unit	Annual Consumption of Standard Units			Energy Consumption (10^{12} BtU)		
		1975	1985	2000	1975	1985	2000
Coal	Million Tonnes	18.37	18.7	34.0	510.1	520	945
Crude Oil	Million Tonnes	11.51	32.6	96.6	483.4	1,368	4,055
Natural Gas	Cubic km	0	0	0	0	0	0
Hydro Power	TWh	1.68	1.8	4.9	19.1	20	56
Tidal Power	TWh	0	0	6.1	0	0	69
Nuclear Power	TWh	0	8.6	45.2	0	98	514
Uranium	Thousand Tonnes U_3O_8	0	1.39	3.97	–	–	–

23.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

COMMERCIAL NUCLEAR POWER PLANTS

Table 23.2.1

Facility Name	Utility	Facility Type	Vendor	Capacity (MWe net)	Status*	COD
Kori-1	Korea Elec. Co.	PWR	Westinghouse	564	O	Apr 1978
Kori-2	Korea Elec. Co.	PWR	Westinghouse	605	U	Dec 1983
Wolsung-1	Korea Elec. Co.	Candu	AECL	600	U	June 1982
Kori-3	Korea Elec. Co.	PWR	Westinghouse	900	U	Sep 1984
Kori-4	Korea Elec. Co.	PWR	Westinghouse	900	U	Sep 1985
Kori-5	Korea Elec. Co.	PWR	-	900	P	1986
Kori-6	Korea Elec. Co.	PWR	-	900	P	1986

* O-Operational; U-Under Construction; P-Planned

PROJECTED NUCLEAR GENERATING CAPACITY
MWe (net)

Table 23.2.2

Year	PWR	BWR	Magnox	AGR	CANDU	Other	FBR	Firm + Planned Cumulative Total	NAC Cumulative Projection
pre-1978								0	0
1978	564							564	564
1979								564	564
1980								564	564
1981								564	564
1982					600			1164	1164
1983	605							1769	1769
1984	900							2669	2669
1985	900							3569	3569
1986	1800							5369	5369
1987	450	450						5369	6269
1988								5369	6269
1989	450	450						5369	7169
1990	450	450						5369	8069
1991	450	450						5369	8969
1992	450	450						5369	9869
1993	600	600						5369	11069
1994	600	600						5369	12269
1995	600	600						5369	13469
1996	600	600						5369	14669
1997	600	600						5369	15869
1998	600	600						5369	17069
1999	600	600						5369	18269
2000	600	600						5369	19469

NUCLEAR REACTOR VENDORS

Overview

There are no reactor vendors in South Korea. The government has announced its intention to establish an architect engineering corporation (through the government's nuclear research branch, the Korea Atomic Energy Research Institute, KAERI and the Korea Nuclear Engineering Services, Inc., KNE) in a joint venture with experienced overseas firms to develop domestic capability for reactor construction. Plans are to develop indigenous capability to the point that 55% of the equipment and site materials could be supplied domestically by 1981 and over 90% by 1990. Towards this end, Hyundai, a major Korean industrial group, signed an agreement with Westinghouse in late 1978 to establish a joint venture company in Korea for the manufacture of reactor systems and turbine generator components. The objective is to develop the ability to design and manufacture complete reactor systems in Korea.

NUCLEAR FUEL CYCLE FACILITIES

Overview

There are no commercial fuel fabrication facilities in Korea, but the government has plans to construct a facility for nuclear fuel research and development. The project will be a part of the Korea Atomic Energy Research Institute (KAERI). Korea's first processing facility for nuclear fuel will probably be a fabrication plant. The government has expressed interest in having fabrication capability, but recognizes that a joint venture with another country (such as Taiwan) would be necessary to justify an economically sized plant. Korea ordered a reprocessing plant from France in 1975, but political pressure caused the two countries to terminate the agreement. A pilot uranium mill began operation in 1978 with a capacity of about 10 MTU/year. The facility is located at Taeduck, south of Seoul.

NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

Vested Interests in Current Reactor Technologies and Fuel Cycles

Korea has little vested interest in any particular fuel cycle or reactor technology. Korea Electric Company (KECO), the state-owned power company, has two Westinghouse PWR's and one CANDU and have ordered two additional units from Westinghouse.

Current Trends in Nuclear Development Programs

Korea has a rapidly expanding economy and a concurrent growth in power requirements (the current growth rate and forecasted near-term growth rate for electricity is 15%/year). Korea plans to meet the increasing demand for electricity with nuclear power, with plans for almost one plant per year from 1982 on. As its commitment to nuclear power increases, the Korean government plans to increase the manufacturing capabilities of domestic industries to provide a greater contribution to the plant construction and fuel processing.

23.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

PROFESSIONAL LABOR FORCE PROFILE

Table 23.3.1

Available information presents the following data for 1973:

369,193 Scientists and Engineers

6,065 Scientists and Engineers engaged in R&D

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 23.3.2

Institution	Location
Pusan National University	Busan
Choong-nam National University	Chungcheng Namdo
Dankook University	Seoul
Dong-A University	Busan
Kon-Kuk University	Seoul
Korea University	Seoul
Gyeong Bug National University	Gyeongsang Bugdo
Kyung Hee University	Seoul
Hanyang University	Seoul
Hongik University	Seoul
Inha University	Inchon
Jeonbug National University	Jeolla Budgo
Jeon-nam National University	Jeolla Namdo
Joseon University	Jeolla Namdo
Chung-ang University	Seoul
Seoul National University	Seoul
Sungjeon University	Seoul
Ulsan Institute of Technology	Gyeongsang Namdo
Yeungnam University	Syongsangbuk-do Taegu
Yonsei University	Seoul

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 23.3.3

Name	Location	Main Activities
Atomic Energy Bureau		
Ministry of Science and Technology	Seoul	Fosters research and development in nuclear energy field; formulates training programs for nuclear energy related specialists and personnel.
Atomic Energy Commission	Seoul	Acts as deliberating and decision-making body on research and development plans for nuclear energy applications.

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 23.3.4

Name	Owner	Location	Main Activities

NOT APPLICABLE

RESEARCH AND TEST REACTORS
List of Reactors

Table 23.3.5

Facility Name	Location	Owner	Constructor	Facility Type	Facility Status MW(th)	Status*	COD
TRIGA-II-Seoul	Seoul	Atomic Energy Authority	General Dynamics Corporation	U-Zr hydride	0.25	O	1962

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

INDIGENOUS CAPABILITY TO DESIGN AND SUPPLY RESEARCH AND TEST REACTORS AND FUEL SERVICES

Summary of Reactor Orders by Vendor and Country

Table 23.3.6

Vendor	Country	Facility Name	Facility Type	Facility Status			Scope of Services
				MW(th)	Status*	COD	

NOT APPLICABLE

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 23.3.7

Facility Name	Location	Facility Type	Capacity Status MT/YR	Status*	Year	Shareholdings

NOT APPLICABLE

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

23.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

ECONOMIC DATA PROFILE

Table 23.4.1

GNP (Current million $)	- 31,488 (1977)	Inflation Rate	- 10.1% (1977)
Exports (million $)	- 10,046 (1977)	Imports (million $)	- 10,811 (1977)
Per Capita Income ($)	- 864 (1977)	Disposable Income ($)	- 503 (1975)
Monetary Unit	- WON	Exchange Rate (/US$)	- 484 (4/77)
Population (million)	- 35.86 (1976)		

23.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

	In Millions of Dollars	
	1975	1976
Nuclear Energy Research (budget, Ministry of Science and Technology (MOST)	4.1	9.5
Other Energy Research (budget for MOST)	Negl.	0.4

The Summary Investment Plan in Energy Sector for 1977/81 has prescribed for total Energy R&D the amount of $90.7 million.

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 23.4.3

Industry University or Laboratory	Program Area	Budget $ (Millions)	Key Personnel
Radiological Research Institute (RRI)	-	-	-
Korean Nuclear Engineering Services, Inc. (KNE)	Performs all architect engineering services required for nuclear power projects	-	-
Atomic Energy Research Institute (KAERI)	Neutron diffraction, radiation chemistry, wood plastics irradiation, cement plastics irradiation, plant breeding, control of diseases and pest insects on crops and livestock, preservation and processing of agricultural products, effects of radiation on living organisms, radiation protection, medical application of radioactive isotopes	-	Young Ku Yoon President
Korean Institute of Science and Technology (KIST)	Conducts development work which can be utilized by Korean industry	-	-
Korea Nuclear Fuel Development Institute (KNFDI)	Chemical technology, fuel fabrication, chemical analysis and instrumentation, contamination control of radioactive material and entire nuclear fuel cycle, ore refining and conversion	-	Dr. Choo Chai-Yang, Director

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 23.4.3 (continued)

Industry University or Laboratory	Program Area	Budget $ (Millions)	Key Personnel
Korea Research Institute of Geoscience and Mineral Resources (KIGAM)	Conducts geological research studies and exploration for minerals, energy and water resources	-	-
Korea Atomic Industrial Forum (KAIF), Inc.	Training of nuclear personnel and non-destructive inspectors	-	-

23.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

There is little involvement by private Korean industry in energy R&D.

R&D work is carried out primarily in government supported institutions such as KAERI AND KIST.

There are three Korean companies, Hyundai, Dong Ah and Yu Yang, which have major roles as subcontractors in performing nuclear grade work. The government plans to gradually substitute foreign technological assistance with domestic ability.

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 23.4.5

Name	Share Capital	Assets	Sales
	Not Applicable		

23.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Korea relies heavily on foreign assistance. Financing total power in 1976 was accomplished through the following resources:

25%	Government Funds
12%	Internal Cash Generation
19.6%	Domestic Loans
42%	Foreign Loans
1.4%	Other Sources

The government prefers to finance loans from as few sources as possible, but has to defer to the availability of loans from the supplier countries. This is complex because different portions of the nuclear units are supplied by different countries. They go to the United Kingdom, Canada and the U. S., but are considering France as another supplier for future units. The financial institutions assisting in payment of Korea's third plant are U. S. Export-Import Bank, Private Export Funding Corporation, Britain's Export Credit Guarantee Department and General Electric.

The long-term nuclear program will require $47.4 billion (escalated) and the government plans are to cover half of those costs with foreign loans. KECO is studying a plan to issue foreign currency-denomination bonds for overseas markets as a way of raising construction money.

The loan to Korea for Kori-3 and Kori-4 (∿ $0.8 billion) was, at the time of signing,the U. S. Export-Import Bank's largest such loan. The interest rate was 8 3/8% with a 15 year repayment term. An additional $180 million was loaned to cover the uranium, enrichment and fabrication for the initial reactor fuel cores. This loan has a 3 year repayment period.

Currently U. S. and French reactor vendors are competing for the next two reactors (total foreign purchases ∿ $1.4 billion). It is believed that the French could offer the loan at 7 1/2% interest, while the U. S. Export-Import Bank offered 8%.

23.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

23.5.1 ENERGY POLICY - BASIC LEGISLATION

Basic legislation on nuclear energy consists of 15 major laws dealing specifically with energy, including the Atomic Energy Law of 1958.

Office of Atomic Energy (OAE) established 1959

Atomic Energy Research Institute (AERI) established 1959

Radiological Research Institute (RRI) established 1966

Korea Atomic Industrial Forum (KAIF), Inc. established 1972

Korea Atomic Energy Research Institute Law promulgated 1973

Korea Atomic Energy Research Institute established in 1973 incorporating AERI, RRI AND RRIA (Radiation Research Institute in Agriculture)

Office of Atomic Energy abolished and Atomic Energy Bureau established 1973

Dae-Duk Engineering Center established as branch institute of KAERI 1975

Established National System of Safeguards and International Cooperation. Directorate in MOST 1976. Ratified Treaty on the Non-Proliferation of Nuclear Weapons 1975.

Korea Nuclear Engineering Services, Inc. (KNE) established 1976

Korea Nuclear Fuel Development Institute (KNFDI) 1976 created from KAERI and reorganizing Dae-Duk Engineering Center

23.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

LEGISLATIVE - A unicameral National Assembly composed of 219 members. Two-thirds are elected by universal suffrage and one-third are appointed by the President.

EXECUTIVE - All real political power as well as executive authority is centered in the President (Chung Hee Park). The Deputy Prime Minister (Duck Woo Ham), who is concurrently chairman of the Economic Planning Board, is responsible for the overall national economic policy framework within which Korean energy programs operate. Ministries with energy responsibility include the Ministry of Science and Technology (MOST) which is responsible for licensing, regulation and supervision of nuclear power projects. However, the design, procurement, construction and operation of nuclear power plants is KECO's responsibility.

Various interagency committees, which include appointed non-ministry experts, play an advisory and review role. These include:

Atomic Energy Commission (headed by Minister of Science and Technology)
Electricity Development Coordination Committee (headed by the Deputy Prime Minister)

Korea's atomic power will be placed under a separate government owned corporation: the Korea Electric Company (KECO). KECO is to handle all affairs relating to the construction and operation of nuclear power plants. It will also deal with the procurement of nuclear fuel.

R&D activities in nuclear fuel cycle were transferred from KAERI to KNFDI in December 1976.

23.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

MINISTRY OF COMMERCE AND INDUSTRY (MCI)

Office of the Assistant Minister for Resources supervises all MCI energy activities.

Energy Development Bureau has the following divisions:

- Energy Development
- Oil Refining
- Electric Power Generation
- Rural Electrification

Mining Bureau is responsible for coal.

MCI also controls the National Geological and Mineral Institute of Korea (GMIK).

MINISTRY OF SCIENCE AND TECHNOLOGY (MOST)

Atomic Energy Bureau reports directly to the Vice Minister of MOST.

Planning Division - Responsible for developing basic policies on enery source development, developing applications and utilization of atomic energy, and international cooperation.

Radiation Safety Division - Supervision of radiation and radioisotope handling, management of radiation and nuclear materials, licensing radioisotopes and other materials.

Nuclear Reactor Division - Plans and implements policies for reactor development, management of fuels and reactors, compensation for nuclear damage and operation of the Nuclear Indemnity Council.

Resource Development Office is responsible for energy R&D and gives assignments to government supported research institutes such as:

- Korea Atomic Energy Research Institute (KAERI)
- Korea Institute of Science and Technology (KIST)

23.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

The objectives of the Fourth Five-Year Economic Development Plan (1977-1981) are as follows:

1. To establish a stable energy supply and demand system

2. To explore and utilize domestic energy resources to the maximum possible extent

3. To apply the science of energy utilization and saving of energy consumption in daily life

Since the beginning of FY 1977, government officials have renewed the call for a reduction in total energy consumption by 10%.

As of 1978, official plans are for two more nuclear power plants, with capacity of 900 MW each for completion by 1986. By then, Korea would have a combined nuclear power production capacity of 5.5 million kilowatts, accounting for 27% of the nation's overall power production target for that year.

23.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

An ambitious program to install nuclear power plants is being pursued. Several plants are scheduled for completion during the next decade. Low grade uranium ore has been discovered. Officials believe that by the 1980's, production will be economically in line with rising international supply costs for enriched uranium.

23.5.6 NUCLEAR ENERGY R&D - PRIORITIES

The established nuclear energy priorities are:

1. Development of nuclear power technology through local participation in design, construction, and operation phases of nuclear power projects.

2. Intensify exploration of uranium and thorium.

23.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

The Atomic Energy Bureau has responsibility as follows:

Nuclear Reactor Regulatory and Licensing

1. Permission for the acquisition, production, import and export, construction, ownership, purchase and sale control and management and operation of nuclear reactor and facilities related.
2. Approval on design and method of work of nuclear reactor facilities.
3. Operation control of nuclear reactor facilities.
4. Security measures of nuclear reactor facilities.
5. License of nuclear reactor operators and senior operators.
6. Management of Advisory Committee for Reactor Safety.

Nuclear Reactor Technology Division

1. Establishment of codes and standards for nuclear facilities.
2. Inspection of nuclear reactor and fuel facilities.
3. Audit for construction of nuclear reactor facilities.
4. Licensing of construction and operation for nuclear fuel facilities.
5. Licensing of nuclear materials.

23.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 23.6.1

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Hwachan		Korea Electric Co.		Hydro	108	0	
Yongwol		Korea Electric Co.		Thermal	100	S 1973	1965
New Yongwol		Korea Electric Co.		Thermal	100	0	
Soeul 1,2		Korea Electric Co.		Thermal	23	0	
Soeul 3		Korea Electric Co.		Thermal	25	0	
Soeul 5		Korea Electric Co.		Thermal	250	0	1969
Pusan 1,2		Korea Electric Co.		Thermal	132	0	1964
Pusan 3,4		Korea Electric Co.		Thermal	210	0	1968-69
Ulsan Diesel		Korea Electric Co.		Oil	150	0	
Incheon 1		Korea Electric Co.		Thermal	250	0	1970
Yeongnam 2		Korea Electric Co.		Thermal	200	0	1970
Seoul 4		Korea Electric Co.		Thermal	138	0	1970
Yeongdong 1		Korea Electric Co.		Thermal	125	0	1972

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 23.6.1 (continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Yeosu 1		Korea Electric Co.		Thermal	200	0	1975
Yeongnam 1		Korea Electric Co.		Thermal	200	0	1972
Yeosu 2		Korea Electric Co.		Thermal	300	0	1976
Donghae 1		Korea Electric Co.		Thermal	220	0	1970
Kyungin Energy		Kyungin Energy Co.		Thermal	325	0	1972
Donghae 2		Korea Electric Co.		Thermal	220	0	1970
Honam	Yosu	Honam Power Co.	Babcock	Thermal	600	0	1972
Donghae 3		Korea Electric Co.		Thermal	220	0	1973
Scyanggang		(Private)		Hydro	200	0	1973
Incheon 2		Korea Electric Co.		Thermal	250	0	1974
Yongwol, Kunsan		Korea Electric Co.		Combined Cycle	600	U	1977-78
Incheon 3,4		Korea Electric Co.		Thermal	650	U	1977-78
Incheon - Thermal Add.		Korea Electric Co.		Thermal	300	U	1979

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 23.6.1 (continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Yeongdong 2		Korea Electric Co.		Coal	200	U	1979
Asan 1,2		Korea Electric Co.		Thermal	600	U	1980
Cheongpyong		Korea Electric Co.		Pumped Storage	400	U	1980
Thermal 1		Korea Electric Co.		Thermal	300	U	1980
Thermal 2		Korea Electric Co.		Thermal	300	U	1981
Thermal 3		Korea Electric Co.		Thermal	500	U	1981
Thermal 4		Korea Electric Co.		Thermal	500	P	1982
Thermal 5,6,7		Korea Electric Co.		Thermal	1,500	P	1983
Thermal 8,9		Korea Electric Co.		Thermal	1,000	P	1985
Thermal 10,11		Korea Electric Co.		Thermal	1,000	P	1986
Imgea		Korea Electric Co.		Hydro	153	P	1983
Coal/Oil Firing 1,2		Korea Electric Co.		Coal/Oil	400	U	1981
Samranjin		Korea Electric Co.		Pumped Storage	300	U	1982

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 23.6.1 (continued)

Facility Name	Location	Utility/Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Chungju		Korea Electric Co.		Hydro	210	P	1983
Hapcheon		Korea Electric Co.		Hydro	80	P	1984
Hapcheon		Korea Electric Co.		Pumped Storage	400	P	1985
Yongdam		Korea Electric Co.		Hydro	160	P	1986
Tidal		Korea Electric Co.		Hydro	400	P	1986

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 23.6.2

Year	Capacity - MWe(net)
1975	5,135
1980	9,190
1985	17,774
1990	
1995	
2000	

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 23.6.3

Facility Name	Location	Owner	Facility Type	Capacity **	Status*
	Kangwonda	Dai Han	Coal Field	13.5	0
	Cholla Namdo	Coal Corp./Private	Coal Field		0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Coal - million tonnes/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 23.6.4

RESOURCE	1985	2000
COAL (million tonnes)		
Indigenous Supply	18.11	19.40
Imports	.59	14.60
Exports	-	-
CRUDE OIL (million tonnes)		
Indigenous Supply	0	0
Imports	32.6	96.6
Exports	-	-
SHALE OIL (million tonnes)		
Indigenous Supply	0	0
Imports		
Exports		
NATURAL GAS (cubic kilometers)		
Indigenous Supply	0	0
Imports	-	-
Exports	-	-
URANIUM (kilotonnes U_3O_8)		
Indigenous Supply	0	0
Imports	1.39	3.97
Exports	0	0

SECTION 24

SPAIN

24.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

INDIGENOUS RESOURCES

Spain has approximately 13% of the total coal resources of southern Europe. These resources are put at 3,562 million tonnes of which 2,370 million tonnes are hard coal. Economically recoverable reserves total 1,643 million tonnes of which 907 million tonnes are hard coal (ref. 1.2). Spain's coal mines can provide 77% of Spain's domestic coal needs at present, and reserves are sufficient to expand this to 88% in the late 1980's and after.

Crude oil is available from the Mediterranean Sea and current figures for quantities give the total resource as 24.2 million tonnes of which 11 million tonnes are economically recoverable. These figures have not been updated from a 1972 survey (see refs. 1.1 and 1.2).

Shale oil deposits are currently estimated at 12 million tonnes, this being the economically recoverable quantity. Shale oil production has been used for alleviating local oil shortage and no figure of total resource quantity is available.

A small amount of onshore natural gas is available (economically recoverable reserves being given as 0.65 km^3, ref. 1.2). No figures are available for total resources nor for likely offshore quantities in the Mediterranean Sea.

Hydro-power is significant with a theoretical potential of 155 TWh of which 55 TWh is economically recoverable. It can provide 12-15% of primary energy needs in a good rainfall year, but can decline to 7% in drier years.

Spain's total indigenous uranium resources are estimated at 18.0 thousand tonnes, of which 8.0 thousand tonnes is considered economically recoverable.

ENERGY SUPPLY

Production of solid fuels was at the rate of 14.2 million tonnes (ref. 1.5) (14.1 million tonnes in ref. 1.2). Imports were given as 4.347 million tonnes in reference 1.5, compared with 4.37 million tonnes in reference 1.6. As much as 56% is imported from the United States.

Crude oil production increased recently but still only stands at 2.24 million tonnes (ref. 1.5) compared with imports of 43.19 million tonnes. The figures given in reference 1.6 are 2.03 million tonnes and 42.3 million tonnes respectively. 95% of petroleum needs are imported.

Gas production is negligible, the total reserve not being sufficient to meet the annual demand.

Domestic production of uranium in 1975 was 187 short tons of U_3O_8. 144 short tons were imported, 100% from the U. S. A.

PATTERNS OF ENERGY USE

Industry and power generation are the major sectors for coal demand.

Petroleum is consumed in all sectors, with industry demanding the largest percentage of the total.

Household consumption of natural gas is significant at about 33% of the total.

Industry is the prime consumer of electricity with over 50% of the total demand. A significant percentage of the overall demand is met by hydro-power and almost 10% by nuclear.

FORECASTS OF ENERGY SUPPLY AND DEMAND

Over the period 1965 to 1974, the average annual rate of economic growth in Spain was 6.5% (ref. 1.43) while in the same period, total primary energy demand increased at an average annual rate of 8.6% and electricity demand at a rate of 11.6% (refs. 1.5 and 1.44). The demand forecasts shown in Table 24.1.4 indicate an average annual rate of energy demand growth from 1975 to 2000 of 4.1% to 5.3% and an electricity demand growth rate of 3.9% to 7.9%. It should be noted that the new energy plan projects total primary energy consumption to go from 99.1 million tonnes of coal equivalent (2752[10^{12}] Btu) in 1977 to 119.6 million in 1982 and 145.0 million in 1987. These projections lie near the high economic growth forecasts of Table 24.1.5.

A considerable growth of nuclear power capacity is expected, as can be seen from Table 24.1.5 (although much lower than even recent forecasts). This will reduce the dependence on oil and coal, however the absolute consumption of these fuels will continue to increase. The increase in coal consumption will be supplied partly by increasing the indigenous production of hard coal and partly by exploiting extensive lignite resources for electricity generation (ref. 1.47). Coal imports are also expected to increase slightly since indigenous production will probably not increase fast enough to meet the growth in demand.

The total installed nuclear capacity is expected to reach 16,909 MW by 2000.

The new energy plan projects the following percentage supply of primary energy:

	1982	1987
Coal	15.9	16.2
Crude Oil	59.5	54.3
Natural gas	4.6	5.3
Hydro Power	10.2	9.4
Nuclear Power	9.8	14.8

Comparison with the 1985 energy consumption projection in Table 24.1.5 indicates the new plan's movement away from nuclear energy towards crude oil and natural gas. In the new plan (not yet accepted) the nuclear percentage would drop from 32% to about 15%, while the combined contribution of oil and gas would rise from 46% to almost 60%.

INDIGENOUS ENERGY RESOURCES

Table 24.1.1

	Economically Recoverable Reserves	Total Indigenous Resources	Location of Identified Reserves
Hard Coal (million tonnes)	907	2,370	Astur Pirenaica, Costera Catalana, Iberica
Soft Coal (million tonnes)	736	1,192	
Crude Oil (million tonnes)	11	24.2	Offshore
Shale Oil (million tonnes)	12	Not Available	Cuenca de Sierra Morena
Natural Gas (cubic km)	0.65	Not Available	
Uranium (thousand tonnes U_3O_8)	8.0	18.0	Cordoba, Salamanca
Hydro Power (TWh/year)	55.0	154.8	
Geothermal (TWh/year)	0	0	

ENERGY SUPPLY 1975

Table 24.1.2

Resource	Indigenous Supply	Imports		Exports	
		Total	% from US	Total	% to US
Hard Coal (million tonnes)	10.816	4.347	56.13	0.032	0
Soft Coal (million tonnes)	3.380	0	0	0	0
Crude Oil (million tonnes)	2.242	43.191	0	0.731	0
Shale Oil (million tonnes)	0	0	0	0	0
Natural Gas (cubic km)	0.00109	1.305	0	0	0
Uranium (thousand tonnes U_3O_8)	0.170	0.131	100	0	0
Electricity (TWh)	81.39	0.65	0	1.50	0

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 24.1.3

Resource	Consuming Sector				Total
	Household and Commercial	Industrial	Transportation	Electrical Generation	
Coal (million tonnes)	0.26	9.64	0.03	6.43	16.36
Petroleum (million tonnes)	3.31	12.03	12.24	7.67	35.25
Natural Gas (cubic km)	0.008	0.013	0	0.003	0.024
Nuclear Power (TWh)	-	-	-	9.0	9.0
Hydro Power (TWh)	-	-	-	28.75	28.75
Geothermal Power (TWh)	-	-	-	0	0
Utility Electricity Distributed (TWh)	20.57	44.74	1.51	14.52	81.34

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 24.1.4

Year	Low Economic Growth 4.0%		Medium Economic Growth 6.0%		High Economic Growth 8.0%	
	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricity (TWh)	Total Primary Energy (10^{12} Btu)	Electricit (TWh)
1975	2,419	81.4	2,419	81.4	2,419	81.4
1985	3,102	119.7	3,637	144.3	3,980	173.4
2000	6,562	213.3	7,559	340.4	8,695	538.8

CONSUMPTION OF ENERGY RESOURCES

Table 24.1.5

Resource	Standard Unit	Annual Consumption of Standard Units			Energy Consumption (10^{12} BtU)		
		1975	1985	2000	1975	1985	2000
Coal	Million Tonnes	16.83	17.8	28.1	467.3	493	781
Crude Oil	Million Tonnes	34.71	38.5	77.3	1,473.1	1,634	3,277
Natural Gas	Cubic km	1.37	0.6	0.4	49.1	20	15
Hydro Power	TWh	28.75	30.1	34.0	327.0	342	387
Other Renewables	TWh	–	–	–	–	–	–
Nuclear Power	TWh	9.00	100.9	272.3	102.4	1,148	3,099
Uranium	Thousand Tonnes U_3O_8	1.51	1.89	3.25	–	–	–

24.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

COMMERCIAL NUCLEAR POWER PLANTS

Table 24.2.1

Facility Name	Utility	Vendor	Facility Type	Capacity (MWe net)	Status*	COD
Almaraz 1	Central Nuclear de Almaraz	Westinghouse	PWR	902	U	Jul 1979
Almaraz 2	Central Nuclear de Almaraz	Westinghouse	PWR	902	U	Jul 1980
Vandellos 1	HIFRENSA	CEA	Magnox	484	O	May 1972
Asco 1	Fuerzas Electricas de Catalona	Westinghouse	PWR	902	U	Jun 1980
Asco 2	Asociacion Nuclear de Asco-2	Westinghouse	PWR	902	U	Jun 1982
Cofrentes	Hidro Electrica Espanola	GE	BWR	930	U	Jul 1981
Lemoniz 1	Iberduero	Westinghouse	PWR	883	U	Dec 1979
Lemoniz 2	Iberduero	Westinghouse	PWR	883	U	Nov 1981
Sayago	Iberduero	Westinghouse	PWR	1034	P	Jul 1986
St. Maria	Central Nuclear del Norte	GE	BWR	440	O	May 1971
J. Cabrera	Union Electrica	Westinghouse	PWR	153	O	Aug 1969
Trillo	Union Electrica	KWU	PWR	985	P	Jun 1988
Valdecab. 1	Central Nuclear de Valdecabelleros	GE	BWR	937	P	Jun 1984

* O-Operational; U-Under Construction; P-Planned

PROJECTED NUCLEAR GENERATING CAPACITY

MWe (net)

Table 24.2.2

Year	PWR	BWR	Magnox	AGR	CANDU	Other	FBR	Firm + Planned Cumulative Total	NAC Cumulative Projection
pre-1978	153	440	484					1077	1077
1978								1077	1077
1979	1785							2862	3764
1980	1804							4666	4666
1981	883	930						6479	6479
1982	902							7381	7381
1983								7381	7381
1984		937						8318	8318
1985								8318	8318
1986	1034							9352	9352
1987	930							9352	10282
1988	985							10337	11267
1989								10337	11267
1990		937						10337	12204
1991								10337	12204
1992	985							10337	13189
1993								10337	13189
1994	930							10337	14119
1995								10337	14119
1996	930							10337	15049
1997								10337	15049
1998		930						10337	15979
1999								10337	15979
2000	930							10337	16909

Notes: The revised Spanish energy plan reduced the nuclear component from 8 reactors (not now under construction), authorized for operation by 1987, to 3. This is shown above. The plan has yet to be approved, however the actual 1978 GNP and electricity demand growths considerably exceeded the projected growths upon which the new plan was based.

NUCLEAR REACTOR VENDORS

Overview

Spain currently possesses no nuclear reactor vendors. However, Westinghouse has been active in Spain since the early 1960's and in 1971 Westinghouse Nuclear Espanola was set up with the aim of project management and maximizing Spanish participation in Westinghouse projects. The organization has been expanded to cover a wider range of activities including nuclear engineering and marketing in Spain and the majority of personnel are Spanish. Westinghouse has entered into a number of license agreements for the manufacture in Spain of major nuclear components, nuclear fuel and nuclear turbine generators.

Based on ENSA (see below) the potential exists for the setting up in the future of a national organization (sale and/or private industry) for the domestic and export of nuclear power plants based on license agreements.

Nuclear Reactor Vendor Support Industries

Since the first nuclear reactors were constructed in Spain, local industry has made, partly through license agreements, an increasing contribution. For the first plants it lay around 40%, for the reactors currently under construction it is around 60% (35% of steam generating plant) and for the future 80-85% local supply is foreseen. Therefore, Spanish industry is already able to supply a significant range of components and equipment for nuclear reactors and the activity is increasing.

For the main components the most important company is Empresa Equipos Nucleare S.A. (ENSA) which was formed in 1972 for the manufacture of complete NSSS sets for Westinghouse, GE and KWU reactors (pressure vessels, steam generators and related items). A license agreement exists with Westinghouse and technology transfer agreements with GE and KWU. The current shareholding consists of: Babcock and Wilcox Espanola 35%, La Manquinista Terrestre y Maritima 34%, Mecanica de la Pena 9%, Stein et Roubaix Espanola 9%, Spanish utilities 15%. A Government decree in 1972 gave the company the characteristics of a "priority national interest"; it is thus the single authorized supplier of nuclear island equipment in Spain. Construction of a new manufacturing facility at Santander started in 1974 and vessel manufacturing has already commenced. The second phase of the facility will be completed in 1980.

The initial target capacity for ENSA is three NSSS sets per year by 1980 and eventually four sets per year. The first pressure vessel to be manufactured is for the GE BWR Valdecaballeros-1 plant for delivery in 1978. For the first two vessels, Breda Termomeccanica of Italy will supply some pre-fabricated parts.

Thereafter, Spanish manufacture will virtually reach the 100% level. Initially ENSA will subcontract rolled plates and forgings (e.g. to B&W Expanola), later plate bending machines will be installed. The first completely Spanish steam generators will be produced for the KWU PWR Trillo-1 plant.

Shop crane capacity is 900 tons and complete pressure vessels can be loaded directly onto ships.

NUCLEAR FUEL CYCLE FACILITIES

Overview

Spain is involved in the fuel cycle in a major way. There are two operating U_3O_8 mines/mills. The oldest and smallest mine at Andujar (near Cordoba) is owned 100% by the Junta de Energia Nucleare (JEN). This plant has been operating since 1959. The second mine/mill complex is the Ciudad Rodrigo complex at Salamanca which is owned 100% by Empresa Nacional del Uranio S.A. (ENUSA). This complex began operation in 1975. Private industry is planning to undertake the extraction of uranium from phosphates. A major effort is being made to maximize domestic uranium production.

JEN is a highly influential government body which has the responsibility for many nuclear decisions including safety, site licensing and the domestic uranium exploration program. JEN currently advises ENUSA which was set up in 1972, to provide fuel services. ENUSA is owned 60% by the Spanish government and 40% by utilities. It has the sole responsibility for nuclear fuel and nuclear fuel services in Spain.

Because the major part of Spanish uranium requirements must be met from imports ENUSA has 10% ownership of COMINAK, a 2,360 tonnes U_3O_8/year mine/mill complex in Niger scheduled for operation in 1979. In addition, ENUSA is involved in uranium exploration activities in Colombia, Canada, Chile, and South Africa.

ENUSA has financial interests in both the Eurodif and Coredif enrichment projects in France. For the details of Eurodif and Coredif see under France. In summary, ENUSA holds an 11.11% interest in Eurodif and through Eurodif a 5.67% interest in Coredif.

ENUSA is planning the construction of an LWR fuel fabrication facility. License agreements for the design and manufacture of fuel have been obtained from Westinghouse, GE and KWU. A construction permit for a site at Juzbada, Salamanca Province has been requested from the Government but this is currently being delayed. It is intended that eventually all fuel for Spanish LWR's will be manufactured by ENUSA.

ENUSA and JEN are studying the feasibility of a national reprocessing plant. JEN has been involved in reprocessing research for many years and has carried out the reprocessing of test reactor fuels. The search for a site for a reprocessing plant/intermediate fuel storage facility is underway.

The main current and planned facilities are summarized in Table 24.2.3.

CURRENT AND PLANNED FACILITIES

Table 24.2.3

Facility Name	Location	Facility Type	Capacity MT/YR	Status Status*	Year	Shareholdings
Ancujar	Cordoba	Mine/Mill	54	O	1959	100% JEN
La Haba	Badajes	Mine/Mill	32	U	1979	100% JEN
Ciudad Rodrigo	Salamanca	Mine/Mill	100**	O	1975	100% ENUSA
Huelva	Huelva	Mine/Mill	77	U	1983	FESA (100% JEN)
Fabrication Facility	Salamanca	LWR Fuel Fabrication	400***	P	1980-81	100% ENUSA

* O-Operational; U-Under Construction; P-Planned

** Capacity expansions under consideration for completion in 1981. At that time capacity will be 460 MTU/year.

*** Will commence with assembly and successively add pellet and powder production

Facility: Andujar Uranium Mining and Milling

Andujar is a very small mining and milling complex which has been in operation since 1959. Mining is by the open pit method. Milling technology was developed domestically, the specific process is not known.

The current capacity is 65 tonnes U_3O_8 (54 tonnes U) per year. The operation is not economic since ore has to be transported from the surrounding area. It is only expected to operate for another 2-3 years.

All production is delivered to ENUSA to be used to fuel domestic reactors.

The amount of uranium produced by Andujar is not known but is estimated to be less than 1150 tonnes U_3O_8 through 1976. For the past five years it has been producing 54-65 tonnes per year.

As the Andujar complex is shut down, production from the new La Haba mine/mill complex will be phased in to replace Andujar production. La Haba will have a capacity of about 32 MTU per year, and is scheduled to be in operation in late 1979.

Facility: Ciudad Rodrigo Uranium Mining and Milling

Ciudad Rodrigo is a modest mining and milling complex which entered into operation in 1975. Mining is by the open pit method. Currently uranium is extracted from ore by pit leaching but a continuous dynamic extraction system is now under construction.

Current capacity is 118 tonnes U_3O_8 (100 MTU) per year. The new dynamic extraction system expansion will increase the capacity to approximately 545 tonnes U_3O_8 per year and will enter operation in 1981. The mining/milling complex is anticipated to have a 20 year lifetime.

All production is reserved for use in domestic reactors.

It is estimated that Ciudad Rodrigo produced approximately 180 tonnes of U_3O_8 through 1976.

Facility: Huelva Uranium Mining and Milling

The facility will recover uranium from phosphate rock imported from Morocco and the Spanish Sahara. The facility's capacity is planned for 100 STU_3O_8 (80 MTU) per year. It was preceded by a small test laboratory in 1969 and then by a pilot plant. Successful operation led to the division to construct the commercial facility. All production will be committed to ENUSA. Initial operation is scheduled for 1983.

NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

Vested Interests in Current Fuel Cycles and Reactor Technologies

Spain has a major vested interest in both current reactor technology and in the fuel cycle.

While slippage has occurred, and a new energy plan has tentatively lowered the number of approved reactors, Spain still has an ambitious nuclear program aimed at reducing dependence on oil. It has a large number of LWR's under construction or ordered, and is rapidly achieving the industrial capability to be practically self-sufficient for the complete supply of LWR power plants (NSSS and nuclear turbine design and manufacture). Spanish industry is generally well organized and capable of supplying a wide range of components and equipment. Modern facilities for the manufacture of complete NSSS sets have been constructed and have entered operation. There is clearly a massive national commitment to LWR technology.

In the fuel cycle, Spain has made a major commitment by way of its participation in the Eurodif and Coredif enrichment project. Self-sufficiency in LWR fuel fabrication is planned within the next few years. There is no current investment in reprocessing but this is planned for the future.

Current Trends in Nuclear Development Programs

For the near mid-term, the emphasis is clearly on attaining the highest degree possible of self-sufficiency in the supply of LWR power plants and associated fuel services. There is apparently no large-scale domestic involvement in advanced technologies and it can be envisaged that Spain will look to more advanced nations to provide proven technology which the experienced domestic industry will supply and manufacture under license or cooperation agreements.

24.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

PROFESSIONAL LABOR FORCE PROFILE

Table 24.3.1

Available information presents the following data for 1972:

8,945 Scientists and Engineers
engaged in R&D

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 24.3.2

Institution	Location
University of Salamanca	Salamanca
University of Valladalid	Valladalid
University of Barcelona	Barcelona
University of Valencia	Valencia
University of Santiago de Compostella	Santiago de Compostella
University of Seville	Seville
University of Madrid	Madrid
University of Granada	Granada
University of Saragossa	Saragossa
University of Oviedo	Oviedo
University of La Paguna	Canary Islands
University of Murcia	Murcia
University of Bilbao	Bilbao
University of Navona	Pamplona
University of Duesto	Bilbao
University of Salamanca	Pontifical

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 24.3.3

Name	Location	Main Activities
Junta de Energia Nuclear (JEN)	Madrid	Development of fundamental nuclear research and nuclear technology
Juan Vigon Nuclear Research Center	Moncloa, Madrid	Spain's major nuclear R&D center - basic research and isotope production - fast reactor experiments - U_3O_8 milling research - reactor fuel production - PU processing - waste treatment

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 24.3.4

Name	Owner	Location	Main Activities

No major private research organizations exist in Spain. Most private organizations are primarily oriented towards commercial applications, with little structure or incentive for significant R&D activity.

RESEARCH AND TEST REACTORS
List of Reactors

Table 24.3.5

Facility Name	Location	Owner	Constructor	Facility Type	Facility Status		
					MW(th)	Status*	COD
JEN-1	Nuclear Research Ctr.	JEN	GE & JEN	GE pool 20% U^{235} MTR assemblies	6	0	1958
JEN-2	"	JEN	JEN	Pool	10kw	0	1968
CORAL-1	"	JEN	JEN	Split bed, fast, zero power	-	0	1968
ARBI	Bilbao	Bilbao Superior Technical School	JEN	Argonaut	10kw	0	1962
ARGOS	Barcelona	Barcelona Superior Technical School	JEN	Argonaut	10kw	0	1962

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

INDIGENOUS CAPABILITY TO DESIGN AND SUPPLY RESEARCH AND TEST REACTORS AND FUEL SERVICES

Summary of Reactor Orders by Vendor and Country

Table 24.3.6

Vendor	Country	Facility Name	Facility Type	Facility Status MW(th)	Status*	COD	Scope of Services

See Table 24.3.5 for research reactors constructed by JEN which are used domestically.

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 24.3.7

Facility Name	Location	Facility Type	Capacity Status MT/YR	Status*	Year	Shareholdings
JEN	Madrid	Fabrication of Plates	Quantity for one research reactor			

JEN, at the National Research Center, has pilot facilities for U_3O_8 purification, production of metallic, carbide and oxide fuel rods, plutonium processing, and waste treatment. These facilities could produce research and test reactor fuel.

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

24.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

ECONOMIC DATA PROFILE

Table 24.4.1

GNP (Current million $)	- 108,100 (1977 est.)	Inflation Rate	- 26% (1977)
Exports (million $)	- 5,167 (1977)	Imports (million $)	- 9,252 (1977)
Per Capita Income ($)	- 2,960 (1977 est.)	Disposable Income ($)	- 2,259 (1974)
Monetary Unit	- Peseta	Exchange Rate (/US$)	- 78.8 (1978)
Population (million)	- 36.2 (1977)		

24.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

While the total government energy R&D budget increased from 34 million dollars in 1974 to 42 million dollars for the year 1977, the nuclear fission budget remained relatively constant (in terms of dollars) at about $19 million. Other research budgets, particularly conservation, geothermal and solar, have dramatically increased during this period.

GOVERNMENTAL SUPPORTED NUCLEAR R&D INDUSTRY, UNIVERSITIES AND NATIONAL LABORATORIES

Table 24.4.3

Industry University or Laboratory	Program Area	Budget $ (Millions)	Key Personnel
National Institute of Industry	Energy applications	-	-
Empreso Nacional Adano	Mining technology	-	-
Sobria Nuclear Energy Center	Designing fuel elements, materials development, irradiated fuel behavior	(under construction)	
Energy Studies Center	-	-	-
Laboratory for Nuclear Applications of Public Works	-	-	-

24.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

Through international agreements, indigenous technical research and mechanical engineering is increasing.

In permits issued by the Ministry of Industry, a clause requires that Spanish manufacturing and engineering firms should perform a specified percentage of work in carrying out the project. The government is aiming toward 80-85% Spanish participation.

Formation of large contracting firms has led to rapid assimilation of relevant technology

1. boiler and mechanical equipment
2. electrical and electronic equipment
3. civil work and erection
4. engineering services

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 24.4.5

Name	Share Capital	Assets	Sales

There are no Spanish reactor vendors. JEN and ENUSA own the two operating U_3O_8 mines/mills. Spain has financial interests in both Eurodif and Coredif enrichment projects and is planning construction of a LWR fuel fabrication facility.

24.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Export-Import Bank has provided loans for U.S. supplied reactors while other U.S. banking institutions have made loans available for additional purchases of U.S.-made nuclear power plant equipment. Similar arrangements have been made in France and West Germany for reactors supplied by these countries.

24.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

24.5.1 ENERGY POLICY - BASIC LEGISLATION

Law of 29 November 1939 established the Higher Council for Scientific Research

Law of 17 October 1951 established the Spanish Nuclear Energy Board which prepared the Spanish Nuclear Plan

Nuclear Energy Commission formed to act as advisory body to government nuclear power in 1951

Law of 22 September 1961 set up non-profit making Research Associations which are promoted by trade groups. A typical example is the Research Association of the Electricity Industry

Decree of 16 October 1964 created the National Fund for the Development of Scientific Research. The fund is in turn controlled by the Advisory Commission for Scientific and Technical Research, created by decree on 7 February 1958

All plans for construction of new electricity generating plans under joint program, "NATIONAL ELECTRICITY SUPPLY PROGRAM." (Second version issued 1972.)

ENUSA was formed for purposes of manufacturing nuclear fuel elements and engaging in all activities of full cycle in 1971.

Government decree, law 2656 of 1972, brought Equipos Nucleares SA into being which made them single authorized supplier for nuclear islands under the entire large nuclear capacity installation program

Decree of 10 December 1974 created the Center of Energy Studies depending on the Ministry of Industry and Energy. This Center is responsible for developing energy conservation measures and carrying out studies on energy development

Decree of 21 July 1974 established the possibility of joint R&D activities in the nuclear field between power companies and the Nuclear Energy Board

Energy Plan approved by the Spanish Government in 1975

1975 - National Power Supply Plan approved and subject to review every two years

National Energy Plan was submitted October 1978, but has been shelved until the general elections are held on March 1, 1979, as well as the municipal elections in April.

24.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

LEGISLATIVE - A unicameral Parliament called the Cortes dominated by the executive (constitutional reform underway to establish a bicameral legislature).

EXECUTIVE - The monarch King Juan Carlos I serves as Head of State. In July 1969, then Prince Juan Carlos de Borbon was sworn in as successor to the Head of State, and following General Franco's death in November 1975, took the oath as King of Spain. Executive authority technically lies with the king, though his acts are subject to countersignature. More likely to dominate all branches of government through his position as Chief of Government is the Prime Minister.

The controlling power in the energy field lies primarily within two ministries:

1. Ministry of Industry and Energy - Rodriguez Sabagun

2. Ministry of Education and Science

Under the Ministry of Industry and Energy, the following subdivisions exist to facilitate government control in the energy field and participation in the private sector:

- Nuclear Energy Board -- responsible for all nuclear-related activities, including the formulation of nuclear energy policy and R&D programs

- Commission of Energy and Mines

- Commission of Scientific Policy

- Nuclear Energy Commission -- Center for research, expert advisors to government and as a body concerned with safety and protection against ionizing radiations. To encourage industrial development in application of nuclear power

- Nuclear Security Council (see government role in construction and operations)

24.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

Primary responsibility for implementation of all energy policy and R&D rests with the Ministry of Industry and Energy, though there are separate organizations for the nuclear and non-nuclear sectors.

Nuclear Energy Board -- Umbrella organization for all nuclear-related activities. The following subdivisions contribute to the overall nuclear energy program:

- Commisariat of Energy and Minerals;

- Research Associations;

- Junta de Energia Nuclear (JEN) -- created in 1951 and responsible for providing advice on all matters related to atomic energy; inspection of nuclear facilities for safety; uranium prospecting and exploitation; training; and research and development;

- Institute of Nuclear Studies -- Director, Amando Duran Miranda;

- Instituto Nacional de Industria (INI) -- created in 1941 as a government holding agency for all petroleum-related activities. Headed by President Don Juan Antonanzas, the Institute grants permits for foreign involvement in the exploration and production of oil. Under this organization are:

    a. Enagas - established to control the importation of gas and the construction of pipelines (natural gas);

    b. Empresa Nacional Carbonera del Sur;

    c. Empresa Nacional Hullera del Norte, S.A. (HUNOSA);

    d. Empresa Nacional del Uranion, S.A. (ENUSA) -- supervises exploration for uranium under the direction of its President, Xavier Saques. Though Spain's nuclear plants are privately owned and operated, INI acts in a consultative role.

24.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

The previous Spanish energy plan contemplated that nuclear energy would make up about 30% of its primary energy consumption by 1985. The new plan (not yet approved) calls for a more modest 15%.

The nuclear objectives of the JEN are in the areas of:

- uranium ore prospecting
- nuclear fuel cycle
- nuclear reactor technology
- fundamental and applied research
- nuclear safety and radiation protection
- technical training

24.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

R&D in such areas as petroleum, coal, nuclear power, hydroelectric power, power transmission and natural gas is well established and it is anticipated that R&D in nuclear power production will increase significantly.

NUCLEAR FISSION R&D

- Development of fuel handling equipment for nuclear power stations
- R&D in prospecting methods for uranium ore deposits
- Development of chemical processing techniques of uranium ores containing lignite and phosphore
- Techniques of fuel elements fabrication and reprocessing

FAST BREEDER R&D

- Studies on fast breeder reactors
- Technology of materials
- Development of sodium loops for thermohydraulic tests and corrosion studies

NUCLEAR FUSION R&D

- Fundamental research on laser fusion
- Studies on plasma confinement

24.5.6 NUCLEAR ENERGY R&D - PRIORITIES

Established nuclear energy priorities are:

- fast breeder technology
- nuclear fuel cycle, including indigenous fabrication and reprocessing capability

24.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

The Ministry of Industry authorizes construction, erection and commissioning of nuclear installations. The procedure is as follows:

> A construction application is submitted to the Nuclear Energy Commission which advises the National Energy Authority on its suitability. The National Energy Authority issues a preliminary authorization and the Nuclear Energy Commission issues a preliminary technical assessment. The building permit is issued by the National Energy Authority which will set up a joint coordinating committee consisting of
>
> 1. representatives of government
> 2. local authorities concerned
> 3. JEN
> 4. operating company
>
> The National Energy Authority gives provisional approval for commissioning of plant and formal operating license. Then the Ministry of Industry will inspect the plant and authorize start up.

Nuclear power plants are privately owned and operated, but the INI maintains a consultative role.

24.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 24.6.1

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Cristobal Colon	Huelva	CSE		Oil	372	O	
Cadiz	Cadiz	CSE		Oil/Coal	122.5	O	
Malaga	Malaga	CSE		Oil	118.0	O	
Almeria	Almeria	CSE		Oil	110.0	O	
Canelles	Ribagorzana	ENHER		Hydro	108.0	O	
Mequinenza	Ebro	ENHER		Hydro	310.0	O	
Ribarrogo	Ebro	ENHER		Hydro	265.0	O	
Besos	Barcelona	ENHER		Gas/Oil	150.0	O	
Salime	Gulf of Salime	EDV		Hydro	126.0	O	
Soto	Soto Ribera	EDV		Coal	321.6	O	
Guardo	Velilla de Guardo	EDV		Coal	148.0	O	
Belesar	Chantada	FEN		Hydro	225.0	O	
Peares	Castro Carballedo	FEN		Hydro	112.0	O	
Soto	Oviedo	HEC			322.0	O	

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 24.6.1 (continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Salime	Asturias	HEC		Hydro	112.0	0	
Alcantara	Caceres	HEE		Hydro	915.2	0	
Valdecanas	Caceres	HEE		Hydro	225.0	0	
Azutan	Toledo	HEE		Hydro	180.0	0	
Torrejon	Caceres	HEE		Hydro	129.6	0	
Cofrentes	Valencia	HEE		Hydro	124.2	0	
Escombreras	Murcia	HEE		Oil	858.0	0	
Aceca	Toledo	HEE		Oil	313.6	0	
Aldeadavila	Salamanca	HEII		Hydro	718.2	0	
Saucelle	Salamanca	HEII		Hydro	240.0	0	
Villarino	Salamanca	HEII		Hydro	540.0	0	
Esla	Zamora	HEII		Hydro	133.0	0	
Compostella 1				Coal	167.0	0	

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 24.6.1 (continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Compostella II				Coal	612.0	0	
La Robla				Coal	270.0	0	
Narcea				Coal	219.0	0	
Lada				Coal	255.0	0	
Escatron				Lignite	172.5	0	
Escucha				Lignite	175.0	0	
Puentes 1400		ENE		Lignite	350.0	0	1976
Serchs				Lignite	175.0	0	
Algeciras				Oil	753.0	0	
Badelona I				Oil	137.0	0	
Badelona II				Oil	344.0	0	
Castellon				Oil	1,083.4	0	
Mata				Oil	126.0	0	

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

ENERGY GENERATION FACILITIES IN EXISTENCE AND FIRMLY PLANNED PRODUCING 100 MWe (net)

Table 24.6.1 (continued)

Facility Name	Location	Utility/ Owner	Vendor	Facility Type (Fuel Type)	Capacity (MWe net)	Status*	COD
Pasajes				Oil	214.0	0	
Puertollano CSE				Oil	220.0	0	
Sabon				Oil	470.0	0	
San Adrian	Catalana	FEC		Oil	1,050.0	0	1976
Santura				Oil	918.9	0	
San Juan de Dios				Oil	200.0	0	
Jinamar				Oil	109.1	0	
Candelaria	Canaries	UEC		Oil	176.2	0	1976

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 24.6.2

Year	Capacity - MWe(net)
1975	24,534
1980	
1985	
1990	
1995	
2000	

[redacted]

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 24.6.3

Facility Name	Location	Owner	Facility Type	Capacity**	Status*
	Puentes		Coal Field		0
	Murama		Coal Field		0
	Andorra		Coal Field		0
Ayoluengo	Burgos		Oil Field	1,405	0
Amposto Marinos	Offshore Tarragone (Mediterranean)			14,510	0

* O-Operational; U-Under Construction; P-Planned; S-Shutdown

** Coal - million tonnes/year; Oil - barrels/day

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 24.6.4

RESOURCE	1985	2000
COAL (million tonnes)		
Indigenous Supply	17.16	19.24
Imports	0.64	8.86
Exports	-	-
CRUDE OIL (million tonnes)		
Indigenous Supply	2.17	2.63
Imports	36.33	74.67
Exports	-	-
SHALE OIL (million tonnes)		
Indigenous Supply	0	0
Imports		
Exports		
NATURAL GAS (cubic kilometers)		
Indigenous Supply	0.02	0.01
Imports	0.58	0.39
Exports	-	-
URANIUM (kilotonnes U_3O_8)		
Indigenous Supply	1.5	2.1
Imports	0.4	1.15
Exports	0	0