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Volume 2

INTERNATIONAL DATA COLLECTION AND ANALYSIS

Prepared for **MASTER**
U.S. Department of Energy
Under Contract No. EN-77-C-01-5072

Task 1
Volume 2
April 1979

NUCLEAR ASSURANCE CORPORATION

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AND

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by

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SECTION 7

CANADA

7.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

INDIGENOUS RESOURCES

Canada has a large coal resource. The World Energy Conference Survey (ref. 1.1) put this at 108,777 million tonnes of which 5,537 million tonnes were considered economically recoverable. Later studies (ref. 1.2) have revised the total indigenous resource to 103,035 million tonnes. However, the economically recoverable quantity has risen to 9,441 million tonnes. Reference 1.3 gives a total resource figure of 110,000 million tonnes. The bulk of Canadian coal resources are in the Rocky Mountains far from major energy markets and this limits the quantity that is economically recoverable. As world demand for coal rises with depletion of oil and gas resources, the reported economically recoverable reserves are expected to be revised upwards significantly.

Canada's oil resources are given as 16,373 million tonnes (ref. 1.2) of which 961 million tonnes are recoverable. These figures originate from a 1974 survey and are similar to those obtained in 1972. No new resources on land are anticipated.

Natural gas reserves have increased in recent years due to significant new finds and now stand at 3,145 km³ of which 2,832 km³ are economically recoverable.

Canada has very large uranium resources and reserves. Almost 215.1 thousand tonnes of U₃O₈ is considered economically recoverable, while total indicated and inferred resources are now estimated to be almost 990.3 thousand tonnes of U₃O₈. There are also very large reserves and resources of thorium.

Canada has significant hydro-power resources (about 7 % of world total) and currently produces about one-third of its ultimate potential.

No geothermal resources are reported.

A tidal scheme at the Bay of Fundy between the provinces of Nova Scotia and New Brunswick has been studied and considered uneconomic at the present time. It will be reviewed periodically, and is estimated to have an annual electrical capacity of 6.5 TWh.

ENERGY SUPPLY

Canada produces a total of approximately 25.3 million tonnes of solid fuels (ref. 1.5). This is equivalent to 14.34 million tonnes of oil and compares with 14.65 million tonnes of oil given in reference 1.6. Imports are significant, due to the location of resources being remote from major load centers, and almost the entire quantity is supplied by the United States. Exports are significant: 11.78 million tonnes (ref. 1.5), 11.9 million tonnes (ref. 1.6) but little goes to the United States.

Crude oil production stands at 80.4 million tonnes (ref. 1.5), 89.23 million tonnes (ref. 1.6). Imports are given as 41.43 million tonnes (ref. 1.5) and 41.45 million tonnes (ref. 1.6). A small quantity comes from the United States but Canada's entire oil exports, 30.94 million tonnes (ref. 1.5), 33.55 million tonnes (ref. 1.6), go to the United States.

Almost all gas requirements are met by internal production. Exports are significant (all going to the United States) and imports minimal.

Canada produced just over 6800 tonnes of U₃O₈ in 1977. There were no imports, but exports were large (actually exceeding that year's production).

PATTERNS OF ENERGY USE

The majority of coal supplies are used for power generation and industrial purposes. There is only a small household/commercial requirement.

Industrial consumption of petroleum is low compared with the other sectors.

The demand for natural gas is similar for both the industrial and household sectors who together consume almost 87 % of the total requirement.

Nuclear energy is used totally for electricity generation.

FORECASTS OF ENERGY SUPPLY AND DEMAND

Primary energy demand in Canada is expected to increase at an average annual rate of 3.5 % to 4.5 % between 1975 and 2000 while electricity demand is expected to increase at an average annual rate of 3.5 % to 6.9 %. The forecasts of demand are presented in Table 7.1.4.

A forecast of Canada's primary energy demand in 1985 was made by the Organization for Economic Co-operation and Development in 1974 which estimated an energy demand of $9,905 \times 10^{12}$ Btu to $11,660 \times 10^{12}$ Btu (248.8 to 292.9 million tonnes oil equivalent) depending upon the price of crude oil, and electricity demand in the same year was expected to reach at least 545 TWh (46.9 to 51.0 million tonnes oil equivalent). However, since the maximum price of oil considered was US\$ 9 per bbl a study based on the present energy price scenario could result in forecasts more in agreement with those presented in Table 7.1.4.

The breakdown of energy supply into its various sources given in Table 7.1.5 shows a small reduction in the relative importance of oil and gas and of hydro-electricity but the major change in the energy supply pattern is in the expansion of nuclear power after 1985. Installed nuclear capacity is expected to reach 12,000 MWe by 1985 and 20,000 - 22,000 MWe by 1990, supplying some 73 to 78 TWh of electricity in 1985 and some 122 to 145 TWh in 1990.

The development of new technology and the continuing escalation of oil prices should eventually make Canada's large reserves of oil in tar sands and in the remote northern regions economically recoverable but oil will remain a high-cost energy source and such changes would probably not significantly affect the trend away from its use.

INDIGENOUS ENERGY RESOURCES

Table 7.1.1

	Economically Recoverable Reserves	Total Indigenous Resources	Location of Identified Reserves
Hard Coal (million tonnes)	5,080	97,040	)) British Columbia) New Brunswick,) Alberta,) Saskatchewan
Soft Coal (million tonnes)	4,361	5,995	
Crude Oil (million tonnes)	961	16,373	Alberta
Shale Oil (million tonnes)	50,250	Not Available	Athabasca
Natural Gas (cubic km)	2,832	3,145	Alberta
Uranium (thousand tonnes U ₃ O ₈)	215.1	990.3	Ontario,
Thorium (thousand tonnes Th)	--	250.0	Saskatchewan
Hydro Power (TWh/year)	358.4	817.3	Quebec, Ontario, Manitoba
Geothermal (TWh/year)	0	0	Western Cordillera, Great Plains,W.Artic Meager Mt.,Br. Col.

ENERGY SUPPLY 1975

Table 7.1.2

Resource	Indigenous Supply	Imports		Exports	
		Total	% from US	Total	% to US
Hard Coal (million tonnes)	21.71	16.327	95.98	11.780	0.94
Soft Coal (million tonnes)	3.549	0	0	0	0
Crude Oil (million tonnes)	80.409	41.430	0.04	30.94	100
Shale Oil (million tonnes)	0	0	0	0	0
Natural Gas (cubic km)	75.8	0.289	100	26.97	100
Uranium (thousand tonnes U ₃ O ₈)	4.14	0	0	5.56	12
Electricity (TWh)	272.62	3.99	100	11.38	100

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 7.1.3

Resource	Consuming Sector				Total
	Household and Commercial	Industrial	Transportation	Electrical Generation	
Coal (million tonnes)	0.25	6.98	0.03	16.12	23.38
Petroleum (million tonnes)	20.44	12.48	36.9	2.92	72.74
Natural Gas (cubic km)	15.38	14.93	0	4.72	35.03
Nuclear Power (TWh)	0	0	0	11.86	11.86
Hydro Power (TWh)	0	0	0	202.4	202.4
Geothermal Power (TWh)	0	0	0	0	0
Utility Electricity Distributed (TWh)	122.81	118.97	0	31.63	273.4

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 7.1.4

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	8,000	272.6	8,000	272.6	8,000	272.6
1985	11,075	383.2	11,585	452.6	12,115	533.4
2000	18,684	638.6	21,110	968.5	23,841	1,460.0

CONSUMPTION OF ENERGY RESOURCES

Table 7.1.5

Resource	Standard Unit	Annual Consumption of Standard Units			Energy Consumption (10 ¹² BtU)		
		1975	1985	2000	1975	1985	2000
Coal	Million Tonnes	25.08	31.5	48.6	696.5	875	1,349
Crude Oil	Million Tonnes	72.23	113.2	183.1	3,112.9	4,878	7,890
Natural Gas	Cubic km	48.80	66.3	91.0	1,753.5	2,380	3,271
Hydro Power	TWh	202.40	231.1	355.2	2,302.0	2,630	4,040
Other Renewables	TWh	-	-	-	-	-	-
Nuclear Power	TWh	11.86	75.5	386.0	134.9	822	4,560
Uranium	Thousand Tonnes U ₃ O ₈	0.49	2.41	8.48	-	-	-

7.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

COMMERCIAL NUCLEAR POWER PLANTS

Table 7.2.1

Facility Name	Utility	Vendor	Facility Type	Capacity (MWe net)	Status*	COD
NPD(1)	Ontario Hydro	CGE	CANDU	20	0	Apr 1962
Douglas Point	Ontario Hydro	AECL	CANDU	208	0	Sep 1968
Gentilly 1	Hydro Quebec	AECL	CANDU (2)	250	0	Feb 1971
Pickering A1	Ontario Hydro	AECL	CANDU	514	0	Jul 1971
Pickering A2	Ontario Hydro	AECL	CANDU	514	0	Dec 1971
Pickering A3	Ontario Hydro	AECL	CANDU	514	0	Apr 1972
Pickering A4	Ontario Hydro	AECL	CANDU	514	0	May 1973
Bruce A1	Ontario Hydro	AECL	CANDU	746	0	Dec 1976
Bruce A2	Ontario Hydro	AECL	CANDU	746	0	Jun 1977
Bruce A3	Ontario Hydro	AECL	CANDU	746	0	Jan 1978
Bruce A4	Ontario Hydro	AECL	CANDU	746	U	Feb 1979
Gentilly 2	Hydro Quebec	AECL	CANDU	637	U	1980
Point Lepreau	N.B. Elec. Pow.	AECL	CANDU	630	U	1981
Pickering B1	Ontario Hydro	AECL	CANDU	514	U	1981
Pickering B2	Ontario Hydro	AECL	CANDU	514	U	1982
Pickering B3	Ontario Hydro	AECL	CANDU	514	U	1982
Pickering B4	Ontario Hydro	AECL	CANDU	514	U	1983
Bruce B1	Ontario Hydro	AECL	CANDU	769	U	1983
Bruce B2	Ontario Hydro	AECL	CANDU	769	U	1984
Bruce B3	Ontario Hydro	AECL	CANDU	769	U	1984
Bruce B4	Ontario Hydro	AECL	CANDU	769	U	1986

Table 7.2.1 (cont'd)

Facility Name	Utility	Vendor	Facility Type	Capacity (MWe net)	Status*	COD
Darlington 1	Ontario Hydro	AECL	CANDU	850	P	1985
Darlington 2	Ontario Hydro	AECL	CANDU	850	P	1986
Darlington 3	Ontario Hydro	AECL	CANDU	850	P	1987
Darlington 4	Ontario Hydro	AECL	CANDU	850	P	1988

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

(1) Demonstration Reactor

(2) BLWR.

PROJECTED NUCLEAR GENERATING CAPACITY
MWe (net)

Table 7.2.2

Year	PWR	BWR	Magnox	AGR	CANDU	Other	FBR	Firm + Planned Cumulative Total	NAC Cumulative Projection
pre-1978					4212			4212	4212
1978					850			5062	5062
1979					745			5807	5807
1980					1200			7007	7007
1981					514			7521	7521
1982					1028			8549	8549
1983					1264			9813	9813
1984					1500			11313	11313
1985					850			12163	12163
1986					1600			13763	13763
1987					2550			16313	16313
1988					2550			16313	18863
1989					2300			16313	21163
1990					3400			16313	24563
1991					2550			16313	27113
1992					3400			16313	30513
1993					2550			16313	33063
1994					3400			16313	36463
1995					2550			16313	39013
1996					3400			16313	42413
1997					2550			16313	44963
1998					3400			16313	48363
1999					2550			16313	50913
2000					3400			16313	54313

NUCLEAR REACTOR VENDORS

Overview

Canada's nuclear reactor vendor is the national government company, Atomic Energy of Canada, Ltd. or AECL. AECL provides the engineering design of the NSSS for the CANDU (CANada Deuterium Uranium) reactor system. AECL established its Nuclear Power Plant Division in 1958. Its first project was the prototype 200 MWe Douglas Point nuclear generating station. AECL owns this station, which was built cooperatively with Ontario Hydro. AECL's Nuclear Power Plant Division managed the project and provided the engineering for the nuclear steam supply system. Ontario Hydro provided the balance of the engineering services and built the station.

Since then, the Nuclear Power Plant Division, now Power Projects, has performed the engineering for the nuclear steam supply systems for the Indian Department of Atomic Energy's two unit (200 MWe each) Rajasthan station; Ontario Hydro's Pickering and Bruce stations, with four 500 MWe and four 750 MWe units, respectively; and the 250 MWe Gentilly-1 nuclear power station. Like Douglas Point, Gentilly-1 is a prototype plant which is owned by AECL. AECL repeated its design of the 2,000 MWe Pickering A station at Pickering B, and the 3,000 MWe Bruce A station at Bruce B and Darlington, although Darlington will incorporate certain evolutionary changes. AECL is also providing the engineering for the NSSS for 600 MWe units at Gentilly-2, New Brunswick, Rio Tercero in Argentina, and Wolsung in South Korea.

In addition to the reactor orders shown in Table 7.2.3, AECL has contracted with Rumania to sell as many as four CANDU 600 MWe nuclear units. One is ordered now with an option on a second unit and the other two will be ordered in the late 1980's.

Other than AECL, Canadian General Electric, CGE, has provided the engineering for Canada's first nuclear power plant, the 20 MWe NPD station. CGE later supplied and built the 137 MWe Kanupp plant at Karachi, Pakistan. In 1968, however, CGE withdrew from the field of plant engineering to concentrate on the engineering of nuclear plant equipment.

Vendor: AECL

Summary of Orders

Table 7.2.3

<u>Country</u>	<u>Reactor Name</u>	<u>Utility</u>	<u>Type</u>	<u>MWe(net)</u>	<u>COD</u>
Canada	Douglas Point	Ontario Hydro	CANDU	208	Sep 1968
Canada	Gentilly 1	Hydro Quebec	CANDU	250	Feb 1971
Canada	Pickering A1	Ontario Hydro	CANDU	514	Jul 1971
Canada	Pickering A2	Ontario Hydro	CANDU	514	Dec 1971
Canada	Pickering A3	Ontario Hydro	CANDU	514	Apr 1972
Canada	Pickering A4	Ontario Hydro	CANDU	514	May 1973
Canada	Bruce A1	Ontario Hydro	CANDU	746	Dec 1976
Canada	Bruce A2	Ontario Hydro	CANDU	746	Jun 1977
Canada	Bruce A3	Ontario Hydro	CANDU	746	1978
Canada	Bruce A4	Ontario Hydro	CANDU	746	1979
Canada	Gentilly 2	Hydro Quebec	CANDU	637	1980
Canada	Point Lepreau	N.B. Elec. Power	CANDU	630	1981
Canada	Pickering B1	Ontario Hydro	CANDU	514	1981
Canada	Pickering B2	Ontario Hydro	CANDU	514	1982
Canada	Pickering B3	Ontario Hydro	CANDU	514	1982
Canada	Pickering B4	Ontario Hydro	CANDU	514	1983
Canada	Bruce B1	Ontario Hydro	CANDU	769	1983
Canada	Bruce B2	Ontario Hydro	CANDU	769	1984
Canada	Bruce B3	Ontario Hydro	CANDU	769	1984
Canada	Bruce B4	Ontario Hydro	CANDU	769	1986

Table 7.2.3 (cont'd)

<u>Country</u>	<u>Reactor Name</u>	<u>Utility</u>	<u>Type</u>	<u>MWe(net)</u>	<u>COD</u>
Canada	Darlington 1	Ontario Hydro	CANDU	850	1985
Canada	Darlington 2	Ontario Hydro	CANDU	850	1986
Canada	Darlington 3	Ontario Hydro	CANDU	850	1987
Canada	Darlington 4	Ontario Hydro	CANDU	850	1988
India	Rajasthan-1	Dept. of Atomic Energy	CANDU	202	Dec 1973
India	Rajasthan-2	Dept. of Atomic Energy	CANDU	202	1979
Argentina	Cordoba-1	CNEA	CANDU	600	1981
South Korea	Wolsung	KECO	CANDU	600	1982

Capacity, Capacity Limiting Factors, Ability to Expand and Expansion Plans

Since AECL provides engineering and project management services, and does not provide the hardware for the nuclear steam supply systems, its capacity is difficult to define. Capacity limiting factors would be only in the area of personnel and the ability to expand is a function of how fast the company could hire and train people.

Past and Present Marketing Strategy

Canada is considered a closed market to non-Canadian reactor vendors. AECL and the utility companies are so closely associated that it is inconceivable that any other supplier could penetrate the market. As long as the CANDU system remains comparable to other designs in terms of costs and reliability, domestic sales will be automatic.

In the international market place, AECL has made sales to developing countries: India, Pakistan, Argentina, and South Korea. A common interest of all of these countries (with South Korea as a possible exception) is not to be dependent on the few countries that provide enrichment services and therefore control fuel supplies.

Market Share Attained: AECL

Table 7.2.4

<u>Year</u>	<u>MWe(net)</u>	<u>Com.</u>	<u>Domestic</u>		<u>%</u>	<u>International</u> <u>(non-Canada, non-US)</u>		
			<u>Uncom.</u>			<u>Com.</u>	<u>Uncom.</u>	<u>%</u>
pre-1978	4419	4232	0		100	32658	0	0.6
1978	850	850	0		100	11609	0	0.0
1979	952	745	0		100	15895	0	1.3
1980	1200	1200	0		100	14957	0	0.0
1981	1114	514	0		100	17415	0	3.4
1982	1628	1028	0		100	10203	0	6.0
1983	1264	1264	0		100	13845	1867	0.0
1984	1500	1500	0		100	14870	4644	0.0
1985	850	850	0		100	15333	5468	0.0
1986	1600	1600	0		100	11643	14404	0.0
1987	1450	850	1700		100	5022	17200	11.9
1988	850	850	1700		100	2268	24930	0.0
1989	0	0	2300		0	1240	23373	0.0
1990	0	0	3400		0	2152	26631	0.0
Total thru 1990	17677	15483	9100		99.9	169160	118517	1.3

Projected Future Marketing Strategy

AECL has a captive market in Canada. The CANDU reactors in operation have performed well in comparison to other reactor types in different countries and costs are competitive, thus there is simply no incentive for Canadian utilities to import new technology.

In the international market, AECL has a stronger position than ever before. This new strength is not due so much to technological advancement or marketing strategy on behalf of AECL, but is a result of the new US policies to curb the threat of proliferation. The CANDU fuel cycle, with its high utilization of natural uranium, can be more attractive in costs and resource conservation. In addition, the CANDU fuel cycle, which is once-through, no recycle, can be more attractive from a non-proliferation standpoint. The CANDU reactor is also technically capable of operating on a thorium cycle (although a new industrial infrastructure, including reprocessing, is necessary to process the fuel), an important factor to countries with large thorium, but small uranium resources. AECL's new market strength is evident from the consideration of Electric Power Development Corp., EPDC, in Japan to introducing the CANDU reactor system, after Japanese industries have spent years building up their capabilities to construct LWR's.

Vendor: Canadian General Electric

Summary of Orders

Table 7.2.5

<u>Country</u>	<u>Reactor Name</u>	<u>Utility</u>	<u>Type</u>	<u>MWe(net)</u>	<u>COD</u>
Canada	NPD	Ontario Hydro	CANDU	20	Apr 1962
Pakistan	Kanupp	AEC	CANDU	137	Apr 1972

Capacity, Capacity Limiting Factors, Ability to Expand, and Expansion Plans

Canadian General Electric discontinued its activities as a reactor supplier in 1968 and has no plans for re-entering the business.

Past and Present Marketing Strategy

See paragraph above.

Projected Future Marketing Strategy

None

Market Share Attained: CGE

Table 7.2.6

<u>Year</u>	<u>MWe(net)</u>	<u>Domestic</u>			<u>International</u>		
		<u>Com.</u>	<u>Uncom.</u>	<u>%</u>	<u>Com.</u>	<u>Uncom.</u>	<u>%</u>
pre-1978	145	4232	0	.6	32658	0	3.0
1978	0	850	0	0	11609	0	0
1979	0	745	0	0	15895	0	0
1980	0	1200	0	0	14957	0	0
1981	0	514	0	0	17415	0	0
1982	0	1028	0	0	10203	0	0
1983	0	1264	0	0	13845	1867	0
1984	0	1500	0	0	14870	4644	0
1985	0	850	0	0	15333	5468	0
1986	0	1600	0	0	11693	14404	0
1987	0	850	1700	0	5022	17200	0
1988	0	850	1700	0	2268	24930	0
1989	0	0	2300	0	1240	23373	0
1990	0	0	3400	0	1240	26631	0
<hr/>							
Total thru 1990	145	15483	9100	0.1	169160	118517	0.07

Nuclear Reactor Vendor Support Industries

AECL does not manufacture reactor components itself (although it does operate laboratories to develop, test, and qualify critical components such as reactor control devices, refueling machines, valves, pumps, etc.). There is a major industrial infrastructure to provide the equipment and hardware for the reactor construction including: Babcock & Wilcox Canada, steam generators, reheaters, heat exchangers; Bristol Aerospace, fuel channel components and pressure tubes, control rod mechanism components and guide tubes; Byron Jackson, large pumps; Canadian General Electric, special reactor components and machinery; Chase Nuclear, pressure tubes; Combustion Engineering, heat exchangers; Dominion Bridge Co., reactor vessels and calandria, refueling machines; Foster Wheeler, steam generators, heat exchangers, condensers, feedwater heaters, reheaters; Horton Steelwork, pressure vessels and reactor containment, storage and waste disposal tanks; Marine Industries, reactor vessels steam generators, core components; MLW Industries, heat exchangers; Standard-Modern Tool Co., fueling heads and handling systems; Westinghouse Canada, calandria tubes and core components.

NUCLEAR FUEL CYCLE FACILITIES

Overview

Canada has fuel cycle facilities to handle all of the fuel processing for the domestic reactor program. The CANDU reactor fuel cycle is relatively simple compared to the light water reactor fuel cycle, involving U₃O₈ to UO₂ powder conversion, pelletizing, and rod and assembly fabrication. The current CANDU reactor fuel cycle is based on a once-through cycle, so no reprocessing is planned for the near-term.

Canada has six uranium producers: Denison Mines Limited and Rio Algom Limited at Elliot Lake, Agnew Lake Mines Limited, near Elliot Lake, Madawaska Mines Limited near Bancroft, Eldorado Nuclear Limited at Beaverlodge and Gulf Minerals Canada Limited/Uranerz Canada Limited at Rabbit Lake. Two additional facilities at Cluff Lake and Key Lake are expected to start operating in the early 1980's. Canada is a major exporter of uranium with more than 90% of its total production exported.

Eldorado Nuclear, a crown corporation, is one of five U₃O₈ to UF₆ converters in the world. All of Eldorado services are provided to non-Canadian customers, since the CANDU reactor fuel does not require enrichment and hence the conversion step to UF₆. Eldorado also provides the U₃O₈ to UO₂ powder conversion step for CANDU fuel.

There are two fabricators of the CANDU reactor fuel elements: Canadian General Electric and Westinghouse Canada. In addition, Combustion Engineering is developing a CANDU fuel fabrication plant and will compete. AECL is involved in the design and testing of fuel, but is not a supplier to the utility industry on a commercial basis.

CURRENT AND PLANNED FACILITIES

Table 7.2.7

Facility Name	Location	Facility Type	MTU/YR	Capacity Status		Shareholdings
				Status*	Year	
Elliot Lake	Elliot Lake, Ontario	mine/mill	2300	0	1953	100% Denison Mines Ltd.
Beaverlodge	Beaverlodge, Saskatchewan	mine/mill	577	0	1953	100% Eldorado Nuclear Ltd.
Quirke	Elliot Lake, Ontario	mine/mill	1922	0	1968	100% Rio Algom Ltd.
Rabbit Lake	Rabbit Lake, Saskatchewan	mine/mill	1730	0	1975	51% Gulf Minerals Canada Ltd. 49% Uranerz Canada Ltd.
Faraday	Bancroft, Ontario	mine/mill	307	0	1976	51% Federal Resources Corp. 49% Consolidated Canadian Faraday
Agnew Lake	Sudburg	mine/mill	385	0	1977	90% Kerr-Addison Mines Ltd. 10% Uranerzbergbau GmbH
Cluff Lake	Cluff Lake, Saskatchewan	mine/mill	1045	P	1981	30% CEA 45% IMETAL 25% Minatome
Key Lake	La Ronge, Saskatchewan	mine/mill	2300	P	1983	50% Saskatchewan Mining & Development Corp. 33.3% Uranerz Exploration & Mining Co. 16.7% Eldorado Nuclear Ltd.
Stanleigh	Elliot Lake, Ontario	mine/mill	770	P	1984	100% Preston Mines

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

CURRENT AND PLANNED FACILITIES

Table 7.2.7 (cont.)

Facility Name	Location	Facility Type	MT/YR	Capacity Status		Shareholdings
				Status*	Year	
Port Hope	Port Hope, Ontario	conversion	4000	O	1970	100% Eldorado Nuclear Ltd.
Sudbury**	Sudbury, Ontario	conversion	10,000	P	1981	100% Eldorado Nuclear Ltd.
Canadian General Electric	Peterborough, Ontario	fabrication	?	O	?	100% Canadian General Electric
Westinghouse Canada	Port Hope, Ontario	fabrication	?	O	?	100% Westinghouse Canada

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

Note: Canada has three heavy water plants in operation: 100 kg/h Bruce Heavy Water Plant and two 50 kg/h plants in Nova Scotia. Two more 100 kg/h units are being considered at the Bruce Heavy Water Plant as well as a 100 kg/h plant near Gentilly power station. Due to uncertainties of power needs, the future of these three additional plants is in question.

** Site has not been determined. Initially selected Port Granby as site, but environmental resistance was encountered. Sudbury has been selected as alternate site.

Facility: Denison Mines U₃O₈ Mine/Mill

Description of Operation

The Denison mine and mill complex is located at Elliot Lake in Ontario and has been in operation since 1953. An acid leach, ion exchange process is employed at the mill. The capacity of the mill was increased from 6000 TPD of ore to 7100 TPD at the end of 1976. Most of the ore comes from the Quirke Lake underground mine which has an average ore assay of 0.09% U₃O₈. A second mine is under evaluation for possible operation in the 1980's. This mine, the Clearwater mine, would be an open pit operation and the ore assay is estimated to be 0.075%. The company's reserves are estimated at over 116,000 MTU. If the Clearwater mine is developed, it will be operated by Consolidated Rexbar Minerals and Chemicals Ltd., a Denison subsidiary. The deposit is estimated to contain about 730 MTU.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The 7100 TPD mill had a nominal capacity of 1900 MTU/year and was enlarged to 2300 MTU/year in 1978. A continuing expansion program will involve gradually increasing the capacity of the existing mill to 12,000 TPD, re-opening of the Stanrock and Can-Met workings and possibly establishing a new mill at this location by 1985 with a capacity of 3000-4000 TPD. The yearly output of the existing facilities is expected to be 2700 MTU in 1980 and 3075 MTU in 1982 as a result of the continuing expansion program.

Past and Present Marketing Strategy

Most of the past contracts which Denison has signed have been with Japanese utilities. A small percentage of the sales have also been to customers in Europe. Over 45% of the past production was sold to the Canadian government in three different joint stockpiling efforts when the market was depressed in the 1960's and early 1970's. The company currently has contract commitments of about 23,000 MTU for delivery through 1994 to customers in Japan. In late 1977 the company entered into an agreement with Ontario Hydro to provide over 48,000 MTU over the period 1980-2011.

Market Share Attained: Denison

Uranium Concentrate

Table 7.2.8
(ST U₃O₈)

Region: Domestic (Canada)

<u>Year</u>	<u>Denison Deliveries to Canada</u>	<u>Total Deliveries to Canada</u>	<u>Total Canadian Requirements</u>	<u>Total Canadian Uncommitted</u>	<u>Denison Market Share of Committed Deliveries, %</u>
pre-1978	6936	4174	3952	0	0.0
1978	0	505	1021	445	0.0
1979	0	451	961	450	0.0
1980	500	1151	1416	222	43.4
1981	500	1301	1429	223	38.4
1982	500	1301	1653	268	38.4
1983	500	1301	1563	268	38.4
1984	1000	2300	2019	265	43.5
1985	1000	2300	2646	566	43.5
1986	1000	2000	2617	715	50.0
1987	1000	2000	3058	943	50.0
1988	1000	2000	3660	1545	50.0
1989	1000	2000	3878	1763	50.0
1990	1000	2000	4572	2457	50.0

Market Share Attained: Denison

Uranium Concentrate

Table 7.2.8 (cont.)
(ST U₃O₈)

Region: International (non-Canada, non-US)

<u>Year</u>	<u>Denison Deliveries</u>	<u>Total Deliveries</u>	<u>Requirements</u>	<u>Uncommitted</u>	<u>Denison Market Share of Committed Deliveries, %</u>
pre-1978	16171	135725	101656	0	11.9
1978	3403	30650	19405	1468	11.1
1979	3627	29495	23866	2602	12.3
1980	2267	20012	25505	3359	11.3
1981	2097	32797	27892	2843	6.4
1982	1812	33617	28684	2566	5.4
1983	1845	34922	35418	4865	5.3
1984	3851	36285	38984	8926	10.6
1985	3700	34723	44311	13144	10.7
1986	2000	31425	50626	20760	6.4
1987	2000	30237	52156	22964	6.6
1988	2000	30645	61210	32474	6.5
1989	2000	28317	62197	32516	7.1
1990	2000	29172	72785	41118	6.9

Production History: Denison
Uranium Concentrates

Table 7.2.9
(MTU)

<u>Year</u>	<u>Quantity</u>
1957	1674.62
1958	1630.77
1959	1890.77
1960	1889.23
1961	2068.85
1962	1863.00
1963	1953.46
1964	1519.23
1965	985.00
1966	1057.31
1967	1365.00
1968	1478.08
1969	
1970	
1971	1636.92
1972	1505.47
1973	1316.92
1974	1079.46
1975	1119.62
1976	1196.92
1977	1538.58

Projected Future Marketing Strategy

Negotiations are continuing for sales in the Canadian market to satisfy the government's policy of assurance of supply to meet domestic requirements. Denison has completed a major contract with Ontario Hydro which will reserve a large portion of the company's capacity for domestic requirements. Much of the existing capacity is committed through the 1980's. Because of the close historical ties with Japan, additional future contracts over and above those to domestic utilities will likely be with Japan. A safeguards agreement with Japan has been concluded and deliveries commenced in 1978.

Facility: Eldorado Nuclear Ltd.

Description of Operation

The Eldorado mill at Beaverlodge, Saskatchewan currently has a nominal capacity of 1800 TPD of ore and uses an alkaline leach, direct precipitation process. Recently the mill has been operating at about 1000 TPD. About 90% of the ore feed to the mill is provided by the Fay mine near the mill. The Verna mine was re-opened in 1976 and provides most of the remainder of the ore feed. Both of the mines are underground operations. Proven reserves for the company are estimated at about 6445 MTU grading 0.20% with the potential for considerably more reserves. The mill has been in operation since 1953.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The annual capacity of the mill is currently 577 MTU/year. Eldorado is conducting a \$44 million expansion program which will double the U_3O_8 production to 1.8 million pounds U_3O_8 per year by late 1979. It is anticipated that the yearly output will be increased to 692 MTU by 1980.

Past and Present Marketing Strategy

In the past, the majority of Eldorado's contracts for U_3O_8 have been with customers in Europe. A few sales have also been made to customers in the US and Japan. Over 25% of the past production was sold to the Canadian government under a joint stockpiling effort in the late 1960's when the uranium market was depressed. Recently the company loaned some material to Agnew Lake Mines to meet contract commitments until that facility was brought into production. Eldorado has contract commitments to deliver about 6900 MTU in 1977-1990 to customers in the US and Europe.

Market Share Attained: Eldorado

Uranium Concentrates

Table 7.2.10

(ST U₃O₈)

Region: Domestic (Canada)

<u>Year</u>	<u>Eldorado Deliveries to Canada</u>	<u>Total Deliveries to Canada</u>	<u>Total Canadian Requirements</u>	<u>Total Canadian Uncommitted</u>	<u>Eldorado Market Share of Committed Deliveries, %</u>
pre-1978	1407	4174	3952	0	0.0
1978	0	505	1021	445	0.0
1979	0	451	961	450	0.0
1980	0	1151	1416	222	0.0
1981	0	1301	1429	223	0.0
1982	0	1301	1653	268	0.0
1983	0	1301	1563	268	0.0
1984	0	2300	2019	265	0.0
1985	0	2300	2646	566	0.0
1986	0	2000	2617	715	0.0
1987	0	2000	3058	943	0.0
1988	0	2000	3660	1545	0.0
1989	0	2000	3878	1763	0.0
1990	0	2000	4572	2457	0.0

Market Share Attained: Eldorado

Uranium Concentrates

Table 7.2.10 (cont.)
(ST U₃O₈)

Region: International (non-Canada, non-US)

<u>Year</u>	<u>Eldorado Deliveries</u>	<u>Total Deliveries</u>	<u>Requirements</u>	<u>Uncommitted</u>	<u>Eldorado Market Share of Committed Deliveries, %</u>
pre-1978	4027	135725	101656	0	2.9
1978	703	30650	19405	1468	2.2
1979	746	29495	23866	2602	2.5
1980	950	20012	25505	3359	4.7
1981	998	32797	27892	2843	3.0
1982	494	33617	28684	2566	1.5
1983	465	34922	35418	4865	1.3
1984	477	36285	38984	8926	1.3
1985	469	34723	44311	13144	1.4
1986	371	31425	50626	20760	1.2
1987	72	30237	52156	22964	0.2
1988	0	30645	61210	32474	0.0
1989	0	28317	62197	32516	0.0
1990	0	29172	72785	41118	0.0

Production History: Eldorado
Uranium Concentrates

Table 7.2.11
(MTU)

<u>Year</u>	<u>Quantity</u>
1953	)
1954	
1955	
1956	
1957	
1958	1950.49
1959	964.49
1960	920.30
1961	944.00
1962	851.88
1963	753.76
1964	713.54
1965	706.55
1966	692.49
1967	649.04
1968	770.53
1969	769.86
1970	600.91
1971	589.19
1972	463.23
1973	513.33
1974	539.45
1975	441.36
1976	379.23
1977	456.92
	455.31

Projected Future Marketing Strategy

Eldorado's capacity is fully committed into the 1980's. Additional sales will likely first be to Canadian utilities to cover future domestic requirements.

Eldorado recently borrowed uranium from the Canadian government stockpile to finance its acquisition of an interest in the Key Lake deposit and therefore is in a position to meet non-Canadian customer needs in the near future.

Facility: Rio Algom U₃O₈ Mine/Mill

Description of Operation

The 7000 TPD Quirke mill operated by Rio Algom at Elliot Lake, Ontario, has been in operation since 1968. An acid leach, ion exchange process is used at the mill. The New Quirke underground mine near the mill provides most of the ore feed to the mill. A second underground mine, the Panel mine, is to be opened in 1980. The total reserves for the company exceed 49,360 MTU. At the New Quirke mine, reserves average 0.12% U₃O₈ while at Panel, the ore assay is estimated at 0.11%.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

Currently, the annual output of the mill is 1923 MTU. An expansion has increased the capacity of the mill to 7000 TPD. It is anticipated that the annual output will be increased to 2700 MTU in 1980 and 3075 MTU in 1982. With the anticipated opening of the Panel mine, a new mill at that site will be placed in operation in 1980. The Stanleigh mine and mill, owned 100% by affiliate, Preston Mines, should start up in 1984 with a capacity of 3000 TPD.

Past and Present Marketing Strategy

Historically, Rio Algom has sold material to Europe, Japan, the US and Canadian customers. The majority of the past sales have been to European customers and the most recent contracts have been with US utilities. Through affiliate, Preston Mines, a sale of 72,000,000 lbs. U₃O₈ to Ontario Hydro was concluded in December 1977 for delivery 1984-2020. Currently the company has contract commitments of over 30,000 MTU to customers in Japan, the US, and Europe. The major long-term commitments are with customers in the US and Europe.

Market Share Attained: Rio Algom

Uranium Concentrates

Table 7.2.12

(ST U₃O₈)

Region: Domestic (Canada)

<u>Year</u>	<u>Rio Algom Deliveries to Canada</u>	<u>Total Deliveries to Canada</u>	<u>Total Canadian Requirements</u>	<u>Total Canadian Uncommitted</u>	<u>Rio Algom Market Share of Committed Deliveries, %</u>
pre-1978	4095	4174	3952	0	92.2
1978	451	505	1021	445	84
1979	451	451	961	450	100.0
1980	451	1151	1416	222	39.2
1981	451	1301	1429	223	34.7
1982	451	1301	1653	268	34.7
1983	451	1301	1563	268	34.7
1984	1000	2300	2019	265	43.5
1985	1000	2300	2646	566	43.5
1986	1000	2000	2617	715	50.0
1987	1000	2000	3058	943	50.0
1988	1000	2000	3660	1545	50.0
1989	1000	2000	3878	1763	50.0
1990	1000	2000	4572	2457	50.0

Market Share Attained: Rio Algom

Uranium Concentrates

Table 7.2.12 (cont.)

(ST U₃O₈)

Region: International (non-Canada, non-US)

<u>Year</u>	<u>Rio Algom Deliveries</u>	<u>Total Deliveries</u>	<u>Requirements</u>	<u>Uncommitted</u>	<u>Rio Algom Market Share of Committed Deliveries, %</u>
pre-1978	19840	135725	101656	0	14.6
1978	2355	30650	19405	1468	7.7
1979	2183	29495	23866	2602	7.4
1980	1326	20012	25505	3359	6.6
1981	1440	32797	27892	2843	4.4
1982	1541	33617	28684	2566	4.6
1983	1821	34922	35418	4865	5.2
1984	2299	36285	38984	8926	6.3
1985	2044	34723	44311	13144	5.9
1986	1000	31425	50626	20760	3.2
1987	1000	30237	52156	22964	3.3
1988	1000	30645	61210	32474	3.3
1989	1000	28317	62197	32516	3.5
1990	1000	29172	72785	41118	3.4

Production History: Rio Algom
Uranium Concentrates

Table 7.2.13
(MTU)

<u>Year</u>	<u>Quantity</u>
1968	
1969	1265.37
1970	1536.53
1971	1727.69
1972	1983.85
1973	1853.08
1974	1096.54
1975	1784.23
1976	1724.23
1977	1625.11

Projected Future Marketing Strategy

Rio Algom, through affiliate, Preston Mines, finalized a contract with Ontario Hydro for supply of 72,000,000 lbs. U₃O₈ in 1977.

Rio Algom could reactivate dormant properties to supply export demands beyond the mid-1980's.

Facility: Gulf Minerals Canada U₃O₈ Mine/Mill

Description of Operation

The Rabbit Lake mine and mill complex owned by Gulf Minerals and Uranerz Canada has been in operation since October, 1975. An acid leach, solvent extraction, counter current decantation process is used and the mill has a nominal capacity of 2000 TPD. Mining is by open pit methods and the average ore assay is estimated to be 0.32%. Proven reserves are estimated at 17,305 MTU, although total potential reserves at Rabbit Lake and surrounding areas may be twice that amount. Full production was attained in the third quarter of 1976. Gulf Minerals is the operator of the complex. The deposit was discovered in 1968.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The 2000 TPD mill has a nominal annual capacity of 1730 MTU per year. No plans exist for further expansions at the present. In 1976, the first full year of operation, production totaled 1430 MTU.

Present and Past Marketing Strategy

Gulf Minerals and Uranerz each market their share of the mill's output independently. At present, Gulf has total contract commitments of about 4450 MTU for delivery to customers in Europe, Canada, and Japan in 1977-1985. Uranerz, a subsidiary of the West German firm Uranerzbergbau GmbH, has total commitments of about 5280 MTU for delivery in 1977-1984. In the past, Uranerz has contracted almost exclusively with European customers. Forward deliveries are to customers in Europe and the US.

Market Share Attained: GMC

Uranium Concentrates

Table 7.2.14
(ST U₃O₈)

Region: Domestic (Canada)

<u>Year</u>	<u>GMC Deliveries to Canada</u>	<u>Total Deliveries to Canada</u>	<u>Total Canadian Requirements</u>	<u>Total Canadian Uncommitted</u>	<u>GMC Market Share of Committed Deliveries, %</u>
pre-1978	26	4174	3952	0	0.6
1978	0	505	1021	445	0.0
1979	0	451	961	450	0.0
1980	200	1151	1416	222	17.4
1981	350	1301	1429	223	26.9
1982	350	1301	1653	268	26.9
1983	350	1301	1563	268	26.9
1984	300	2300	2019	265	13.0
1985	300	2300	2646	566	13.0
1986	0	2000	2617	715	0.0
1987	0	2000	3058	943	0.0
1988	0	2000	3660	1545	0.0
1989	0	2000	3878	1763	0.0
1990	0	2000	4572	2457	0.0

Market Share Attained: GMC

Uranium Concentrates

Table 7.2.14 (cont.)
(ST U₃O₈)

Region: International (non-Canada, non-US)

<u>Year</u>	<u>GMC Deliveries</u>	<u>Total Deliveries</u>	<u>Requirements</u>	<u>Uncommitted</u>	<u>GMC Market Share of Committed Deliveries, %</u>
pre-1978	2647	135725	101656	0	2.0
1978	245	30650	19405	1468	0.8
1979	245	29495	23866	2602	0.8
1980	200	20012	25505	3359	1.0
1981	704	32797	27892	2843	2.1
1982	840	33617	28684	2566	2.5
1983	306	34922	35418	4865	0.9
1984	200	36285	38984	8926	0.6
1985	200	34723	44311	13144	0.6
1986	0	31425	50626	20760	0.0
1987	0	30237	52156	22964	0.0
1988	0	30645	61210	32474	0.0
1989	0	28317	62197	32516	0.0
1990	0	29172	72785	41118	0.0

Production History: GMC
Uranium Concentrates

Table 7.2.15
(MTU)

<u>Year</u>	<u>Quantity</u>
1975	278.85
1976	1432.69
1977	1934.67

Projected Future Marketing Strategy

A portion of the future output of the mill will be reserved for use in meeting domestic requirements under the government policy. Gulf and Uranerz each have a contract with a Canadian utility. Because of the ties with West Germany, future sales by Uranerz will probably be to Europe, in particular to West Germany. The US would have to be considered a strong candidate as a future customer of Gulf Minerals, although Europe and Japan are also likely possibilities.

Facility: Agnew Lake U₃O₈ Mine/Mill

Description of Operation

The in-situ leaching operation of Agnew Lake at Sudburg began operations in June, 1977. In this type of process, sulfuric acid is pumped into the ore zone or sprayed on an ore stockpile, and the pregnant solution is collected and processed using an ion exchange, solvent extraction method. The ore is rather low grade material with the average ore assay estimated at 0.0545%. Reserves at the mine are estimated to be 4700 MTU. Initial production came from surface stockpiles and subsequent production will be from underground sources.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The existing annual rated capacity of the mill is about 385 MTU. No plans exist at present to expand the capacity beyond this figure. Technical difficulties have prevented the attainment of this capacity to date and maximum capacity is projected to be achieved in 1980.

Past and Present Marketing Strategy

Agnew Lake currently has contract commitments of about 1850 MTU for delivery in 1977-1990. Uranerzbergbau markets its 10% share of the output independently to customers in Europe. Agnew Lake has contracted with customers in Korea, Sweden, and the United States. All contracts have recently been approved for export by the Canadian government.

Market Share Attained: Agnew Lake

Uranium Concentrates

Table 7.2.16

(ST U₃O₈)

Region: Domestic (Canada)

<u>Year</u>	<u>Agnew Lake Deliveries to Canada</u>	<u>Total Deliveries to Canada</u>	<u>Total Canadian Requirements</u>	<u>Total Canadian Uncommitted</u>	<u>Agnew Lake Market Share of Committed Deliveries, %</u>
pre-1978	1	4174	3952	0	0
1978	0	505	1021	445	0
1979	0	451	961	450	0
1980	0	1151	1416	222	0
1981	0	1301	1429	223	0
1982	0	1301	1653	268	0
1983	0	1301	1563	268	0
1984	0	2300	2019	265	0
1985	0	2300	2646	566	0
1986	0	2000	2617	715	0
1987	0	2000	3058	943	0
1988	0	2000	3660	1545	0
1989	0	2000	3878	1763	0
1990	0	2000	4572	2457	0

Market Share Attained: Agnew Lake

Uranium Concentrates

Table 7.2.16 (cont.)
(ST U₃O₈)

Region: International (non-Canada, non-US)

<u>Year</u>	<u>Agnew Lake Deliveries</u>	<u>Total Deliveries</u>	<u>Requirements</u>	<u>Uncommitted</u>	<u>Agnew Lake Market Share of Committed Deliveries, %</u>
pre-1978	638	135725	101656	0	0.3
1978	233	30650	19405	1468	0.4
1979	225	29495	23866	2602	0.4
1980	303	20012	25505	3359	1.0
1981	225	32797	27892	2843	0.4
1982	40	33617	28684	2566	0.1
1983	28	34922	35418	4865	0.1
1984	0	36285	38984	8926	0
1985	50	34723	44311	13144	0
1986	50	31425	50626	20760	0
1987	50	30237	52156	22964	0
1988	50	30645	61210	32474	0
1989	50	28317	62197	32516	0
1990	50	29172	72785	41118	0

Projected Future Marketing Strategy

A portion of the future output will have to be reserved for domestic Canadian use. In addition, Agnew Lake must repay Eldorado for the material which was borrowed in 1976 to meet commitments until production could begin. Future sales will likely be to the US and Europe.

Facility: Madawaska Mines U₃O₈ Mine/Mill

Description of Operation

Madawaska Mines, 51% owned by the US firm Federal Resources Corp. and 49% by Consolidated Canadian Faraday, operates a mine and mill complex near Bancroft, Ontario. The 1500 TPD mill started up in September, 1976, and uses an acid leach, solvent extraction process. Mining is conducted by open pit methods and the ore assay is estimated at 0.12%. Indicated reserves of about 2192 MTU have been identified with an additional 1077 MTU of inferred reserves present. The mine was in production between 1957 and 1964, but was shut down when the market declined. Start-up in 1976 was slow due to labor unavailability and lengthy rehabilitation, and production in 1976 totaled only about 50 MTU.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The nominal annual capacity is currently 308 MTU. No plans exist to increase the capacity further. The mill has the capability to process 1500 TPD of ore.

Past and Present Marketing Strategy

A long-term sales contract with AGIP, an agency of the Italian government, calls for firm delivery of about 2370 MTU in 1977-1984. This essentially commits all of the future production of the complex to AGIP. The contract also stipulates that AGIP has first call on any additional production. A small spot sale was negotiated with a Canadian utility in 1977 at world market price and approved by the Canadian government. Madawaska and AGIP negotiated an agreement on the price to be paid under the existing contract and deliveries resumed in 1978. The agreement covers deliveries scheduled for 1978-1979. Further negotiations on 1980 delivery prices are scheduled.

Market Share Attained: Madawaska

Uranium Concentrates

Table 7.2.17

(ST U₃O₈)

Region: Domestic (Canada)

<u>Year</u>	<u>Madawaska Deliveries to Canada</u>	<u>Total Deliveries to Canada</u>	<u>Total Canadian Requirements</u>	<u>Total Canadian Uncommitted</u>	<u>Madawaska Market Share of Committed Deliveries, %</u>
pre-1978	0	4174	3952	0	0.0
1978	54	505	1021	445	10.7
1979	0	451	961	450	0.0
1980	0	1151	1416	222	0.0
1981	0	1301	1429	223	0.0
1982	0	1301	1653	268	0.0
1983	0	1301	1563	268	0.0
1984	0	2300	2019	265	0.0
1985	0	2300	2646	566	0.0
1986	0	2000	2617	715	0.0
1987	0	2000	3058	943	0.0
1988	0	2000	3660	1545	0.0
1989	0	2000	3878	1763	0.0
1990	0	2000	4572	2457	0.0

Market Share Attained: Madawaska

Uranium Concentrates

Table 7.2.17 (cont.)

(ST U₃O₈)

Region: International (non-Canada, non-US)

<u>Year</u>	<u>Madawaska Deliveries</u>	<u>Total Deliveries</u>	<u>Requirements</u>	<u>Uncommitted</u>	<u>Madawaska Market Share of Committed Deliveries, %</u>
pre-1978	0	135725	101656	0	0.0
1978	385	30650	19405	1468	0.7
1979	400	29495	23866	2602	0.0
1980	400	20012	25505	3359	0.0
1981	400	32797	27892	2843	0.0
1982	400	33617	28684	2566	0.0
1983	400	34922	35418	4865	0.0
1984	400	36285	38984	8926	0.0
1985	400	34723	44311	13144	0.0
1986	0	31425	50626	20760	0.0
1987	0	30237	52156	22964	0.0
1988	0	30645	61210	32474	0.0
1989	0	28317	62197	32516	0.0
1990	0	29172	72785	41118	0.0

Production History: Madawaska
Uranium Concentrates

Table 7.2.18
(MTU)

<u>Year</u>	<u>Quantity</u>
1976	47.60
1977	169.20

Projected Future Marketing Strategy

It is unlikely that any major future contracts other than small spot sales will be negotiated. AGIP will have first call on any production over the firm contract quantity.

Facility: Amok Ltd. U₃O₈ Mine/Mill

Description of Operation

The planned Amok mill at Cluff Lake, Saskatchewan, was approved by the Saskatchewan government in 1978. The mill is planned for operation in 1981 and will use an acid leach, solvent extraction process. Three ore zones have been delineated. The "D" zone has reserves of 6500 MTU averaging 8.20%, with the "N" and Claude zones containing a combined total of about 12,000 MTU at an average grade of 0.50%. Mining will be conducted by open pit.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The anticipated nominal capacity of the mill will be about 1500 MTU. Initial production should begin in 1981 with full production in 1982. No plans exist to expand the capacity further.

Past and Present Marketing Strategy

Amok has not sold any material to date and has no contracts for future delivery.

Projected Future Marketing Strategy

Approximately 25% of the future output of the facility will be retained in Canada for domestic use. Because the French firms COGEMA (Compagnie Generale des Matieres Nucleaires), Minatome, and IMETAL combined have a 100% interest in the venture, most of the remainder of the output will probably be committed to France to meet that country's domestic requirements. It is unlikely that future sales will be to a market other than Europe.

Facility: Key Lake U₃O₈ Mine/Mill

Description of Operation

The planned mill near La Ronge, Saskatchewan, will be jointly owned by Saskatchewan Mining and Development (SMDC), Uranerz Exploration and Mining Company, and Eldorado Nuclear Ltd. Previously, Inexco Oil had a 33.3% interest in the deposit, but SMDC and Eldorado bought Inexco's interest. Currently the ownership is 50% SMDC, 33.3% Uranerz, and 16.7% Eldorado. Uranerz will be the operator of the project and has announced plans to start up the mill in 1983. A go-ahead decision is being held up pending the Saskatchewan government's Bayda inquiry into uranium mining and the federal government's restrictions on foreign ownership. Two deposits have been delineated. The Gartner deposit is reported to contain reserves of about 20,000 MTU with an average grade of 2.84% U₃O₈, and the Deilman deposit is reported to have about 19,000 MTU of reserves with an average grade of 2.11% U₃O₈. These are some of the highest grade deposits in existence in Canada. The milling process has yet to be established.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

A maximum production rate of about 2300 MTU/year is anticipated pending approval. No expansion plans have been considered yet.

Past and Present Marketing Strategy

No contracts have been negotiated to date.

Projected Future Marketing Strategy

A portion of the future output, as determined by the government, will be retained for domestic use. Because of the ownership by a West German firm (Uranerz), some future sales, pending government approval, will likely be to West Germany.

Facility: Eldorado Nuclear Port Hope and Port Granby UF₆
Conversion Facilities

Description of Operation

Eldorado's existing UF₆ facility at Port Hope, Ontario, began operation in 1970. The refinery has actually been in operation since 1933, but uranium hexafluoride production did not begin until 1970. In addition to UF₆ production, the refinery complex has the capability to produce natural and enriched uranium dioxide (UO₂), zirconium, and uranium metal billets. The UF₆ conversion facility uses a wet solvent extraction process in which the U₃O₈ concentrates are dissolved in nitric acid, denitrated to form UO₃, reacted with hydrogen to form UO₂, converted to UF₄, and contacted with fluorine gas to obtain UF₆. A second plant is planned for operation in 1981. The site of this plant was initially slated for Port Granby, Ontario, but environmental opposition has led to the selection of Sudbury in northern Ontario as an alternate site.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The capacity of the existing refinery at Port Hope is 4000 MTU per year. The new plant is projected to have a capacity of 10,000 MTU when operation begins in 1981. A third refinery is being contemplated for location in Saskatchewan in the late 1980's, but no firm decision has been made yet.

Past and Present Marketing Strategy

In the past, Eldorado has provided conversion services to customers in Europe, Japan, and the US. Eldorado has future contract commitments for UF₆ deliveries of about 37,000 MTU into the 1990's to the same markets. Most of the existing production at Port Hope is fully committed. Additional contracts would be possible when the new refinery comes into operation.

Market Share Attained: Eldorado

Uranium Hexafluoride

Table 7.2.19

(MTU UF₆)

Region: Domestic (Canada)

<u>Year</u>	<u>Eldorado Deliveries to Canada</u>	<u>Total Deliveries to Canada</u>	<u>Total Canadian Requirements*</u>	<u>Total Canadian Uncommitted**</u>	<u>Eldorado Market Share of Committed Deliveries, %</u>
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	0	0	0.0
1981	0	0	0	0	0.0
1982	0	0	0	0	0.0
1983	0	0	0	0	0.0
1984	0	0	0	0	0.0
1985	0	0	0	0	0.0
1986	0	0	0	0	0.0
1987	0	0	0	0	0.0
1988	0	0	0	0	0.0
1989	0	0	0	0	0.0
1990	0	0	0	0	0.0

* Firm + futura

** Assuming all futura requirements are uncommitted

Market Share Attained: Eldorado

Uranium Hexafluoride

Table 7.2.19 (cont.)

(MTU UF₆)

Region: International (non-Canada, non-US)

<u>Year</u>	<u>Eldorado Deliveries</u>	<u>Total Deliveries</u>	<u>Requirements</u>	<u>Uncommitted</u>	<u>Eldorado Market Share of Committed Deliveries, %</u>
pre-1978	7550	72621	45569	0	8.8
1978	5832	26959	11630	32	21.1
1979	5650	23740	17226	951	22.2
1980	4328	22095	17000	2230	17.0
1981	4742	21445	18027	3332	19.1
1982	4278	22628	18971	3815	15.9
1983	3680	22705	24784	7404	13.2
1984	5036	22618	26388	11863	19.2
1985	4973	21546	29077	19425	18.9
1986	3152	17690	36800	24069	14.2
1987	3069	16684	36319	27392	14.6
1988	3432	14013	42098	32699	19.9
1989	2925	13339	44689	37179	17.2
1990	2925	13244	50787	44361	17.3

Projected Future Marketing Strategy

Eldorado will continue to provide conversion of all Canadian uranium exports since exports can only be made in the form of UF_6 . In the future, a diversity of markets will likely be exhibited by Eldorado's UF_6 marketing as has been the case in the past.

Facility: Canadian General Electric

Description of Operation

Canadian General Electric, CGE, has been a major participant in Canadian nuclear industry since 1955. CGE worked closely with AECL in the planning, design, and construction of Canada's first nuclear power plant, the Nuclear Power Demonstration (NPD) Station, which went into operation in 1962. CGE was also the prime contractor for the construction of the Kanupp reactor. After the Kanupp project, CGE discontinued its role in the plant's engineering and restricted its activities to the production of plant components and nuclear fuel.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

No information was available about the fabrication capacity of CGE.

CGE has provided the fuel for the initial cores of NPD, Douglas Point, Kanupp and Pickering, and has supplied reload fuel to most of these stations.

Marketing Strategy

No information was available about the marketing strategy of CGE.

Facility: Westinghouse Canada

Description of Operation

Westinghouse Canada has been involved in atomic energy programs since 1956. The company initially provided components and systems for Canada's research reactors and expanded its operation to supply fuel and reactor components to commercial power plants, and the power reactor program developed. Westinghouse Atomic Power Division plants are located at Port Hope and Hamilton in Ontario. Westinghouse Canada provided the fuel for the initial core loadings for Gentilly-1 and Rajasthan-1 and-2. Reload fuel has been supplied to Douglas Point, Pickering, and NPD reactors.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

No information was available about the capacity of Westinghouse Canada.

Marketing Strategy

No information was available about the marketing strategy of Westinghouse Canada.

NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

Vested Interests in Current Fuel Cycles and Reactor Technologies

The government, private industry, and the utilities have a strong vested interest in CANDU reactor technology. The entire technology has been developed in Canada with the framework of Canada's resources and industrial capabilities. The government, primarily through the research and development organization of AECL, industry, and utilities, has demonstrated a high degree of cooperation in Canada's nuclear development program, with AECL providing the basic research to industry, industry developing the manufacturing capabilities, and the utilities sharing in the design and construction of the plants. In the case of prototype reactors, AECL has maintained responsibility for operations, providing AECL valuable insights in understanding the problems of both the manufacturers and the utilities.

Current Trends in Nuclear Development Programs

Development programs are oriented toward improvements in the existing system, such as scaling up the size of the CANDU reactors and studying alternative fuel cycles, such as the thorium cycle or plutonium recycle. Development of enrichment capacity has been studied for years, but construction of an enrichment plant would be solely for export purposes.

7.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

PROFESSIONAL LABOR FORCE PROFILE

Table 7.3.1

Available information presents the following data
for 1973:

15,244 Scientists & Engineers engaged in R&D.

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 7.3.2

<u>Institution</u>	<u>Location</u>
Acadia University	Wolfville, Nova Scotia
University of Calgary	Calgary, Alberta
Carleton University	Ottawa, Ontario
Concordia University	Montreal, Quebec
Dalhousie University	Halifax, Nova Scotia
University of Guelph	Guelph, Ontario
Lakehead University	Thunder Bay, Ontario
McGill University	Montreal, Quebec
McMaster University	Hamilton, Ontario
University of Manitoba	Winnipeg, Manitoba
Memorial University of Newfoundland	St. Johns, Newfoundland
Queens University	Kingston, Ontario
Mt. Allison University	Sackville, New Brunswick
University of Alberta	Edmonton, Alberta
University of New Brunswick	Fredericton, New Brunswick
University of British Columbia	Vancouver, British Columbia
Nova Scotia Technical College	Halifax, Nova Scotia
Simon Fraser	Vancouver, British Columbia
University of Prince Edward Island	Charlottetown, P.E. Island
University of Regina	Regina, Saskatchewan
St. Francis Xavier University	Antigonish, Nova Scotia
St. Mary's University	Halifax, Nova Scotia
University of Saskatchewan	Saskatchewan
University of Toronto	Toronto, Ontario
University of Waterloo	Waterloo, Ontario
University of Western Ontario	London, Ontario
University of Windsor	Windsor, Ontario

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 7.3.3

<u>Name</u>	<u>Location</u>	<u>Main Activities</u>
Atomic Energy of Canada, Ltd. (AECL)		Lead agency for nuclear energy
Chalk River Nuclear Labs	Chalk River, Ontario	-Nuclear Utilization & Support -Power reactor -Nuclear fuel cycle
Whiteshell Nuclear Research Establishment	Pinawa, Manitoba	-Environmental and Radioactive waste -Heavy water -Advanced systems
Radiochemical unit	South March, Ontario	-Radiation equipment and radioisotopes
Chemical unit	Nova Scotia	-Operation of heavy water plants
Atomic Energy Control Board (AECB)	Ottawa, Ontario	Nuclear regulatory research
National Research Council	--	Nuclear fusion
Canadian Nuclear Association	Toronto, Ontario	Non-profit organization - analysis of problems and opportunities related to nuclear energy

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 7.3.4

<u>Name</u>	<u>Owner</u>	<u>Location</u>	<u>Main Activities</u>
Nuclear research is primarily undertaken by the government or by Crown corporations (i.e. Eldorado Nuclear). Several large electrical and manufacturing companies are involved in nuclear R&D, but their work is best characterized as commercial development.			
Canadian General Electric	100% Canadian GE	Peterborough, Ontario	Fuel fabrication
Westinghouse Canada	100% Westinghouse Canada	Port Hope, Ontario	Fuel fabrication
Ontario Hydro	100% Ont. Hydro	Toronto	Applied reactor metallurgy, heavy water process.
Quebec Hydro	100% Quebec Hydro	Valcartin	fusion
Carver Institute	University of British Columbia	Vancouver, B.C.	

RESEARCH AND TEST REACTORS
List of Reactors

Table 7.3.5

<u>Facility Name</u>	<u>Location</u>	<u>Owner</u>	<u>Constructor</u>	<u>Facility Type</u>	<u>Facility Status</u>		
					<u>MW(th)</u>	<u>Status*</u>	<u>COD</u>
NRX	Chalk River (Ont.)	AECL	AECL	Research tank, D ₂ O	33	0	1947
NRU	Chalk River (Ont.)	AECL	AECL	Research tank	110	0	1957
PTR	Chalk River (Ont.)	AECL	AECL	Critical Exp.	0	0	1957
MNR	Hamilton (Ont.)	McMaster University	AECL	Research pool	2	0	1959
Zed-2	Chalk River (Ont.)	AECL	AECL	Critical Exp.	0	0	1960
WR-1	Pinawa (Man.)	WNRE	AECL	Heavy water test	60	0	1965
Slowpoke-1	Toronto (Ont.)	Toronto University	AECL	Research pool	.021	0	1970
Slowpoke-2	Ottawa (Ont.)	AECL	AECL	Research pool	.021	0	1971
TUR	Toronto (Ont.)	Toronto University	AECL	Zero Power	0	0	1958

* 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 7.3.6

<u>Vendor</u>	<u>Country</u>	<u>Facility Name</u>	<u>Facility Type</u>	<u>Facility Status</u>			<u>Scope of Services</u>
				<u>MW(th)</u>	<u>Status*</u>	<u>COD</u>	
Defense Industries Ltd.	Canada	ZEEP	D2O	0	S	1945	
Defense Industries Ltd.	Canada	WRX	D2O	33	0	1947	
C. D. Howe Co.	Canada	NRU	D2O	110	0	1957	
Canadair	Canada	PTR	H2O	0	0	1957	
AECL	Canada	ZED-2	D2O	0	0	1960	
AECL	Canada	TUR	D2O	0	0	1958	
AECL	Canada	Slowpoke 1	H2O	20KW	0	1970	
AECL	Canada	Slowpoke 2	H2O	20KW	0	1971	
AECL	Canada	MNR	H2O	2	0	1959	
CGE	Canada	WR-1	D2O	60	0	1965	
AECL	India	CIRUS	D2O	40	0	1960	
AECL	Taiwan	TRR	D2O	40	0	1973	

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

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 7.3.7

<u>Facility Name</u>	<u>Location</u>	<u>Facility Type</u>	<u>Capacity Status</u>			<u>Shareholdings</u>
			<u>MT/YR</u>	<u>Status*</u>	<u>Year</u>	
Canadian General Electric	Petersborough, Ontario	Fuel Fabrication	--	0	--	100% Canadian GE

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

7.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

7.4.1 ECONOMIC DATA PROFILE

GNP (Current million \$)	- 210,132 (1977)	Inflation Rate	- 8% (1977)
Exports (million \$)	- 52,716 (1977)	Imports (million \$)	- 57,232 (1977)
Per Capita Income (\$)	- 5,838 (1975)	Disposable Income (\$)	- 6,120 (1975)
Monetary Unit	- Canadian Dollar	Exchange Rate (/US\$)	- 1.06 (1977)
Population (million)	- 22.772		

7.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

FY 1977

Nuclear Fission

HWR-Canada \$81,000,000

Fuel Cycle 7,300,000

Fusion \$ 1,800,000

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

<u>Industry University or Laboratory</u>	<u>Program Area</u>	<u>Budget \$ (Millions)</u>	<u>Key Personnel</u>
Atomic Energy of Canada Limited	Heavy water & reactor development	100% government funded	Dr. A. J. Mooradian
Hydro-Quebec	Electrical production & transmission, fusion	Provincial government	Dr. Lionel Boulet
Ontario Hydro	Applied reactor metallurgy	Provincial government	Mr. F. J. Simpson
Eldorado Nuclear	Uranium extraction research	100% government funded	Mr. R. G. Dakers

7.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

Private industry is not heavily involved in nuclear R&D (total identified industrial expenditure of approximately \$7,000,000 in 1977). Private industry is involved more heavily in commercial production of equipment, fuel, and services for the nuclear program.

7.4.5 ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

	<u>Share Capital</u>	<u>Assets</u>	<u>Sales</u>
Westinghouse Canada Limited	--	--	--
Canadian General Electric	--	--	--
Eldorado Nuclear	--	--	--
Culf Minerals Canada		--	--
Intsel of Canada	--	--	--
Amok	--	--	--
Combustion Engineering	--	--	--

AECL is the sole reactor vendor; however, it does not manufacture reactors and all components are purchased competitively.

7.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

All nuclear power stations are financed by the provincial governments.

7.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

7.5.1 ENERGY POLICY - BASIC LEGISLATION

Eldorado Nuclear established as Federal Crown Corporation in 1942.

Atomic Energy Control Board established in 1946.

Atomic Energy of Canada established in 1952.

National Energy Board established in 1960.

Department of Energy, Mines and Resources established in 1966 by restructuring previously existing Department of Mines and Technical Surveys, long active in resource assessment and fossil fuel fields.

Pan-Arctic Oils Ltd. (joint government/industry company) established in 1966.

Cape Breton Development Corporation (Federal agency mining coal in that region of Nova Scotia) established in 1968.

Office of Energy Conservation established within Department of Energy, Mines and Resources, January, 1974.

Interdepartmental Task Force and Panel on Energy R&D to coordinate and plan Federal Energy R&D activities, together with supporting Office of Energy Research and Development, established in January 1974, and May 1975 respectively.

Petroleum Administration Act passed by Parliament in April 1975.

Petro-Canada established as Federal Crown Corporation in July 1975.

Atomic Energy of Canada Limited reorganized in 1978.

- Atomic Energy of Canada Engineering Co. - responsible for design and marketing of CANDU system.
- Atomic Energy of Canada Chemical Co. - responsible for the Glace Bay, Port Hawkesbury (Nova Scotia) and La Prade (Quebec) heavy water plants. J. Howard Langstaff.
- Atomic Energy of Canada Research Co. - responsible for the research laboratories at Chalk River (Ontario) and Pinawa (Winnipeg). Robert Hart.
- Atomic Energy of Canada Radiochemical Co. - responsible for radio-isotopes and other medical applications. John M. Beddoes.

7.5.2

GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

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

Department of Energy, Mines and Resources

Hon. Alastair Gillespie, Minister

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graph LR; Minister[Hon. Alastair Gillespie, Minister] --- AEC[Atomic Energy of Canada Ltd.
Mr. James Donnelly, President]; Minister --- AECB[Atomic Energy Control Board
Mr. Jon H. Jennekens, President]; Minister --- NEB[National Energy Board
Mr. Marshall Crowe, Chairman]; Minister --- ENL[Eldorado Nuclear Ltd.
Mr. N. M. Ediger, President];
```
- Atomic Energy of Canada Ltd.  
Mr. James Donnelly, President
  - Atomic Energy Control Board  
Mr. Jon H. Jennekens, President
  - National Energy Board  
Mr. Marshall Crowe, Chairman
  - Eldorado Nuclear Ltd.  
Mr. N. M. Ediger, President

Mr. M. A. Cohen, Deputy Minister

Panel on Energy R&D (all federal agencies active in  
Energy R&D represented)

Dr. C.H. Smith, Chairman  
Senior Assistant Deputy Minister

Office of Energy R&D (Secretariat for Panel)

Dr. R.P. Charbonnier, Director

Energy Policy Sector

Mr. A. D. Hunt, Assistant Deputy Minister

Senior Advisors, Oil, Coal, Nuclear, Electrical, etc.



#### 7.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

Fundamental nuclear policy and objectives are to create and maintain a self-reliant (Canadian nuclear industry and Canadian fuel resources) nuclear power industry.

#### 7.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

Canada has a strong commitment to nuclear energy. The current CANDU nuclear program is expected to continue its expansion.

#### 7.5.6 NUCLEAR ENERGY R&D - PRIORITIES

Nuclear energy is ranked after conservation, supply of oil and gas fuels, and coal in Canada's R&D priorities. Within nuclear energy, continued development of the CANDU system, heavy water production, and minerals extractions are priority items.

#### 7.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION

The Government, through AECL (promotion), AECB (regulation), and various other agencies, provides facility R&D, design, licensing, and registration. Reactor equipment, construction, and installation is contracted to commercial firms. The owner-utilities operate the nuclear plants, with regulations by the government.

7.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

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

Table 7.6.1

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/ Owner</u>                      | <u>Vendor</u>        | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------|-----------------|--------------------------------------------|----------------------|----------------------------------|---------------------------|----------------|------------|
| Deer Lake            | Newfoundland    | Bowater Power Co. Ltd.                     | AW/BT AW/AW<br>NN/NN | Hydro                            | 131                       | 0              | 1925-29    |
| Churchill Falls      | Newfoundland    | Churchill Falls (Labrador) Co.Ltd.         | DE/CG/MH/MH          | Hydro                            | 5,225                     | 0              | 1971-74    |
| Bay d'Espoir         | Newfoundland    | Newfoundland and Labrador Power Commission | CA/CG                | Hydro                            | 459                       | 0              | 1967-70    |
| Twin Falls           | Newfoundland    | Twin Falls Power Corp. Ltd.                | EE/CW/DE/CW          | Hydro                            | 234                       | 0              | 1962-68    |
| Mactaquac            | New Brunswick   | New Brunswick Electric Power Commission    | WY/DE                | Hydro                            | 418                       | 0              | 1968-72    |
| Beechwood            | New Brunswick   | New Brunswick Electric Power Commission    | DE/CG/CA/WY          | Hydro                            | 113                       | 0              | 1957-62    |
| Chute des Passes     | Quebec          | Aluminium Co. of Canada Ltd.               | EE/CG                | Hydro                            | 743                       | 0              | 1959-60    |
| Shipshaw             | Quebec          | Aluminium Co. of Canada Ltd.               | AC/CG/SM/CW          | Hydro                            | 717                       | 0              | 1942-43    |
| Isle Maligae         | Quebec          | Aluminium Co. of Canada Ltd.               | CA/CW                | Hydro                            | 336                       | 0              | 1925-26    |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>            | <u>Vendor</u>  | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|-----------------|--------------------------------------|----------------|------------------------------------------|-------------------------------|----------------|------------|
| Chute a la Savanne       | Quebec          | Alumnum Co. of Canada Ltd.           | DE/CG          | Hydro                                    | 187                           | 0              | 1953       |
| Chute du Diable          | Quebec          | Aluminum Co. of Canada Ltd.          | CA/CW          | Hydro                                    | 187                           | 0              | 1952       |
| Chute a Caron            | Quebec          | Aluminum Co. of Canada Ltd.          | SM/CW          | Hydro                                    | 180                           | 0              | 1931/34    |
| Manie No. 5              | Quebec          | Commission Hydroelectrique de Quebec | MH/MH          | Hydro                                    | 1,292                         | 0              | 1970/71    |
| Manie No. 2              | Quebec          | Commission Hydroelectrique de Quebec | DE/CG          | Hydro                                    | 1,015                         | 0              | 1965/67    |
| Bersimis No. 1           | Quebec          | Commission Hydroelectrique of Quebec | EE/MV<br>NY/CG | Hydro                                    | 912                           | 0              | 1956/59    |
| Outardes No. 3           | Quebec          | Commission Hydroelectrique de Quebec | DE/CG          | Hydro                                    | 756                           | 0              | 1969       |
| Bersimis No. 2           | Quebec          | Commission Hydroelectrique of Quebec | DE/CG          | Hydro                                    | 655                           | 0              | 1959-60    |

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

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

Table 7.6.1 (Continued)

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/ Owner</u>                | <u>Vendor</u>  | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------|-----------------|--------------------------------------|----------------|----------------------------------|---------------------------|----------------|------------|
| Carillon             | Quebec          | Commission Hydroelectrique de Quebec | DE/CG          | Hydro                            | 655                       | 0              | 1962-64    |
| Outardes No.4        | Quebec          | Commission Hydroelectrique de Quebec | NY/CG          | Hydro                            | 632                       | 0              | 1969       |
| Beauharnois No.3     | Quebec          | Commission Hydroelectrique de Quebec | EE/CW          | Hydro                            | 553                       | 0              | 1959-61    |
| Beauharnois No. 1    |                 | Commission Hydroelectrique de Quebec | DE/CG          | Hydro                            | 538                       | 0              | 1932-48    |
| Beauharnois No. 2    | Quebec          | Commission Hydroelectrique de Quebec | DE/CW<br>CA/CG | Hydro                            | 483                       | 0              | 1950-53    |
| La Trenché           | Quebec          | Commission Hydroelectrique de Quebec | DE/CG          | Hydro                            | 286                       | 0              | 1950-55    |
| Beaumont             | Quebec          | Commission Hydroelectrique de Quebec | CA/CG          | Hydro                            | 243                       | 0              | 1958/59    |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>                  | <u>Vendor</u>      | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>      |
|--------------------------|-----------------|--------------------------------------------|--------------------|------------------------------------------|-------------------------------|----------------|-----------------|
| La Tuque                 | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | DE/CG              | Hydro                                    | 216                           | 0              | 1940/55         |
| Paugan                   | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | DE/CW<br>DE/CG     | Hydro                                    | 202                           | 0              | 1928/31<br>1956 |
| Manie No. 3              | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | DE/MH              | Hydro                                    | 197                           | 0              | 1975            |
| Manie No. 1              | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | CA/AH              | Hydro                                    | 184                           | 0              | 1966/67         |
| Rapide Blanc             | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | IP/CW<br>DE/AA     | Hydro                                    | 184                           | 0              | 1934/55         |
| Shawinigan<br>No. 2      | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | IP/CW<br>/CG       | Hydro                                    | 163                           | 0              | 1911-29         |
| Les Cedres               | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | IP/<br>WS/CG<br>DF | Hydro                                    | 162                           | 0              | 1914-24         |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>                  | <u>Vendor</u>      | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|-----------------|--------------------------------------------|--------------------|------------------------------------------|-------------------------------|----------------|------------|
| Shawinigan<br>No. 3      | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | DE/CG              | Hydro                                    | 150                           | 0              | 1948-49    |
| Grand Mere               | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | DE/CW<br>IP/CW     | Hydro                                    | 148                           | 0              | 1915-30    |
| Rapide des<br>Iles       | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | DE/CW              | Hydro                                    | 147                           | 0              | 1966-73    |
| Chelsea                  | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | DE/CW              | Hydro                                    | 144                           | 0              | 1927-39    |
| Premiere<br>Chute        | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | DE/CW              | Hydro                                    | 124                           | 0              | 1968-75    |
| La Gaballe               | Quebec          | Commission<br>Hydroelectrique<br>de Quebec | IP/<br>WS/CG<br>DE | Hydro                                    | 137                           | 0              | 1924-31    |
| McCormick Dam            | Quebec          | The Manicouagan<br>Power Co.               | SM/GE<br>AC/GE     | Hydro                                    | 304                           | 0              | 1951-65    |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>                        | <u>Vendor</u>       | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>       |
|--------------------------|-----------------|--------------------------------------------------|---------------------|------------------------------------------|-------------------------------|----------------|------------------|
| Sir Adam Beck<br>No. 2   | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CG<br>DE/<br>CW     | Hydro                                    | 1,224                         | 0              | 1954-58          |
| Robert H.<br>Saunders    | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CG<br>EE/<br>CW     | Hydro                                    | 912                           | 0              | 1958-59          |
| Sir Adam Beck<br>No. 1   | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CR/<br>WS/<br>DE/CW | Hydro                                    | 415                           | 0              | 1922-30          |
| Des Jachims              | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | DE/CW               | Hydro                                    | 360                           | 0              | 1950-51          |
| Lower Notch              | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | DE/CG               | Hydro                                    | 228                           | 0              | 1971             |
| Abitibi Canyon           | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CA/CG               | Hydro                                    | 212                           | 0              | 1933-36,<br>1959 |
| Otto Holden              | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CA/<br>IJ/<br>CW    | Hydro                                    | 205                           | 0              | 1952-53          |

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



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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>                        | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|-----------------|--------------------------------------------------|---------------|------------------------------------------|-------------------------------|----------------|------------|
| Wells                    | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | DE/CG         | Hydro                                    | 203                           | 0              | 1970       |
| Sir Adam Beck<br>P. + G. | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | EE/CW         | Hydro                                    | 177                           | 0              | 1957-58    |
| Otter Rapids             | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CA/CG         | Hydro                                    | 175                           | 0              | 1961-63    |
| Stewartville             | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CA/CG         | Hydro                                    | 153                           | 0              | 1948,69    |
| Barrett Chute            | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CA/CG         | Hydro                                    | 152                           | 0              | 1942-68    |
| Mountain Chute           | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | EE/CW         | Hydro                                    | 140                           | 0              | 1967       |
| Aubrey Falls             | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | DE/CG         | Hydro                                    | 130                           | 0              | 1969       |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>                        | <u>Vendor</u>        | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|-----------------|--------------------------------------------------|----------------------|------------------------------------------|-------------------------------|----------------|------------|
| Harmon                   | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | IJ/CW                | Hydro                                    | 129                           | 0              | 1965       |
| Pine Portage             | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CA/<br>SM/CW         | Hydro                                    | 129                           | 0              | 1950-54    |
| Kipling                  | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | DE/CW                | Hydro                                    | 125                           | 0              | 1966       |
| Chenau                   | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | DE/CG                | Hydro                                    | 122                           | 0              | 1950-51    |
| Little Long              | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | EE/CW                | Hydro                                    | 122                           | 0              | 1963       |
| Decew Falls<br>No. 2     | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | CA/CG                | Hydro                                    | 115                           | 0              | 1943-47    |
| Ontario Power            | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | JV/WE,WS,CG<br>WS/CG | Hydro                                    | 101                           | 0              | 1905-13    |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>        | <u>Vendor</u>       | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|-----------------|----------------------------------|---------------------|------------------------------------------|-------------------------------|----------------|------------|
| Kettle Rapids            | Manitoba        | Manitoba Hydro                   | DE/MG               | Hydro                                    | 1,224                         | 0              | 1970-74    |
| Grand Rapids             | Manitoba        | Manitoba Hydro                   | IJ/<br>CA/CG        | Hydro                                    | 437                           | 0              | 1965-68    |
| Kelsey                   | Manitoba        | Manitoba Hydro                   | DE/CG               | Hydro                                    | 236                           | 0              | 1960-72    |
| Seven Sisters            | Manitoba        | Manitoba Hydro                   | AC/<br>DE/CG<br>SM/ | Hydro                                    | 150                           | 0              | 1931,49-52 |
| Great Falls              | Manitoba        | Manitoba Hydro                   | DE/<br>SM/CG        | Hydro                                    | 132                           | 0              | 1923-28    |
| Island Falls             | Saskatchewan    | Churchill River<br>Power Company | DE/GE               | Hydro                                    | 107                           | 0              | 1930-59    |
| Squaw Rapids             | Saskatchewan    | Saskatchewan<br>Power Corp.      | JO/EE<br>AC/WY      | Hydro                                    | 280                           | 0              | 1963-67    |
| Coteau Creek             | Saskatchewan    | Saskatchewan<br>Power Corp.      | EE/WY               | Hydro                                    | 168                           | 0              | 1968       |
| Big Bend                 | Alberta         | Calgary Power<br>Co. Ltd.        | DE/CW               | Hydro                                    | 306                           | 0              | 1965-67    |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>     | <u>Utility/<br/>Owner</u>                        | <u>Vendor</u>           | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|---------------------|--------------------------------------------------|-------------------------|------------------------------------------|-------------------------------|----------------|------------|
| Big Horn                 | Alberta             | Calgary Power<br>Co. Ltd.                        | DE/EE                   | Hydro                                    | 103                           | 0              | 1972       |
| Kemano                   | British<br>Columbia | Alcan Smelters<br>+Chemicals Ltd.                | CA/CG<br>PW/CW<br>DE/EE | Hydro                                    | 813                           | 0              | 1954-67    |
| Gordon M.<br>Shrum       | British<br>Columbia | British Columbia<br>Hydro and Power<br>Authority | MS/CG<br>TO/TO<br>FU/FU | Hydro                                    | 2,116                         | 0              | 1968-74    |
| Kootenay<br>Canal        | British<br>Columbia | British Columbia<br>Hydro and Power<br>Authority | MS/CG                   | Hydro                                    | 529                           | 0              | 1975       |
| MICA                     | British<br>Columbia | British Columbia<br>Hydro and Power<br>Authority | --                      | Hydro                                    | 868                           | 0              | --         |
| Bridge River<br>No. 1    | British<br>Columbia | British Columbia<br>Hydro and Power<br>Authority | VA/CW                   | Hydro                                    | 248                           | 0              | 1948-54    |
| Bridge River<br>No. 2    | British<br>Columbia | British Columbia<br>Hydro and Power<br>Authority | VE/<br>NY/CW            | Hydro                                    | 180                           | 0              | 1959-60    |
| Jordan River             | British<br>Columbia | British Columbia<br>Hydro and Power<br>Authority | NI/MS                   | Hydro                                    | 150                           | 0              | 1971       |

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

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

Table 7.6.1 (Continued)

CANADA-86

| <u>Facility Name</u> | <u>Location</u>  | <u>Utility/ Owner</u>                      | <u>Vendor</u>           | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------|------------------|--------------------------------------------|-------------------------|----------------------------------|---------------------------|----------------|------------|
| Cheakamus            | British Columbia | British Columbia Hydro and Power Authority | VA/CW                   | Hydro                            | 140                       | 0              | 1957       |
| John Hart            | British Columbia | British Columbia Hydro and Power Authority | DE/WY                   | Hydro                            | 120                       | 0              | 1947-53    |
| Ruskin               | British Columbia | British Columbia Hydro and Power Authority | DE/CW                   | Hydro                            | 106                       | 0              | 1930-50    |
| Waneta               | British Columbia | Cominco Ltd.                               | DE/CW<br>CA/CG          | Hydro                            | 293                       | 0              | 1954-66    |
| Brilliant            | British Columbia | Cominco Ltd.                               | DE/CW                   | Hydro                            | 109                       | 0              | 1944-68    |
| Holyrood             | Newfoundland     | Newfoundland + Labrador Power Commission   | CE/CG                   | Oil                              | 300                       | 0              | 1970-71    |
| Point Tupper         | Nova Scotia      | Nova Scotia Power Corp.                    | BW/SR<br>CE/HP          | Oil                              | 231                       | 0              | 1969-73    |
| Trenton              | Nova Scotia      | Nova Scotia Power Corp.                    | BF/PC<br>CE/HP<br>BW/HP | Coal/Oil                         | 210                       | 0              | 1951-69    |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>                        | <u>Vendor</u>           | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|-----------------|--------------------------------------------------|-------------------------|------------------------------------------|-------------------------------|----------------|------------|
| Tufts Cove               | Nova Scotia     | Nova Scotia<br>Power Corp.                       | BF/AE<br>BW/HP          | Oil/Coal                                 | 350                           | 0              | 1965-72    |
| Lower Water<br>Street    | Nova Scotia     | Nova Scotia<br>Power Corp.                       | /PC<br>BF/MV<br>/EE     | Oil/Coal                                 | 165                           | 0              | 1944-59    |
| Courtenay Bay            | New Brunswick   | New Brunswick<br>Electric Power<br>Commission    | CE/EE<br>BW/BB          | Oil                                      | 263                           | 0              | 1961-67    |
| Coleson Cove             | New Brunswick   | New Brunswick<br>Electric Power<br>Commission    |                         |                                          | 700                           |                |            |
| Dalhousie                | New Brunswick   | New Brunswick<br>Electric Power<br>Commission    | CE/BB                   | Oil                                      | 100                           | 0              | 1969       |
| Tracy                    | Quebec          | Commission<br>Hydroelectrique<br>de Quebec       | CE/PC                   | Oil                                      | 600                           | 0              | 1964-68    |
| Nanticoke                | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | BW/HP                   | Coal                                     | 3,000                         | 0              | 1972-75    |
| Lakeview                 | Ontario         | Hydro Electric<br>Power Commission<br>of Ontario | BF/PC<br>CE/RE<br>BW/HP | Coal                                     | 2,400                         | 0              | 1961-68    |

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

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

Table 7.6.1 (Continued)

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/ Owner</u>                      | <u>Vendor</u>            | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>      |
|----------------------|-----------------|--------------------------------------------|--------------------------|----------------------------------|---------------------------|----------------|-----------------|
| Lennox               | Ontario         | Hydro Electric Power Commission of Ontario | CE/CG                    | Oil                              | 2,295                     | 0              | 1975-77         |
| Lambton              | Ontario         | Hydro Electric Power Commission of Ontario | CE/CG                    | Coal                             | 2,000                     | 0              | 1969-70         |
| Richard L. Hearn     | Ontario         | Hydro Electric Power Commission of Ontario | BF/<br>CE/PC             | Gas/Coal                         | 1,200                     | 0              | 1951-61         |
| J. Clark Keith       | Ontario         | Hydro Electric Power Commission of Ontario | BF/EE                    | Coal                             | 264                       | 0              | 1951-53         |
| Thunder Bay          | Ontario         | Hydro Electric Power Commission of Ontario | FW/EE                    | Coal                             | 100                       | 0              | 1962            |
| Brandon              | Manitoba        | Manitoba Hydro                             | CE/MV<br>BW/BB           | Coal/Petroleum/<br>Coke/Gas/Oil  | 237                       | 0              | 1957-58<br>1970 |
| Selkirk              | Manitoba        | Manitoba Hydro                             | BW/PC                    | Coal/Oil                         | 132                       | 0              | 1960            |
| Boundary Dam         | Saskatchewan    | Saskatchewan Power Corp.                   | BW/<br>CE/PC<br>CG<br>HT | Coal/Gas                         | 582                       | 0              | 1959-73         |

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

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

Table 7.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>     | <u>Utility/<br/>Owner</u>                        | <u>Vendor</u>                | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|---------------------|--------------------------------------------------|------------------------------|------------------------------------------|-------------------------------|----------------|------------|
| Queen Elizabeth          | Saskatchewan        | Saskatchewan<br>Power Company                    | BB<br>FW/EE<br>BW/HI         | Coal/Oil/Gas                             | 241                           | 0              | 1958-72    |
| A. L. Cole               | Saskatchewan        | Saskatchewan<br>Power Company                    | BW/<br>FW/PC<br>CE/          | Coal/Oil/Gas                             | 105                           | 0              | 1928-57    |
| Battle River             | Alberta             | Alberta<br>Power Ltd.                            | CE/<br>BB<br>GE              | Coal/Petroleum/<br>Coke/Gas              | 362                           | 0              | 1956-75    |
| H. R. Milner             | Alberta             | Alberta<br>Power Ltd.                            | BW/HI                        | Coal                                     | 150                           | 0              | 1973       |
| Sundance                 | Alberta             | Calgary<br>Power Ltd.                            | CE/EE                        | Coal                                     | 1,000                         | 0              | 1970-73    |
| Wabamun                  | Alberta             | Calgary<br>Power Ltd.                            | BF/MV<br>CE/ME               | Coal/Gas                                 | 582                           | 0              | 1956-67    |
| Rossdale                 | Alberta             | Edmonton Power<br>Production Div.                | BW/<br>PC<br>BB              | Gas/Oil                                  | 345                           | 0              | 1932-66    |
| Clover Bar               | Alberta             | Edmonton Power<br>Production Div.                | BW/EW                        | Gas/Oil                                  | 330                           | 0              | 1970-73    |
| Burrard                  | British<br>Columbia | British Columbia<br>Hydro and Power<br>Authority | CB/<br>AE<br>AX<br>CE/<br>EE | Gas/Oil                                  | 912                           | 0              | 1962-75    |

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



SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 7.6.2

| <u>Year</u> | <u>Capacity - MWe(net)</u> |
|-------------|----------------------------|
| 1975        | 59,886                     |
| 1980        |                            |
| 1985        |                            |
| 1990        |                            |
| 1995        |                            |
| 2000        |                            |

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 7.6.3

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Owner</u>             | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|-----------------|--------------------------|--------------------------|-------------------|----------------|
| St. Rose                 | Nova Scotia     | Evans Coal Mines         | Coal Field               | 0.009             | 0              |
| Lingan                   | Nova Scotia     | DEVCO                    | Coal Field               | 1.233             | 0              |
| Point Aconi              | Nova Scotia     | DEVCO                    | Coal Field               | 0.165             | 0              |
| Westville                | Nova Scotia     | Drummond Coal Co.        | Coal Field               | 0.016             | 0              |
| --                       | Nova Scotia     | River Hebert Coal        | Coal Field               | 0.030             | 0              |
| Minto, Chipman           | New Brunswick   | N. B. Coal Limited       | Coal Field               | .430              | 0              |
| Bienfait                 | Saskatchewan    | Manitoba & Sask. Coal    | Coal Field               | .763              | 0              |
| Estevan                  | Saskatchewan    | Manitoba & Sask. Coal    | Coal Field               | 1.527             | 0              |
| Estevan                  | Saskatchewan    | Manalta Coal Ltd.        | Coal Field               | 1.140             | 0              |
| Estevan                  | Saskatchewan    | Malalta Coal Ltd.        | Coal Field.              | 1.247             | 0              |
| Estevan                  | Saskatchewan    | Saskatchewan Power Corp. | Coal Field               | 0.019             | 0              |
| East Coulee              | Alberta         | Century Coals Ltd.       | Coal Field               | 0.042             | 0              |
| Sheerness                | Alberta         | Manalta Coal Ltd.        | Coal Field               | 0.362             | 0              |

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

\*\* Coal - Million Tonnes/year; Oil - Barrels/day; Natural Gas - km<sup>3</sup>/year

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 7.6.3 (Continued)

| <u>Facility<br/>Name</u>                                                                                        | <u>Location</u> | <u>Owner</u>          | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|-----------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|--------------------------|-------------------|----------------|
| Halkirk                                                                                                         | Alberta         | Manalta Coal Ltd.     | Coal Field               | 0.533             | 0              |
| Forestburg                                                                                                      | Alberta         | Forestburg Collieries | Coal Field               | 0.773             | 0              |
| Wabamun                                                                                                         | Alberta         | Manalta Coal Ltd.     | Coal Field               | 2.059             | 0              |
| Sundance                                                                                                        | Alberta         | Manalta Coal Ltd.     | Coal Field               | 2.589             | 0              |
| (Nine additional coal mines are located in Canada. Their chief markets are for cokemaking in Japan and Europe.) |                 |                       |                          |                   |                |
| Acheson                                                                                                         | Alberta         |                       | Oil Field                | 10,398            | 0              |
| Bonnie Glen                                                                                                     | Alberta         |                       | Oil Field                | 45,033            | 0              |
| Carson Creek North                                                                                              | Alberta         |                       | Oil Field                | 18,460            | 0              |
| Fenn-Big Valley                                                                                                 | Alberta         |                       | Oil Field                | 22,629            | 0              |
| Golden Spike                                                                                                    | Alberta         |                       | Oil Field                | 23,178            | 0              |

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

\*\* Coal - Million Tonnes/year; Oil - Barrels/day; Natural Gas - km<sup>3</sup>/year

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 7.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity **</u> | <u>Status*</u> |
|--------------------------|-----------------|--------------|--------------------------|--------------------|----------------|
| Judy Creek               | Alberta         |              | Oil Field                | 57,481             | 0              |
| Kaybob                   | Alberta         |              | Oil Field                | 11,041             | 0              |
| Kaybob South             | Alberta         |              | Oil Field                | 10,600             | 0              |
| Leduc                    | Alberta         |              | Oil Field                | 16,463             | 0              |
| Mitsue                   | Alberta         |              | Oil Field                | 39,980             | 0              |
| Nipisi                   | Alberta         |              | Oil Field                | 36,929             | 0              |
| Pembina                  | Alberta         |              | Oil Field                | 87,671             | 0              |
| Provost                  | Alberta         |              | Oil Field                | 10,137             | 0              |
| Rainbow                  | Alberta         |              | Oil Field                | 78,082             | 0              |
| Redwater                 | Alberta         |              | Oil Field                | 73,158             | 0              |
| Sturgeon Lakes           | Alberta         |              | Oil Field                | 14,674             | 0              |
| Swan Hills               | Alberta         |              | Oil Field                | 106,027            | 0              |
| Swan Hills South         | Alberta         |              | Oil Field                | 58,767             | 0              |

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

\*\* Oil - Barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 7.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>  | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|------------------|--------------|--------------------------|-------------------|----------------|
| Turner Valley            | Alberta          |              | Oil Field                | 3,110             | 0              |
| Virginia Hills           | Alberta          |              | Oil Field                | 18,140            | 0              |
| Westrose                 | Alberta          |              | Oil Field                | 11,142            | 0              |
| Willesden Green          | Alberta          |              | Oil Field                | 14,041            | 0              |
| Wizard Lake              | Alberta          |              | Oil Field                | 34,151            | 0              |
| Other                    | Alberta          |              | Oil Field                | 438,108           | 0              |
| Boundary Lake            | British Columbia |              | Oil Field                | 6,882             | 0              |
| Other                    | British Columbia |              | Oil Field                | 36,337            | 0              |
| Other                    | Manitoba         |              | Oil Field                | 10,926            | 0              |
| Dollard                  | Saskatchewan     |              | Oil Field                | 6,884             | 0              |
| Midale                   | Saskatchewan     |              | Oil Field                | 7,400             | 0              |
| Weyburn                  | Saskatchewan     |              | Oil Field                | 18,112            | 0              |

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

\*\* Oil - Barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 7.6.3 (Continued)

| <u>Facility<br/>Name</u>    | <u>Location</u>        | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|-----------------------------|------------------------|--------------|--------------------------|-------------------|----------------|
| Other                       | Saskatchewan           |              | Oil Field                | 152,037           | 0              |
| Other                       | Ontario                |              | Oil Field                | 2,063             | 0              |
| Other                       | New Brunswick          |              | Oil Field                | 17                | 0              |
| Other                       | North West Territories |              | Oil Field                | 299               | 0              |
|                             | New Brunswick          |              | Gas Field                | 0.0028            | 0              |
|                             | Quebec                 |              | Gas Field                | negligible        | 0              |
|                             | Ontario                |              | Gas Field                | 0.14              | 0              |
|                             | Saskatchewan           |              | Gas Field                | 1.72              | 0              |
|                             | Alberta                |              | Gas Field                | 83.6              | 0              |
| Yukon + Painted<br>Mountain | North-West Territories |              | Gas Field                | 0.98              | 0              |
|                             | British Columbia       |              | Gas Field                | 10.71             | 0              |

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

\*\* Oil - Barrels/day; Natural Gas - km<sup>3</sup>/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 7.6.4

| <u>RESOURCE</u>                                            | <u>1985</u> | <u>2000</u> |
|------------------------------------------------------------|-------------|-------------|
| <u>COAL</u> (million tonnes)                               |             |             |
| Indigenous Supply                                          | 54.0        | 273.0       |
| Imports                                                    | --          | --          |
| Exports                                                    | 22.5        | 224.4       |
| <u>CRUDE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                          | 60.83       | 11.95       |
| Imports                                                    | 52.37       | 171.15      |
| Exports                                                    | --          | --          |
| <u>SHALE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                          | --          | --          |
| Imports                                                    |             |             |
| Exports                                                    |             |             |
| <u>NATURAL GAS</u> (cubic kilometers)                      |             |             |
| Indigenous Supply                                          | 104.63      | 55.19       |
| Imports                                                    | --          | --          |
| Exports                                                    | 38.33       | 35.81       |
| <u>URANIUM</u> (kilotonnes U <sub>3</sub> O <sub>8</sub> ) | 14.8        | 12.9        |
| Indigenous Supply                                          | 0           | 0           |
| Imports                                                    | 11.9        | 4.5         |
| Exports                                                    |             |             |

SECTION 8

EGYPT



## 8.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

### INDIGENOUS RESOURCES

Egypt has a small quantity of coal estimated at 25 million tonnes of which 13 million tonnes are economically recoverable (ref. 1.1). No information is available from the 1976 World Energy Conference Survey (ref. 1.2). The figures from the 1974 Survey appear to be the best available, and are quoted in reference 1.21. However, no breakdown by type is given.

Crude oil deposits are much more significant with 456 million tonnes economically recoverable (ref. 1.2) out of a total resource of 1,499 million tonnes. The economically recoverable figure compares with 375.2 million tonnes given by reference 1.22.

Natural gas reserves are also significant at 142 km<sup>3</sup> (ref. 1.2.) though no figure for total resources is available.

The theoretical maximum capacity of hydro-power in Egypt is not available. Current and planned generation amount to 6.57 TWh.

There are no known resources of uranium. There appear to be small reserves of thorium in the Nile Delta region.

### ENERGY SUPPLY

Egypt produces no solid fuels internally. Import level was 1.538 million tonnes in 1975 (ref. 1.5) 13% of which was from the United States.

Crude oil production was 8.428 million tonnes (ref. 1.5), 11.5 million tonnes (ref. 1.21). No oil trade takes place with the United States.

A small quantity of natural gas is produced: 0.055 km<sup>3</sup> (ref. 1.5).

### PATTERN OF ENERGY USE

The figures given in Table 8.1.3 were supplied by private communication.

### FORECASTS OF ENERGY SUPPLY AND DEMAND

The projected growth of demand for energy and electricity is shown in Table 8.1.4. A high economic growth of 8% per year over the period 1975-2000 would result in a 4.7% average annual rate of increase of energy demand and an increase of electricity demand at an annual rate of 8.8%. Low economic growth would considerably reduce the rate of growth of energy and electricity demand to 2.0% and 4.4%, respectively. The forecast electricity demand figures compare favorably with a forecast of 86 TWh total electricity demand in 2000 (ref. 1.39) after allowance has been made for the effect of the escalation of fuel prices that has occurred since that forecast was made in 1974.

The breakdown of energy demand into sources of supply shown in Table 8.1.5 indicates that a rapidly growing nuclear power generation capacity will help to maintain the consumption of fossil fuels at a relatively constant level. In 2000, the total nuclear capacity in Egypt could be as high as 6,400 MW which would produce the 36.9 TWh demand for medium economic growth.

# INDIGENOUS ENERGY RESOURCES

Table 8.1.1

EGYPT-3

|                                     | Economically<br>Recoverable Reserves | Total Indigenous<br>Resources | Location of<br>Identified Reserves   |
|-------------------------------------|--------------------------------------|-------------------------------|--------------------------------------|
| Hard Coal (million tonnes)          | 13*                                  | 25*                           | Suez                                 |
| Soft Coal (million tonnes)          | 0                                    | 0                             | -                                    |
| Crude Oil (million tonnes)          | 455.8                                | 1,499                         | Eastern and Western<br>Desert, Sinai |
| Shale Oil (million tonnes)          | 0                                    | 0                             | -                                    |
| Natural Gas (cubic km)              | 142                                  | Not Available                 | Abu Madi, Morganfields,<br>Abu Atr   |
| Uranium (thousand tonnes $U_3O_8$ ) | 0                                    | 0                             | -                                    |
| Hydro Power (TWh/year)              | 6.57                                 | Not Available                 | Nile River                           |
| Geothermal (TWh/year)               | 0                                    | 0                             | -                                    |

\* Type of coal unknown - assumed hard

ENERGY SUPPLY 1975

Table 8.1.2

| Resource                            | Indigenous<br>Supply | Imports |           | Exports |         |
|-------------------------------------|----------------------|---------|-----------|---------|---------|
|                                     |                      | Total   | % from US | Total   | % to US |
| Hard Coal (million tonnes)          | 0                    | 1.538   | 13.0      | 0       | 0       |
| Soft Coal (million tonnes)          | 0                    | 0       | 0         | 0       | 0       |
| Crude Oil (million tonnes)          | 8.428                | 2.081   | 0         | 0.923   | 0       |
| Shale Oil (million tonnes)          | 0                    | 0       | 0         | 0       | 0       |
| Natural Gas (cubic km)              | 0.055                | 0       | 0         | 0       | 0       |
| Uranium (thousand tonnes $U_{38}$ ) | 0                    | 0       | 0         | 0       | 0       |
| Electricity (TWh)                   | 10.421               | 0       | 0         | 0       | 0       |

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 8.1.3

| Resource                                 | Consuming Sector            |               |                |                          | Total |
|------------------------------------------|-----------------------------|---------------|----------------|--------------------------|-------|
|                                          | Household and<br>Commercial | Industrial    | Transportation | Electrical<br>Generation |       |
| Coal (million tonnes)                    | 0                           | 1.1           | 0.01           | 0                        | 1.11  |
| Petroleum (million tonnes)               | 0.03                        | 4.1           | 3.5            | 1.05                     | 8.68  |
| Natural Gas (cubic km)                   | Not Available               | Not Available | Not Available  | 0                        | -     |
| Nuclear Power (TWh)                      | -                           | -             | -              | 0                        | 0     |
| Hydro Power (TWh)                        | -                           | -             | -              | 6.8                      | 6.8   |
| Geothermal Power (TWh)                   | -                           | -             | -              | 0                        | 0     |
| Utility Electricity<br>Distributed (TWh) |                             |               |                |                          | 10.42 |

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 8.1.4

| Year | Low Economic Growth                               |                      | Medium Economic Growth                            |                      | High Economic Growth                              |                      |
|------|---------------------------------------------------|----------------------|---------------------------------------------------|----------------------|---------------------------------------------------|----------------------|
|      | 4.0%                                              |                      | 6.0%                                              |                      | 8.0%                                              |                      |
|      | Total Primary<br>Energy<br>(10 <sup>12</sup> BtU) | Electricity<br>(TWh) | Total Primary<br>Energy<br>(10 <sup>12</sup> BtU) | Electricity<br>(TWh) | Total Primary<br>Energy<br>(10 <sup>12</sup> BtU) | Electricity<br>(TWh) |
| 1975 | 473                                               | 10.4                 | 473                                               | 10.4                 | 473                                               | 10.4                 |
| 1985 | 574                                               | 16.0                 | 711                                               | 19.7                 | 734                                               | 24.2                 |
| 2000 | 773                                               | 30.4                 | 1,119                                             | 51.2                 | 1,500                                             | 85.3                 |

# CONSUMPTION OF ENERGY RESOURCES

Table 8.1.5

| Resource         | Standard Unit                                 | Annual Consumption of<br>Standard Units |      |      | Energy Consumption<br>(10 <sup>12</sup> BtU) |      |      |
|------------------|-----------------------------------------------|-----------------------------------------|------|------|----------------------------------------------|------|------|
|                  |                                               | 1975                                    | 1985 | 2000 | 1975                                         | 1985 | 2000 |
| Coal             | Million Tonnes                                | 1.54                                    | 1.6  | 1.6  | 42.7                                         | 45   | 43   |
| Crude Oil        | Million Tonnes                                | 8.25                                    | 12.3 | 12.7 | 351.2                                        | 523  | 542  |
| Natural Gas      | Cubic km                                      | 0.06                                    | 0.1  | 0.1  | 2.05                                         | 2    | 2    |
| Hydro Power      | TWh                                           | 6.80                                    | 8.3  | 9.8  | 77.3                                         | 94   | 112  |
| Other Renewables | TWh                                           | -                                       | -    | -    | -                                            | -    | -    |
| Nuclear Power    | TWh                                           | -                                       | 4.1  | 36.9 | -                                            | 47   | 420  |
| Uranium          | Thousand Tonnes U <sub>3</sub> O <sub>8</sub> | -                                       | 0.11 | 4.3  | -                                            | -    | -    |

## 8.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

### COMMERCIAL NUCLEAR POWER PLANTS

Table 8.2.1

| Facility<br>Name | Utility                | Vendor | Facility<br>Type | Capacity<br>(MWe net) | Status* | COD      |
|------------------|------------------------|--------|------------------|-----------------------|---------|----------|
| Egypt-1          | Egyptian<br>Government | -      | PWR              | 600                   | P       | Sep 1984 |

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



PROJECTED NUCLEAR GENERATING CAPACITY  
MWe (net)

Table 8.2.2

| Year     | PWR | BWR | Magnox | AGR | CANDU | Other | FBR | Firm +<br>Planned<br>Cumulative<br>Total | NAC<br>Cumulative<br>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     | 600 |     |        |     |       |       |     | 600                                      | 600                             |
| 1985     |     |     |        |     |       |       |     | 600                                      | 600                             |
| 1986     | 600 |     |        |     |       |       |     | 600                                      | 1200                            |
| 1987     |     |     |        |     |       |       |     | 600                                      | 1200                            |
| 1988     |     |     |        |     |       |       |     | 600                                      | 1200                            |
| 1989     | 300 | 300 |        |     |       |       |     | 600                                      | 1800                            |
| 1990     | 300 | 300 |        |     |       |       |     | 600                                      | 2400                            |
| 1991     |     |     |        |     |       |       |     | 600                                      | 2400                            |
| 1992     | 500 | 500 |        |     |       |       |     | 600                                      | 3400                            |
| 1993     |     |     |        |     |       |       |     | 600                                      | 3400                            |
| 1994     |     |     |        |     |       |       |     | 600                                      | 3400                            |
| 1995     | 500 | 500 |        |     |       |       |     | 600                                      | 4400                            |
| 1996     |     |     |        |     |       |       |     | 600                                      | 4400                            |
| 1997     | 500 | 500 |        |     |       |       |     | 600                                      | 5400                            |
| 1998     |     |     |        |     |       |       |     | 600                                      | 5400                            |
| 1999     | 500 | 500 |        |     |       |       |     | 600                                      | 6400                            |
| 2000     |     |     |        |     |       |       |     | 600                                      | 6400                            |

## NUCLEAR REACTOR VENDORS

### Overview

Egypt possesses no nuclear reactor vendors and none are planned.

### Nuclear Reactor Vendor Support Industries

The capability of Egyptian industry to supply nuclear equipment and components will only become clear when the first nuclear unit is ordered. Capability to supply the major components does not exist at present and in view of the state of technological development and limited domestic nuclear program, it is unlikely that such facilities will be installed.

## NUCLEAR FUEL CYCLE FACILITIES

### Overview

Egypt possesses no nuclear fuel cycle facilities and none are firmly planned at this time. Potential uranium reserves exist within the country though no economic deposits have yet been located. Foreign investors are being invited to take part in uranium exploration.

## NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

### Vested Interests in Current Fuel Cycles and Reactor Technologies

At this stage of the development of the Egyptian commercial nuclear power program there are no identifiable major vested interests in either current reactor technologies or fuel cycles.

### Current Trends in Nuclear Development Programs

Egypt has no known plans to independently develop nuclear power systems and will rely on imports from experienced vendors abroad.

### 8.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

#### PROFESSIONAL LABOR FORCE PROFILE

Table 8.3.1

Available information presents the following data  
for 1973:

|         |                                         |
|---------|-----------------------------------------|
| 593,254 | Scientists and Engineers                |
| 10,665  | Scientists and Engineers engaged in R&D |

### KEY TECHNICAL EDUCATIONAL RESOURCES

Table 8.3.2

| <u>Institution</u>           | <u>Location</u> |
|------------------------------|-----------------|
| Cairo University             | Cairo           |
| Alexandria University        | Alexandria      |
| Ein Shams University         | Cairo           |
| Asyut Universtiy             | Asyut           |
| Al-Ayhar University          | Cairo           |
| American University in Cairo | Cairo           |
| Mansoura University          | Mansoura        |
| Tauta University             | Tauta           |

### KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 8.3.2

| <u>Name</u>                 | <u>Location</u> | <u>Main Activities</u>                                                                                                                                                                               |
|-----------------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Atomic Energy Establishment | Cairo           | Research and training in nuclear energy. Responsible for research institutions, production of nuclear materials, and equipment, security and safeguards, regulation and licensing of nuclear plants. |

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 8.3.4

| <u>Name</u> | <u>Owner</u> | <u>Location</u> | <u>Main Activities</u> |
|-------------|--------------|-----------------|------------------------|
|-------------|--------------|-----------------|------------------------|

Not Applicable

RESEARCH AND TEST REACTORS  
List of Reactors

Table 8.3.5

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Owner</u> | <u>Constructor</u> | <u>Facility<br/>Type</u> | <u>Facility Status</u> |                |            |
|--------------------------|-----------------|--------------|--------------------|--------------------------|------------------------|----------------|------------|
|                          |                 |              |                    |                          | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u> |
| WWR-C-Cairo              | Inshas          | AEE          | USSR               | Research<br>tank         | 2                      | 0              | 7/61       |

\* 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 8.3.6

| <u>Vendor</u> | <u>Country</u> | <u>Facility<br/>Name</u> | <u>Facility<br/>Type</u> | <u>Facility Status</u> |                |            | <u>Scope of<br/>Services</u> |
|---------------|----------------|--------------------------|--------------------------|------------------------|----------------|------------|------------------------------|
|               |                |                          |                          | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u> |                              |

Not Applicable

EGYPT-15

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

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 8.3.7

| <u>Facility</u><br><u>Name</u> | <u>Location</u> | <u>Facility</u><br><u>Type</u> | <u>Capacity</u><br><u>MT/YR</u> | <u>Status</u><br><u>Status*</u> | <u>Year</u> | <u>Shareholdings</u> |
|--------------------------------|-----------------|--------------------------------|---------------------------------|---------------------------------|-------------|----------------------|
|--------------------------------|-----------------|--------------------------------|---------------------------------|---------------------------------|-------------|----------------------|

Not Applicable

EGYPT-16

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



#### 8.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

##### ECONOMIC DATA PROFILE

Table 8.4.1

|                          |                 |                        |                |
|--------------------------|-----------------|------------------------|----------------|
| GNP (Current million \$) | - 17,430 (1977) | Inflation Rate         | - 25% (1977)   |
| Exports (million \$)     | - 2,160 (1977)  | Imports (million \$)   | - 5,375 (1977) |
| Per Capita Income (\$)   | - 386 (1977)    | Disposable Income (\$) | - 263 (1976)   |
| Monetary Unit            | - Pound         | Exchange Rate (/US\$)  | - 2.56 (1977)  |
| Population (million)     | - 39.2 (1977)   |                        |                |

#### 8.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

|                            | <u>FY 1976</u><br><u>US \$MILLION</u> |
|----------------------------|---------------------------------------|
| National Research Center   |                                       |
| Research programs          | .179                                  |
| Atomic energy programs     | .248                                  |
| Qattara Depression Project | 2.5                                   |
| FRG Funding on Qattara     | 4.2                                   |

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

Table 8.4.3

| <u>Industry<br/>University or<br/>Laboratory</u>           | <u>Program<br/>Area</u>                                                                                                                                                                                           | <u>Budget<br/>\$ (Millions)</u> | <u>Key<br/>Personnel</u>      |
|------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------------------------|
| Inchass Research<br>Center                                 | 2MW research reactor<br>2.5 Van de Graaf<br>accelerator, isotopes<br>production, activation<br>analysis lab with<br>SUNVIC 100 channel<br>analyzer & research<br>on uranium contaminants<br>and ultra pure metals | --                              | --                            |
| Academy of Scientific<br>Research and Tech-<br>nology      | --                                                                                                                                                                                                                | --                              | Dr. Abdel Moneim<br>Aboul Azm |
| Lahmeyer (FRG)                                             | Qattara Project                                                                                                                                                                                                   |                                 | --                            |
| Salzgitter (FRG)                                           | Qattara Project                                                                                                                                                                                                   |                                 | --                            |
| Deutsche Project<br>Union                                  | Qattara Project                                                                                                                                                                                                   |                                 | --                            |
| Bundesanstalt fur<br>Wissenschaften and<br>Rohstoffe (FRG) | Qattara Project                                                                                                                                                                                                   |                                 | --                            |
| CER Nuclear (USA)                                          | Qattara Project                                                                                                                                                                                                   |                                 | --                            |

8.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

Not Applicable

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 8.4.5

| <u>Name</u> | <u>Share Capital</u> | <u>Assets</u> | <u>Sales</u> |
|-------------|----------------------|---------------|--------------|
|-------------|----------------------|---------------|--------------|

Not Applicable

#### 8.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Egypt has negotiated with Westinghouse and the U.S. to buy a PWR for completion in 1983. Financing is seen at the time to be accomplished through government-to government aide, possibly through Exim Bank.

8.5. GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

8.5.1 ENERGY POLICY - BASIC LEGISLATION

1. Permanent Council of National Production established in 1952.
2. Political parties outlawed in 1953, legalized in 1976.
3. Egyptian Atomic Energy Establishment (AEE) created in 1957.
4. Electricity supply industry placed under unified national control by the formation of the Ministry of Electric Power in 1964..
5. Law 43 of 1974 greatly modified restrictive tax, labor and protection against nationalization, confiscation and sequestration.
6. Ministry of ElectricPower restructured in 1976 and renamed Ministry of Electric Power and Energy.
7. Nuclear Power Plants Authority (NPPA) and the Qattara Depression Authority created in 1976.

#### 8.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

##### LEGISLATIVE

Under the constitution the unicameral People's Assembly (360 member) has sole authority to enact legislation while it is in session.

##### EXECUTIVE

Egypt has a strong presidential-type government. President popularly elected to 6 year term. President appoints Vice-President, Prime Minister and Council of Ministers. When Peoples Assembly is not in session he rules by decree, but legislation so promulgated must be submitted to the assembly for approval when it reconvenes.

Key personnel: President Anwar Sadat, Vice President Hosni Mobarek and Prime Minister Mamdouh Salem.

##### MINISTRY OF ATOMIC ENERGY AND SCIENTIFIC RESEARCH (MINSRI)

Responsible for:

1. Overall research priorities and planning.
2. Nuclear research and research facilities.
3. Share responsibility with Ministry of Electricity and others for nuclear power generation and directly related facilities.

Key Personnel:

Minister - Mohammed Abdel Maaboud El-Guebeily

Director General - Dr. Abdel Sabet

Undersecretary - Dr. El Shazli Mohamed El Shazli

##### MINISTRY OF ELECTRICITY POWER AND ENERGY (MINELECTRIC)

Responsible for all uses of electric power and power generation, including nuclear power generation. Includes Egyptian Electricity Authority (EEA) and Rural Electrification Authority (REA).

Key Personnel:

Minister - Ahmad Sultan (Also Deputy Premier for Production and Government of Egypt's top energy official)

First Deputy Minister - Maher Abaza

### 8.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

#### EGYPTIAN ATOMIC ENERGY ESTABLISHMENT (AEE)

Reports to MINSCE

Responsible for:

- a. training nuclear specialists
- b. research in atomic energy
- c. institutions for nuclear training and research
- d. nuclear materials (exploration, extraction, trade and use)
- e. production of nuclear materials and equipment
- f. security and safeguards
- g. proposal of atomic energy legislation and projects
- h. international cooperation
- i. regulation and licensing of nuclear plants

AEE collaborates with all ministries and government organizations concerned with nuclear matters and national planning as well as with scientific research centers and universities.

Director is Kamal Effat

NUCLEAR POWER PLANTS AUTHORITY (NPPA) was created in 1976.

#### QATTARA DEPRESSION AUTHORITY

Created 1976 under auspices of Ministry of Electric Power and Energy to manage the Qattara Depression Project.

Twelve member steering committee established with equal number of representatives from FRG and GOE.

Board of Advisors made up of German, Egyptian, American and French citizens includes Kenneth Fields (former USAEC General Manager) and Wendell E. Johnson ( former Chief of the Engineering Division, Civil Works Department, US Army Corps of Engineers)

#### 8.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

According to Egypt's top energy official Ahmad Sultan (Minister of Electric Power and Energy and Deputy Premier for Production), the government is anxious to develop domestic energy resources which can provide adequate cheap power supplies for Egypt's industrial development. By the year 2000 an additional 14,000 MW of installed electric capacity is planned to be available from a small hydro plant on the Nile (1500MW), the Qattara Depression Project (10000MW) and nuclear or other (2500MW). If the Qattara Project fails, 2500 to 12500MW is to be made up by nuclear.

#### 8.5.5 NUCLEAR ENERGY R&D -- STATUS AND OUTLOOK

Inchass Research Center (AEE site NE of Cairo) has a Soviet-supplied 2 MW research reactor (critical 1961). Principal activities to date have been conducted there. A 600 MW reactor is planned for completion in 1981 pending completion of U.S.-Egypt Agreement for Cooperation in Peaceful Uses of Atomic Energy. Planned site is Sidi Kreir (35 kms east of Alexandria). Egypt plans construction of an additional US-supplied 1000 MW reactor by 1983. Long-range plans call for construction of several nuclear power stations over next 20 years, with reactors purchased from Western Europe as well as the USA. Egypt is thought to be interested in cooperative agreement with Canada on heavy water production (Egypt produces some heavy water as a by-product of a fertilizer plant at Aswan).



#### 8.5.6 NUCLEAR ENERGY R&D - PRIORITIES

According to Ministry of Electric Power and Energy, the Qattara Depression Project is the number one R&D priority. While the order of importance is unclear, the following areas are mentioned as priorities.

- A. Petroleum sources of power
- B. Solar sources of power
- C. Wind power (Oklahoma University-sponsored 60kw wind driven generator)

Research in above areas being conducted largely by non-Egyptian experts. The only current in-house MINELECTRIC R&D of significance is in area of network load distribution and similar problems.

Since development of atomic energy sources is far advanced, reactors are commercially available and Egypt is faced with questions of choice of LWR technology and project implementation, rather than nuclear R&D.

#### 8.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

The Egyptian Atomic Energy Establishment (AEE) is responsible for regulation and licensing of nuclear power plants. The AEE collaborates with all ministries and government organizations concerned with nuclear matters.

8.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

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

Table 8.6.1

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>   | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------|-----------------|-----------------------------|---------------|------------------------------------------|-------------------------------|----------------|------------|
| Kafr El-Dowar        |                 | Egyptian Elec.<br>Authority |               | Steam                                    | 220                           | U              | 1978       |
| El Tebin             |                 | Egyptian Elec.<br>Authority |               | Gas                                      | 120                           | U              | 1978       |
| Talkha               |                 | Egyptian Elec.<br>Authority |               | Gas                                      | 180                           | U              | 1978       |
| Cairo West<br>No. 4  |                 | Egyptian Elec.<br>Authority |               | ?                                        | 87                            | P              | 1979       |
| Abu Kier             |                 | Egyptian Elec.<br>Authcrity |               | Steam                                    | 600                           | U              | 1980/81    |
| Ismailia             |                 | Egyptian Elec.<br>Authority |               | Steam                                    | 300                           | P              | 1982       |
| Suez                 |                 | Egyptian Elec.<br>Authority |               | Steam                                    | 600                           | U              | 1982       |
| Aswan Dam            |                 | Egyptian Elec.<br>Authority |               | Hydro                                    | 381                           | O              | 1961       |
| High Dam             |                 | Egyptian Elec.<br>Authority |               | Hydro                                    | 2,064                         | O              | 1967-70    |

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

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

Table 8.6.1 (Continued)

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/ Owner</u>    | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------|-----------------|--------------------------|---------------|----------------------------------|---------------------------|----------------|------------|
| West Cairo           |                 | Egyptian Elec. Authority |               | Thermal                          |                           | 0              |            |
| South Cairo          |                 | Egyptian Elec. Authority |               | Thermal                          |                           | 0              |            |
| North Cairo          |                 | Egyptian Elec. Authority |               | Thermal                          |                           | 0              |            |
| Talkha               |                 | Egyptian Elec. Authority |               | Thermal                          |                           | 0              |            |
| Damanhour            |                 | Egyptian Elec. Authority |               | Thermal                          |                           | 0              |            |
| El Syof              |                 | Egyptian Elec. Authority |               | Thermal                          |                           | 0              |            |
| Asiut                |                 | Egyptian Elec. Authority |               | Thermal                          |                           | 0              | 1967       |
| El Max               |                 | Egyptian Elec. Authority |               | Thermal                          |                           | 0              |            |
| Gas Suez             |                 | Egyptian Elec. Authority |               | Gas/Oil                          |                           | 0              |            |

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

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

Table 8.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>   | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|--------------------------|-----------------|-----------------------------|---------------|------------------------------------------|-------------------------------|----------------|------------|
| El Tebine                |                 | Egyptian Elec.<br>Authority |               |                                          |                               | 0              |            |
| Karmouz                  |                 | Egyptian Elec.<br>Authority |               |                                          |                               | 0              |            |

EGYPT-29

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

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 8.6.2

| <u>Year</u> | <u>Capacity - MWe(net)</u> |
|-------------|----------------------------|
| 1975        | 3,893                      |
| 1980        | 4,491                      |
| 1985        | 7,191                      |
| 1990        |                            |
| 1995        |                            |
| 2000        |                            |

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 8.6.3

| <u>Facility Name</u> | <u>Location</u>   | <u>Owner</u>  | <u>Facility Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|----------------------|-------------------|---------------|----------------------|-------------------|----------------|
| Abu Gharadig         | West Desert       | AMOCO         | Oil Field            | 11,425            | 0              |
| El Morgan, Kareem    | Offshore, Red Sea | EGPC          | Oil Field            | 76,998            | 0              |
| El Morgan, Belayin   | Offshore, Red Sea | EGPC          | Oil Field            | 7,708             | 0              |
| July, Rudeis         | Offshore, Red Sea | EGPC          | Oil Field            | 44,287            | 0              |
| July, Cretaceous     | Offshore, Red Sea | EGPC          | Oil Field            | 1,105             | 0              |
| July, Nubian         | Offshore, Red Sea | EGPC          | Oil Field            | 53,183            | 0              |
| Ramadan              | Offshore, Red Sea | EGPC          | Oil Field            | 79,217            | 0              |
| Rayzak               | West Desert       | EGPC          | Oil Field            | 9,729             | 0              |
| West Desert 33       | West Desert       | EGPC          | Oil Field            | 7                 | 0              |
| West Desert 19       | West Desert       | EGPC          | Oil Field            | 61                | 0              |
| El-Alamein           | West Desert       | Phillips-EGPC | Oil Field            | 7,490             | 0              |
| Yidma                | West Desert       | Phillips-EGPC | Oil Field            | 4,054             | 0              |
| Umbarka              | West Desert       | Phillips-EGPC | Oil Field            | 1,206             | 0              |

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

\*\* Oil - Barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 8.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>   | <u>Owner</u>  | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|-------------------|---------------|--------------------------|-------------------|----------------|
| Umbarka                  | West Desert       | Phillips-EGPC | Oil Field                | 1,206             | 0              |
| Belayim                  | East Desert       | ENI-EGPC      | Oil Field                | 34,000            | 0              |
| Belayim                  | Offshore, Red Sea | ENI-EGPC      | Oil Field                | 35,000            | 0              |
| Gharib                   | East Desert       | EGPC          | Oil Field                | 7,187             | 0              |
| Sudr                     | East Desert       | EGPC          | Oil Field                | 1,942             | 0              |
| Asl                      | East Desert       | EGPC          | Oil Field                | 1,610             | 0              |
| Bahr                     | East Desert       | EGPC          | Oil Field                | 8,103             | 0              |
| Kareem                   | East Desert       | EGPC          | Oil Field                | 631               | 0              |
| Amer                     | Offshore          | EGPC          | Oil Field                | 2,025             | 0              |
| Shukheir                 | East Desert       | EGPC          | Oil Field                | 506               | 0              |
| El-Ayoun                 | East Desert       | EGPC          | Oil Field                | 1,807             | 0              |
| El-Yusr                  | East Desert       | EGPC          | Oil Field                | 5,087             | 0              |
| Kheir                    | East Desert       | EGPC          | Oil Field                | 244               | 0              |

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

\*\* Oil - Barrels/day



LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 8.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>  | <u>Owner</u>        | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|------------------|---------------------|--------------------------|-------------------|----------------|
| Abu Madi                 | Nile Delta       | Delta Petroleum Co. | Gas Field                |                   | 0              |
| Abu Qir                  | NE of Alexandria |                     | Gas Field                |                   | 0              |
| Abu Gharadiq             | Western Desert   |                     | Gas Field                |                   | 0              |

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

\*\* Natural Gas - km<sup>3</sup>/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 8.6.4

| <u>RESOURCE</u>                                                | <u>1985</u> | <u>2000</u> |
|----------------------------------------------------------------|-------------|-------------|
| <u>COAL</u> (million tonnes)                                   |             |             |
| Indigenous Supply                                              | 0           | 0           |
| Imports                                                        | 1.6         | 1.6         |
| Exports                                                        | --          | --          |
| <br><u>CRUDE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                              | 25.58       | 41.98       |
| Imports                                                        | --          | --          |
| Exports                                                        | 13.28       | 29.28       |
| <br><u>SHALE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                              | 0           | 0           |
| Imports                                                        |             |             |
| Exports                                                        |             |             |
| <br><u>NATURAL GAS</u> (cubic kilometers)                      |             |             |
| Indigenous Supply                                              | 2.76        | 5.46        |
| Imports                                                        | --          | --          |
| Exports                                                        | 2.66        | 5.36        |
| <br><u>URANIUM</u> (kilotonnes U <sub>3</sub> O <sub>8</sub> ) |             |             |
| Indigenous Supply                                              | 0           | 0           |
| Imports                                                        | .11         | 1.32        |
| Exports                                                        | 0           | 0           |

SECTION 9

FEDERAL REPUBLIC OF GERMANY

## 9.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

### INDIGENOUS RESOURCES

Germany produces about equal quantities of high-ranking and brown coals. The quantity of reserves and resources has remained constant for both World Energy Conference Surveys (refs. 1.1 and 1.2) though some of the regions (Ruhr, Saar, Aachen and Ibbenburen) have not up-dated their estimates.

Figures for economically recoverable reserves of crude oil have increased from 52.9 million tonnes in 1973 to 72.0 million tonnes in 1975 (see refs. 1.1 and 1.2, Appendix 3). No figures are currently available for total resources.

Proved recoverable reserves of natural gas have remained constant for both World Energy Conference Surveys mentioned above; however, the estimate of original gas-in-place has been revised upwards from 327.0 km<sup>3</sup> in 1973 to 607.6 km<sup>3</sup> in 1975.

There is little scope for increasing energy supply via hydro-power. The economically recoverable reserves would generate 21.8 TWh annually and maximum theoretical capacity is only 33.1 TWh (ref. 1.2, Appendix 6). Small quantities of uranium have been found.

No geothermal resources have been reported.

### ENERGY SUPPLY

West Germany produced 222.4 million tonnes of solid fuels in 1975 (ref. 1.2). This is equivalent to 92.61 million tonnes of oil and compares with the figure of 89.86 million tonnes in reference 1.6. Of this production 123.4 million tonnes were hard coal, 22.17 million tonnes of which were exported (ref. 1.5). The export figure quoted in reference 1.6 is equivalent to 22.74 million tonnes and compares well. A small percentage of this export goes to the United States. West Germany imports a small quantity of coal (9.421 million tonnes, ref. 1.5, 9.37 million tonnes, ref. 1.6) of which approximately 29% is supplied by the United States.

Production of crude oil was given at 5.74 million tonnes (refs. 1.2, 1.5) and 5.82 (ref. 1.6). Imports were significant at 91.85 million tonnes (ref. 1.5) (92.77, ref. 1.6). None of this oil was imported from the United States.

Production of natural gas was 18.88 km<sup>3</sup> (ref. 1.5). Reference 1.2 gives only the 1974 figure which was 20.2 km<sup>3</sup>. Imports were 26.33 km<sup>3</sup> principally from the Netherlands. No gas is imported or exported to the United States.

All uranium was imported, 13% from the United States.

#### PATTERNS OF ENERGY USE

Since no figures are available for solid fuel demand by type, the production of hard coal, soft coal and peat has been converted into a hard coal equivalent. This results in a figure of 129.8 million tonnes of hard coal, and the sectoral demand is given in terms of this quantity. The majority of this supply goes towards electricity production.

In addition to the petroleum produced from crude oil, Germany imports a significant quantity (37.71 million tonnes in 1975, ref. 1.6). It is used in every sector, household/commercial demand being particularly high.

No natural gas is used for transportation but significant quantities go towards electrical energy generation.

Electricity is distributed evenly between the household/commercial and industrial sectors, with a small quantity going to transportation.

#### FORECASTS OF ENERGY SUPPLY AND DEMAND

The expected annual rate of increase of primary energy demand over the period 1975 to 2000 ranges from 1.7% to 3.5%, while the corresponding growth of electricity demand over the same period is expected to be between 2.6% and 6.3%. As can be seen from Table 9.1.4, these demand growth figures correspond to economic growth rates ranging from 2% to 5%.

The forecast of total primary energy demand in West Germany in 1985 presented to the Commission of the European Communities (ref. 1.16) was  $13,973 \times 10^{12}$  Btu (351 million tonnes of oil equivalent) which lies between the medium and high economic growth scenario forecasts presented in Table 9.1.4.

The breakdown of the forecast energy demand into its sources of supply shown in Table 9.1.5 is for 1985 as presented by West Germany to the CEC (ref. 1.16). In the period 1985-2000 the trends of the previous ten years are expected to continue with the relative importance of fossil fuels declining in relation to the contribution of nuclear energy to the total demand.

# INDIGENOUS ENERGY RESOURCES

Table 9.1.1

|                                                          | Economically<br>Recoverable Reserves | Total Indigenous<br>Resources | Location of<br>Identified Reserves              |
|----------------------------------------------------------|--------------------------------------|-------------------------------|-------------------------------------------------|
| Hard Coal (million tonnes)                               | 30,000                               | 230,303                       | } Ruhr, Rheinland,<br>Aachen, Saar              |
| Soft Coal (million tonnes)                               | 9,571                                | 55,851                        |                                                 |
| Crude Oil (million tonnes)                               | 72                                   | Not Available                 | Neidersachsen, River<br>Ems, Schleswig-Holstein |
| Shale Oil (million tonnes)                               | 0                                    | 0                             | -                                               |
| Natural Gas (cubic km)                                   | 335                                  | 486                           | Weser and Ems Rivers                            |
| Uranium (thousand tonnes U <sub>3</sub> O <sub>8</sub> ) | 2.4                                  | 6.5                           | Black Forest                                    |
| Hydro Power (TWh/year)                                   | 21.8                                 | 33.1                          | Danube, Rhine                                   |
| Geothermal (TWh/year)                                    | 0                                    | 0                             | } Ruhr, Rheinland,<br>Aachen, Saar              |
| Peat (million tonnes)                                    | 900                                  | 900                           |                                                 |

# ENERGY SUPPLY 1975

Table 9.1.2

| Resource                                                 | Indigenous<br>Supply | Imports |           | Exports |         |
|----------------------------------------------------------|----------------------|---------|-----------|---------|---------|
|                                                          |                      | Total   | % from US | Total   | % to US |
| Hard Coal (million tonnes)                               | 98.8                 | 9.421   | 29.4      | 22.157  | 0.271   |
| Soft Coal (million tonnes)                               | 123.4                | 0       | 0         | 0       | 0       |
| Crude Oil (million tonnes)                               | 5.749                | 91.850  | 0         | 0       | 0       |
| Shale Oil (million tonnes)                               | 0                    | 0       | 0         | 0       | 0       |
| Natural Gas (cubic km)                                   | 18.88                | 26.33   | 0         | 0.088   | 0       |
| Uranium (thousand tonnes U <sub>3</sub> O <sub>8</sub> ) | 0                    | 2.36    | 13.2      | 0       | 0       |
| Electricity (TWh)                                        | 301.8                | 17.63   | 0         | 9.79    | 0       |
| Peat                                                     | 0.22                 | 0       | 0         | 0       | 0       |



PATTERNS OF ENERGY SOURCES AND USES 1975

Table 9.1.3

| Resource                                 | Consuming Sector            |            |                |                          | Total |
|------------------------------------------|-----------------------------|------------|----------------|--------------------------|-------|
|                                          | Household and<br>Commercial | Industrial | Transportation | Electrical<br>Generation |       |
| Coal*(million tonnes)                    | 10.41                       | 22.8       | 0.4            | 60.3                     | 93.91 |
| Petroleum (million tonnes)               | 43.17                       | 28.96      | 31.91          | 4.78                     | 108.8 |
| Natural Gas (cubic km)                   | 9.52                        | 17.89      | 0              | 12.59                    | 40.0  |
| Nuclear Power (TWh)                      | 0                           | 0          | 0              | 21.40                    | 21.40 |
| Hydro Power (TWh)                        | 0                           | 0          | 0              | 17.11                    | 17.11 |
| Geothermal Power (TWh)                   | 0                           | 0          | 0              | 0                        | 0     |
| Utility Electricity<br>Distributed (TWh) | 118.63                      | 131.77     | 8.84           | 47.05                    | 306.3 |

\* Soft Coal and peat have been reduced to a hard-coal equivalent.

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 9.1.4

| Year | Low Economic Growth<br>2.0%                       |                      | Medium Economic Growth<br>3.5%                    |                      | High Economic Growth<br>5.0%                      |                      |
|------|---------------------------------------------------|----------------------|---------------------------------------------------|----------------------|---------------------------------------------------|----------------------|
|      | Total Primary<br>Energy<br>(10 <sup>12</sup> Btu) | Electricity<br>(TWh) | Total Primary<br>Energy<br>(10 <sup>12</sup> Btu) | Electricity<br>(TWh) | Total Primary<br>Energy<br>(10 <sup>12</sup> Btu) | Electricity<br>(TWh) |
| 1975 | 9,462                                             | 301.8                | 9,462                                             | 301.8                | 9,462                                             | 301.8                |
| 1985 | 12,042                                            | 400.7                | 13,139                                            | 478.4                | 14,319                                            | 569.5                |
| 2000 | 14,380                                            | 574.5                | 17,883                                            | 894.4                | 22,170                                            | 1,383.4              |

# CONSUMPTION OF ENERGY RESOURCES

Table 9.1.5

| Resource         | Standard Unit                                 | Annual Consumption of<br>Standard Units |       |       | Energy Consumption<br>(10 <sup>12</sup> BtU) |       |       |
|------------------|-----------------------------------------------|-----------------------------------------|-------|-------|----------------------------------------------|-------|-------|
|                  |                                               | 1975                                    | 1985  | 2000  | 1975                                         | 1985  | 2000  |
| Coal             | Million Tonnes                                | 105.95                                  | 104.1 | 103.0 | 2,942.3                                      | 2,891 | 2,861 |
| Crude Oil        | Million Tonnes                                | 107.66                                  | 147.1 | 176.6 | 4,560.8                                      | 6,232 | 7,482 |
| Natural Gas      | Cubic km                                      | 42.33                                   | 62.2  | 64.7  | 1,521.0                                      | 2,234 | 2,325 |
| Hydro Power      | TWh                                           | 17.11                                   | 18.0  | 18.3  | 194.6                                        | 205   | 208   |
| Other Renewables | TWh                                           | 0                                       | 0     | 0     | 0                                            | 0     | 0     |
| Nuclear Power    | TWh                                           | 21.41                                   | 138.6 | 440.0 | 243.5                                        | 1,577 | 5,007 |
| Uranium          | Thousand Tonnes U <sub>3</sub> O <sub>8</sub> | 1.00                                    | 4.62  | 10.88 | -                                            | -     | -     |

## 9.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

### COMMERCIAL NUCLEAR POWER PLANTS

Table 9.2.1

| Facility Name    | Utility           | Vendor | Facility Type | Capacity (MWe net) | Status* | COD      |
|------------------|-------------------|--------|---------------|--------------------|---------|----------|
| VAK-KAHL         | RWE (VAK)         | GE     | BWR           | 15                 | O       | Feb 1962 |
| Isar-1           | Bayernwerk        | KWU    | BWR           | 870                | O       | Oct 1978 |
| Grafenrheinfeld  | Bayernwerk        | KWU    | PWR           | 1229               | U       | Nov 1980 |
| Neckarwestheim-1 | GK-Neckarwestheim | KWU    | PWR           | 805                | O       | Dec 1976 |
| Neckarwestheim-2 | GK-Neckarwestheim | KWU    | PWR           | 760                | U       | Jul 1985 |
| Brokdorf         | KK-Brokdorf       | KWU    | PWR           | 1300               | U       | Jul 1987 |
| Brunsbüttel      | KK-Brunsbüttel    | KWU    | BWR           | 770                | O       | Feb 1977 |
| Grohnde          | KK-Grohnde        | KWU    | PWR           | 1294               | U       | Jun 1985 |
| Obrigheim        | KWO               | KWU    | PWR           | 328                | O       | Mar 1969 |
| Kruemmel         | KK-Kruemmel       | KWU    | BWR           | 1260               | U       | Jul 1981 |
| Philippsburg-1   | KK-Philippsburg   | KWU    | BWR           | 864                | O       | Dec 1978 |
| Philippsburg-2   | KK-Philippsburg   | KWU    | PWR           | 1283               | U       | Oct 1983 |
| Stade            | KK-Stade          | KWU    | PWR           | 630                | O       | May 1972 |
| Sued-1           | KK-Sued           | KWU    | PWR           | 1283               | U       | Jun 1988 |
| Unterweser       | KK-Unterweser     | KWU    | PWR           | 1230               | U       | Jul 1979 |
| Wuergassen       | KK-Wuergassen     | KWU    | BWR           | 640                | O       | Nov 1975 |
| Gundremmingen-A  | RWE (KRB)         | GE     | BWR           | 237                | O       | Apr 1967 |

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

COMMERCIAL NUCLEAR POWER PLANTS

Table 9.2.1 (cont.)

| Facility<br>Name        | Utility           | Vendor  | Facility<br>Type | Capacity<br>(MWe net) | Status* | COD      |
|-------------------------|-------------------|---------|------------------|-----------------------|---------|----------|
| Biblis-A                | RWE               | KWU     | PWR              | 1146                  | O       | Feb 1975 |
| Biblis-B                | RWE               | KWU     | PWR              | 1240                  | O       | Jan 1977 |
| Biblis-C                | RWE               | KWU     | PWR              | 1240                  | U       | Jul 1985 |
| Muehlheim-<br>Kaelich   | RWE               | BBR     | PWR              | 1215                  | U       | Jul 1981 |
| Gundremmingen-B         | RWE (KRB)         | KWU     | BWR              | 1249                  | U       | Jul 1982 |
| Gundremmingen-C         | RWE (KRB)         | KWU     | BWR              | 1249                  | U       | Jul 1983 |
| Lingen                  | VEW (KWL)         | KWU     | BWR              | 256                   | O       | Oct 1968 |
| THTR                    | VWE (HKG)         | HRB     | HTGR             | 300                   | U       | Apr 1983 |
| Hamm                    | VEW (KKH)         |         | PWR              | 1240                  | U       | Jul 1989 |
| VEW-B                   | VEW               |         | PWR              | 1240                  | P       | Jul 1992 |
| Niederaichbach**        | KK-Niederaichbach | Siemens | GCHWR            | 100                   | O       | Dec 1972 |
| KKW-Kalkar<br>(SNR-300) | SBK               | INB     | LMFBR            | 292                   | U       | Jan 1984 |
| Isar-2                  | Bayernwerk        |         | PWR              | 1300                  | P       | Jan 1986 |
| Borken                  | KK-Borken         |         | PWR              | 1300                  | P       | Jul 1989 |
| Neupotz-A               | RWE               |         | PWR              | 1215                  | U       | Jul 1986 |
| Neupotz-B               | RWE               |         | PWR              | 1230                  | P       | Jul 1988 |
| Vahnum-A                | RWE               |         | PWR              | 1230                  | P       | Jul 1989 |
| Vahnum-B                | RWE               |         | PWR              | 1230                  | P       | Jul 1992 |
| Rehling-A               | RWE               |         | PWR              | 1230                  | P       | Jul 1988 |
| Rehling-B               | RWE               |         | PWR              | 1230                  | P       | Jul 1990 |
| RWE-15                  | RWE               |         | PWR              | 1230                  | P       | Jul 1991 |

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

\*\* Shutdown mid-1974

PROJECTED NUCLEAR GENERATING CAPACITY  
MWe (net)

Table 9.2.2

| Year     | PWR  | BWR  | Magnox | AGR | CANDU | Others | FBR  | Firm &<br>Planned<br>Cumulative<br>Total | NAC<br>Cumulative<br>Projection |
|----------|------|------|--------|-----|-------|--------|------|------------------------------------------|---------------------------------|
| pre-1978 | 4149 | 1918 |        |     |       |        |      | 6167                                     | 6167                            |
| 1978     |      | 1734 |        |     |       |        |      | 7901                                     | 7901                            |
| 1979     | 1230 |      |        |     |       |        |      | 9131                                     | 9131                            |
| 1980     | 1229 |      |        |     |       |        |      | 10360                                    | 10360                           |
| 1981     | 1215 | 1260 |        |     |       |        |      | 12835                                    | 12835                           |
| 1982     |      | 1249 |        |     |       |        |      | 14084                                    | 14084                           |
| 1983     | 1283 | 1249 |        |     |       | 300    |      | 16916                                    | 16916                           |
| 1984     |      |      |        |     |       |        | 292  | 17208                                    | 17208                           |
| 1985     | 3294 |      |        |     |       |        |      | 20502                                    | 20502                           |
| 1986     | 3755 |      |        |     |       |        |      | 21717                                    | 24257                           |
| 1987     | 1300 |      |        |     |       |        |      | 23017                                    | 25557                           |
| 1988     | 3743 |      |        |     |       |        |      | 24300                                    | 29300                           |
| 1989     | 3770 |      |        |     |       |        |      | 25540                                    | 33070                           |
| 1990     | 1230 |      |        |     |       |        |      | 25540                                    | 34300                           |
| 1991     | 1230 |      |        |     |       |        |      | 25540                                    | 35530                           |
| 1992     | 1230 |      |        |     |       |        | 1300 | 25540                                    | 38060                           |
| 1993     | 1300 | 1300 |        |     |       |        |      | 25540                                    | 40660                           |
| 1994     | 1300 | 1300 |        |     |       |        |      | 25540                                    | 43260                           |
| 1995     | 1300 |      |        |     |       |        | 1300 | 25540                                    | 45860                           |
| 1996     | 1300 | 1300 |        |     |       |        |      | 25540                                    | 48460                           |
| 1997     | 1300 | 1300 |        |     |       |        |      | 25540                                    | 51060                           |
| 1998     | 1300 |      |        |     |       |        | 1300 | 25540                                    | 53660                           |
| 1999     | 1300 | 1300 |        |     |       |        |      | 25540                                    | 56260                           |
| 2000     | 1300 | 1300 |        |     |       |        |      | 25540                                    | 58860                           |

## NUCLEAR REACTOR VENDORS

### Overview

German industry entered into the commercial nuclear reactor vendor business in the 1960's when Siemens obtained a license from Westinghouse (PWR technology) and AEG became a licensee of General Electric (BWR technology). Then on April 1, 1969, Siemens and AEG merged to form Kraftwerk Union AG (KWU) who is the major supplier of light water reactors in the Federal Republic of Germany today. Since that time, the Westinghouse license agreement was terminated (in 1970), the GE license was transferred to KWU, and a Combustion Engineering Agreement for free exchange of information and experience in PWR engineering was also transferred from Siemens to KWU.

KWU also has a large vested interest in FBR technology through International Atomreaktorbau GmbH (Interatom), 100% daughter of KWU. Interatom was formed in 1957 by DEMAG AG and North American Aviation. In 1966, Deutsche Babcock and Wilcox AG bought into the company. Through a series of transactions, the shares of the US partner were sold and Siemens became the majority shareholder and then the sole owner. On April 1, 1973, Siemens transferred full interest of Interatom to KWU. Interatom is engaged primarily in sodium-cooled reactors and has consequently built the KNK reactor at Karlsruhe (ZrH-moderated; Na-cooled) which was modified for a fast core and recently obtained fuel loading permission. This facility, now designated as the KNK-II, will provide basic data and experience for the next major Interatom project, the SNR-300.

The Federal Republic of Germany, the Netherlands and Belgium participate in the SNR 300 fast breeder reactor project. The owner/operator of the reactor is Schnellbruter Kernkraftwerksgesellschaft (SBK), a utility consortium composed of Synatom (Belgium), 14.8%; RWE (Federal Republic of Germany), 68.8%; SEP (the Netherlands), 14.8%; and the CEGB (UK), 1.6%. Through SBK, a contract was awarded to a tripartite organization, the Internationale Natrium-Brutreaktor-Bau Gesellschaft (INB) for the manufacture of the plant. The participants in INB are Interatom, 70%; Neratom, 15%; and Belgonucleaire, 15%. Therefore, through the INB, Interatom is the major technology/supply source for the SNR-300.

Both the SNR-300 (FRG) and Phenix (France) are prototype fast breeder reactors, and two multi-national European utilities, ESK and NERSA, have been established to construct and operate the respective follow-on projects (SNR-2 in FRG and Super-Phenix in France). SBK has vested interests in both ESK (51%) and NERSA (16%), and through this relationship, it is expected that Interatom will have a major stake in the supply of the SNR-2.

Siemens also developed heavy water reactor technology in the FRG. In 1966, a prototype pressurized heavy water reactor (the MZFR) began operation producing 52 MWe. This reactor design was consequently commercially tested when the Atucha-1 reactor (365 MWe) began operation in Argentina in 1974. Siemens had since discontinued the offering of heavy water power reactors, although they are competing for the Argentina Atucha-2 contract.

Another German company, Brown, Boveri and Cie AG (BBC), has played a key role in commercial nuclear power development. In 1956, BBC began development of high temperature gas reactors (HTGR's) which culminated in the construction of the AVR experimental reactor (15 MWe) by a subsidiary company. After BBC had performed the original development work, Brown Boveri/Krupp Reaktorbau GmbH (BBK), a subsidiary of BBC and Fried Krupp GmbH, took over the construction of the AVR which began operation in 1967.

In 1971 a consortium of BBC, BBK and Nukem received a contract for the 300 MWe THTR reactor with Nukem providing the fuel, BBK providing the NSSS and BBC providing the balance-of-plant. Shortly before the signing of the contracts, Krupp withdrew its 50% share of BBK. Consequently, for an interim period, BBC took 90% of BBK and the owner/operator of the THTR held the remaining 10%. At this time, BBK was renamed Hochtemperatur Reaktorbau GmbH (HRB).

As a result of BBC's search for a new partner in HRB, Gulf General Atomic obtained 45% of HRB in 1973. BBC holds the remaining 55% of the shares. Included in this agreement was reciprocal license agreements providing access to the respective HTGR technologies.



Gesellschaft für Hochtemperaturreaktor-Technik mbH (GHT), a subsidiary of KWU (60%) and Interatom (40%), has also contributed to the development of HTGR's. The main thrust of the developmental work has been on the application of HTGR's to coal gasification. However, GHT has participated in the development of HTGR's for commercial power applications in anticipation of future commercial bids. Presently, no business along these lines has materialized.

Finally, in 1971 BBC formed a consortium with Babcock and Wilcox (US) to adopt and market the B & W PWR design in Europe. The resulting company, Babcock Brown Boveri Reaktor GmbH (BBR), has a firm order for one reactor and a letter of intent for a second. The first, Muhlheim-Kaerlich in FRG, is under construction and planned for operation in 1981. BBR is performing preliminary engineering work on the second, Neupotz. BBR also had a letter of intent for the Remerschenn reactor, but this was withdrawn when the Luxembourg government decided against proceeding with the reactor. In view of the current state of the nuclear market in Europe, it is doubtful that BBR will obtain a significant future business.

No reactors have been ordered in FRG since 1975 and no construction permits have been issued since mid-1977. In fact, construction efforts on three reactors have ceased due to court injunctions. This, combined with problems in export markets, indicates a lean near future for both FRG reactor vendors. While increased licensing requirements have kept engineering staffs intact, growth has been slow.

Vendor: Kraftwerk Union AG (KWU)

Summary of Orders

Table 9.2.3

| Country     | Reactor Name     | Utility            | Type | MWe (net) | COD      |
|-------------|------------------|--------------------|------|-----------|----------|
| Argentina** | Atucha-1         | CNEA               | PHWR | 365       | Jun 1974 |
| Austria     | Tullnerfeld      | GK Tullnerfeld     | BWR  | 692       | Unknown  |
| Brazil      | Angra Dos Reis-2 | CE Furnas          | PWR  | 1240      | May 1984 |
| Brazil      | Angra Dos Reis-3 | CE Furnas          | PWR  | 1240      | Nov 1985 |
| FRG         | Isar-1           | Bayernwerk         | BWR  | 870       | Oct 1978 |
| FRG         | Grafenrheinfeld  | Bayernwerk         | PWR  | 1229      | Nov 1980 |
| FRG         | Neckarwestheim-1 | GK-Neckar-westheim | PWR  | 805       | Dec 1976 |
| FRG         | Neckarwestheim-2 | GK-Neckar-westheim | PWR  | 760       | Jul 1985 |
| FRG         | Brokdorf         | KK-Brokdorf        | PWR  | 1300      | Jul 1987 |
| FRG         | Brunsbüttel      | KK-Brunsbüttel     | BWR  | 770       | Feb 1977 |
| FRG         | Grohnde          | KK-Grohnde         | PWR  | 1294      | Jun 1985 |
| FRG         | Obrigheim        | KWO                | PWR  | 328       | Mar 1969 |
| FRG         | Kruemmel         | KK-Kruemmel        | BWR  | 1260      | Jul 1981 |
| FRG         | Philippsburg-1   | KK-Philippsburg    | BWR  | 864       | Dec 1978 |
| FRG         | Philippsburg-2   | KK-Philippsburg    | PWR  | 1283      | Oct 1983 |
| FRG         | Stade            | KK-Stade           | PWR  | 630       | May 1972 |
| FRG         | Sued-1           | KK-Sued            | PWR  | 1283      | Jun 1988 |
| FRG         | Unterweser       | KK-Unterweser      | PWR  | 1230      | Jul 1979 |
| FRG         | Wuergassen       | KK-Wuergassen      | BWR  | 640       | Nov 1975 |
| FRG         | Biblis-A         | RWE                | PWR  | 1146      | Feb 1975 |
| FRG         | Biblis-B         | RWE                | PWR  | 1240      | Jan 1977 |
| FRG         | Biblis-C         | RWE                | PWR  | 1240      | Jul 1985 |
| FRG         | Gundremmingen-B  | RWE (KRB)          | BWR  | 1249      | Jul 1982 |
| FRG         | Gundremmingen-C  | RWE (KRB)          | BWR  | 1249      | Jul 1983 |
| FRG         | Lingen           | VEW (KWL)          | BWR  | 256       | Oct 1968 |
| FRG         | Hamm             | VEW                | PWR  | 1240      | Jul 1989 |

\*\* Sold by Siemens

| Country     | Reactor Name | Utility         | Type | MWe(net) | COD      |
|-------------|--------------|-----------------|------|----------|----------|
| Iran        | Bushehr-1    | Gov't of Iran   | PWR  | 1240     | Jan 1981 |
| Iran        | Bushehr-2    | Gov't of Iran   | PWR  | 1240     | Jan 1982 |
| Iran        | Isfahan-1    | Gov't of Iran   | PWR  | 1240     | 1984     |
| Iran        | Isfahan-2    | Gov't of Iran   | PWR  | 1240     | 1985     |
| Iran        | Iran-7       | Gov't of Iran   | PWR  | 1240     | 1986     |
| Iran        | Iran-8       | Gov't of Iran   | PWR  | 1240     | 1987     |
| Netherlands | Borssele     | PZEM            | PWR  | 445      | Nov 1973 |
| Spain       | Trillo       | Union Electrica | PWR  | 985      | Jun 1988 |
| Switzerland | Goesgen      | KK Goesgen      | PWR  | 920      | May 1979 |

In summary, KWU has received orders for thirty-four units; twenty-five are PWR's and nine are BWR's. Nine of these plants are operating, thirteen are under construction and twelve are planned. Eleven of the plants are non-domestic. There is significant question regarding the four latter plants in Iran; the outcome of these contracts is uncertain. At best they should suffer considerable delay; probably they will be cancelled.

#### Capacity, Capacity-Limiting Factors, Ability to Expand, and Expansion Plans

KWU provides a full range of design and engineering services for nuclear power plants. In addition, turbine-generator sets are a major product for both fossil and nuclear plants alike. Consequently, since the supply of nuclear plants is not a major portion of their business, the production capacity is expressed in terms of turnkey plants rather than NSSS islands and components (see Marketing Strategy). KWU offers both PWR's and BWR's, but is currently refraining from expanded BWR sales until a proven operating ability can be demonstrated. However, the current capacity of KWU is expressed as six turnkey plants (PWR or BWR) per year. Since the nuclear portion of the business is not fully utilized at this time, it is not expected that KWU will entertain expansion until the worldwide nuclear market shows significant improvement.

### Past and Present Marketing Strategy

KWU markets both PWR's and BWR's of various sizes. Standard PWR offerings include 2000, 2900 and 3800 MWth plants with two, three or four loops. Currently, only three and four loop plants are quoted. The standard large size BWR offering is equivalent to 1300 MWe, although smaller size plants have been previously sold. Due to an early rash of problems with the BWR design, it is not being actively marketed until its reliability can be proven by some of the new plants.

KWU would like to maintain a 50:50 split between domestic sales and exports (3 domestic and 3 foreign plants). However, due to public opposition and licensing problems within FRG, this will be a difficult goal to achieve.

KWU has been aggressive in most all nuclear markets (France, UK, Japan and the US are notable exceptions). This aggressiveness is enhanced in several ways. Due to the FRG's economic achievements, KWU has been able to offer excellent financing packages, often a serious problem in selling nuclear plants. KWU has also proved itself very flexible in its marketing approach. For example, recent reactor sales to Iran included complete fuel packages (delivery of finished fuel for ten years with an additional 10 years of options). Also, the well-publicized deal with Brazil included technology support and supply for the total fuel cycle. KWU has the ability to provide whatever services the market requires.

### Projected Future Marketing Strategy

KWU will continue to be aggressive in most all nuclear markets. Due to a relatively closed market in Europe (France and the UK are closed; Italy is uncertain), much emphasis will be placed on non-European, non-US countries.

Flexibility and reliability will remain relative strengths in KWU's marketing strategy. A high degree of standardization is being pursued. If necessary, KWU feels that it can adjust to a mandatory move away from turnkey plants. Finally, the present large size reactor can be expanded to 5000 MWth size with little or no modification should the market present itself. In contrast, KWU will continue marketing 600 MWe plants for those developing countries in which large plants are impractical.

Market Share Attained: KWU

Table 9.2.4

| Year               | MWe<br>(net) | Domestic |        |       | Regional |        |       | International (non-US) |        |      |
|--------------------|--------------|----------|--------|-------|----------|--------|-------|------------------------|--------|------|
|                    |              | Com.     | Uncom. | %     | Com.     | Uncom. | %     | Com.                   | Uncom. | %    |
| pre-1978           | 6605         | 6052     | 0      | 96.1  | 17934    | 0      | 2.5   | 41402                  | 0      | 1.9  |
| 1978               | 1734         | 1734     | 0      | 100.0 | 4170     | 0      | 0.0   | 10725                  | 0      | 0.0  |
| 1979               | 2842         | 1230     | 0      | 100.0 | 10874    | 0      | 14.8  | 15410                  | 0      | 10.5 |
| 1980               | 1229         | 1229     | 0      | 100.0 | 13508    | 0      | 0.0   | 14928                  | 0      | 0.0  |
| 1981               | 2500         | 2475     | 0      | 50.9  | 11621    | 0      | 0.0   | 15454                  | 0      | 8.0  |
| 1982               | 2489         | 1249     | 0      | 100.0 | 3694     | 0      | 0.0   | 9762                   | 0      | 12.7 |
| 1983               | 2532         | 2832     | 0      | 89.4  | 6570     | 300    | 0.0   | 12057                  | 2087   | 0.0  |
| 1984               | 2480         | 292      | 0      | 0.0   | 7424     | 0      | 0.0   | 15858                  | 4864   | 15.6 |
| 1985               | 5774         | 3294     | 0      | 100.0 | 6952     | 0      | 0.0   | 12889                  | 5468   | 19.2 |
| 1986               | 1240         | 1215     | 2540   | 0.0   | 7566     | 2250   | 0.0   | 12078                  | 11864  | 10.3 |
| 1987               | 2540         | 1300     | 0      | 100.0 | 1882     | 12300  | 0.0   | 4572                   | 18900  | 27.1 |
| 1988               | 2268         | 1283     | 2460   | 100.0 | 985      | 11900  | 100.0 | 1835                   | 24170  | 53.7 |
| 1989               | 1240         | 1240     | 2530   | 100.0 | 0        | 10950  | 0.0   | 0                      | 23143  | 0.0  |
| 1990               | 0            | 0        | 1230   | 0.0   | 2152     | 10250  | 0.0   | 2152                   | 28799  | 0.0  |
| <hr/>              |              |          |        |       |          |        |       |                        |        |      |
| Total thru<br>1990 | 35473        | 25425    | 8760   | 87.2  | 95332    | 47950  | 3.2   | 169122                 | 119533 | 7.9  |

### Nuclear Reactor Support Industries

Being a highly industrialized country, the FRG has a wide range of reactor vendor support companies. Gutehoffnugshutte Sterkrade AG (GHH) and Klockner provide pressure vessels. Deutsche Babcock and Wilcox, GHH, and Balcke manufacture steam generators and pressurizers.

Historically, only one pressure vessel has been provided internationally by these vendors. GHH provided the vessel for Oskarshamn 1 in Sweden. Domestically, however, these companies have dominated the market. GHH alone has orders for seven vessels; Klockner has orders for four. Together, GHH and Klockner have provided or will provide three additional vessels.

Only one steam generator has been provided abroad by German manufacturers. Balcke provided the steam generator for the Borssele unit in the Netherlands. However, domestically GHH has provided six steam generators; Balcke has provided one; and GHH together with Balcke has an additional three steam generators.

## NUCLEAR FUEL CYCLE FACILITIES

### Overview

The Federal Republic of Germany is involved in almost all areas of the nuclear fuel cycle. The areas with German vested interests include uranium exploration, enrichment,  $UO_2$  and mixed oxide fuel fabrication, reprocessing, and transportation of irradiated fuel. There is only a very small domestic uranium production capability (less than 50 tonnes  $U_3O_8$ ).

Uranengesellschaft mbH (UG) is very active in exploration and development of uranium supplies. UG has 6.5% vested interest in SOMAIR (Niger) and is currently exploring for economically viable uranium deposits in Australia, Canada, US, Brazil, Colombia, Indonesia, Niger, and the FRG. The corporate objectives include exploration and development of uranium deposits; operation of uranium mines and mills; joint ventures in these activities; and trade in uranium ores, concentrates, and chemical components. The shareholders of UG since its inception in 1967 are Metallgesellschaft AG, 33 1/3%; STEAG AG, 33 1/3%; and VEBA AG, 33 1/3%.

Uranerzbergbau (URZ) is also involved in uranium mining and exploration throughout the world. URZ has significant holdings in Canada with a 49% share of the Rabbit Lake mine/mill complex (51% is held by Gulf Oil Corporation), and a 10% share of Agnew Lake Mines. URZ is essentially a subsidiary of the German utility RWE.

In 1970, Uran-Isotopentrennungs-GmbH (Uranit) was formed as the German partner in the tripartite organization for centrifuge enrichment, URENCO with a 33 1/3% share. The shareholders in Uranit are Farbwerke Hoechst AG, 20%; Gelsenberg AG, 40%; and Nukem GmbH, 40%. URENCO, headquartered in the UK, has two pilot plants at Almelo, Netherlands, and one pilot plant at Capenhurst, UK (see also the Netherlands and the UK). German centrifuge technology was used in the SP-2 and SP-3 enrichment plants at Almelo. Gesellschaft für nukleare Verfahrenstechnik (GnV) is the German partner in CENTEC, the tripartite centrifuge development organization. The shareholders of GnV are MAN, 50% and INTERATOM, 50%.

Germany is heavily involved in the manufacture of varying types of fuel for commercial nuclear power plants. Plutonium bearing fuels have been manufactured by Alkem GmbH since 1966. Alkem is located at Wolfgang on Hanau and has the capacity to manufacture fuel for both LWR's and FBR's. The original shareholders of Alkem were AEG-Telefunken, 30%; Siemens, 30%; and Nukem GmbH, 40%. After the AEG-Siemens merger, their shareholdings were transferred to KWU who now owns 60% of Alkem.



FRG also has the capability to produce fuel for high temperature gas-cooled reactors through Hochttemperaturreaktor-Brennelement GmbH (HOBEG), also located at Wolfgang on Hanau. HOBEG was founded in 1972 as a 100% subsidiary of Nukem GmbH. The facility is involved in production and development of spherical and prismatic fuel elements.

The manufacture of uranium fuel elements for light water reactors is performed by Reaktor-Brennelement Union GmbH (RBU). RBU maintains two fabrication facilities. RBU-I assembles fuel for PWR's and RBU-II assembles fuels for BWR's. RBU-I (formerly Reaktor-Brennelement GmbH, RBG) is located at Wolfgang on Hanau. RBG was formed in 1969 when it took over the fuel manufacturing capability of its shareholders (Nukem and Siemens). RBU-II, located at Grosswelzheim, was formerly Kernreaktorteile GmbH (KRT) owned by AEG-Telefunken and GE. In 1974, RBG and KRT were merged into one company, RBU. The shareholders of RBU are KWU, 50%; Nukem, 30%; and GE, 20%.

Reprocessing capability in FRG consists of one operating plant and one planned facility. Gesellschaft zur Wiederaufarbeitung von Kernbrennstoffen mbH (GWK) operates the Wiederaufarbeitungsanlage Karlsruhe (WAK) pilot reprocessing facility at Karlsruhe. The facility began hot operation in 1971, primarily for providing engineering and operating experience to the German industry. The original shareholders of GWK are Nukem GmbH, 20%; Gelsenberg AG, 20%; Bayer, 20%; Hoechst, 20%; and Deutsche Gesellschaft für Wiederaufarbeitung von Kernbrennstoffen mbH (DWK), 20%. DWK is owned by 12 German utilities. The foundation has been laid for GWK to become a 100% daughter of DWK by January 1, 1979.

Also represented in FRG is United Reprocessors (UNIREP), a tripartite organization including BNFL (UK), Cogema (France), and KEWA (FRG). UNIREP was formed in 1971 to coordinate commercial reprocessing efforts in Europe and exploit this technology with maximum economy. For the German participation in this agreement, KEWA was formed originally as a daughter of Nukem, Gelsenberg, Bayer, and Hoechst. Recently, however, KEWA became a 100% daughter of DWK, thereby becoming exclusively owned by the electric utilities. A commercial reprocessing plant to be operated by KEWA is currently scheduled to begin operation in the late 1980's, a schedule which will most probably be delayed.

FRG also has companies active in the transport of materials utilized in the nuclear fuel cycle. Transnuklear GmbH located at Wolfgang on Hanau participates in the transportation requirements of all aspects of the fuel cycle. Founded in 1966, Transnuklear has become the major nuclear transport company in Germany. The current shareholders are Nukem, 80% and Transnucleaire SA (France), 20%. In order to improve the utilization of existing containers in Europe, BNFL (UK), Transnucleaire SA (France) and Transnuklear GmbH (FRG) formed Nuclear Transport Ltd. (NTL) at Risley, UK, to

provide transportation services of irradiated oxide fuel elements from nuclear power plants.

Finally, the Gesellschaft fur Nukleartransporte mbH (GNT) was formed in 1974 by Gelsensberg and STEAG to participate in the transportation of spent nuclear fuel. However, STEAG has recently taken a more direct interest in nuclear transport, thereby relieving GNT of its original charter.

# CURRENT AND PLANNED FACILITIES

Table 9.2.5

| Facility Name | Location           | Facility Type                                         | MT/YR                                           | Capacity | Status  | Year        | Shareholdings                                                        |
|---------------|--------------------|-------------------------------------------------------|-------------------------------------------------|----------|---------|-------------|----------------------------------------------------------------------|
|               |                    |                                                       |                                                 |          | Status* |             |                                                                      |
| Alkem         | Wolfgang bei Hanau | Thermal and Fast Reactor Mixed Oxide Fuel Fabrication | 50**                                            | 0        | O       | 1966        | 60% KWU<br>40% Nukem                                                 |
| Hobeg         | Wolfgang bei Hanau | Spherical and Prismatic HTGR Fuel Fabrication         | N/A                                             | 0        | O       | 1972        | 100% Nukem                                                           |
| RBU-I         | Wolfgang bei Hanau | LWR Fuel Fabrication<br>PWR Final Fuel Assembly       | 1000 (powder)<br>750 (pellet)<br>600 (assembly) | 0        | O       | 1964        | 50% KWU<br>30% Nukem<br>20% GE                                       |
| RBU-II        | Grosswelzheim      | BWR Final Fuel Assembly                               | 150 (assembly only)                             | 0        | O       | 1966        | 50% KWU<br>30% Nukem<br>20% GE                                       |
| WAK (GWK)     | Karlsruhe          | Pilot Reprocessing                                    | 35                                              | 0        | O       | 1971        | 20% Nukem**<br>20% Gelsenberg<br>20% Bayer<br>20% Hoescht<br>20% DWK |
| KEWA          | -                  | Commercial Reprocessing                               | 1400                                            | P        | P       | late 1980's | 100% DWK                                                             |
| Gronau        | Gronau             | Centrifuge Enrichment                                 | 400                                             | P        | P       | 1983-1985   | 100% URENCO                                                          |

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

\*\* Nominal Capacity. Actual operating capacity is slightly lower.

\*\*\* GWK will become a 100% daughter of DWK by January 1, 1979.

Facility: Alkem GmbH

Description of Operation

The Alkem mixed oxide fuel fabrication facility located in Wolfgang be Hanau (near Frankfurt) is a small but quite sophisticated operation. The facility has two production lines. The smaller line (originally a pilot scale line) is dedicated to fast reactor fuels. The larger automated line is used for light water reactor fuels.

The facilities for nitrate receipt and weighing and for powder blending are elaborate. The entire plant is computer controlled with override capability at each glove box. This allows for the operation to be run by very small crews on the back shift.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The small line has a nominal capacity of approximately 10 MTHM/year, and the larger line is rated at 40 MTHM/year. Actual operating capacity is 3 MTHM/year and 10 MTHM/year. The operation is limited by very light conversion capability. Using oxalate precipitation, only 400 grams per batch may be processed.

Past and Present Marketing Strategy

Unlike Belgonucleaire, Alkem has not aggressively sought an international plutonium-bearing fuel fabrication market. In actuality, KWU does most of the marketing work in conjunction with its uranium fuel fabrication market campaigns. Internationally, Alkem has supplied a small amount of plutonium fuel for the Garigliano reactor in Italy (in conjunction with BN). However, in Germany, Alkem has been quite active. Most of the fuel fabrication for the SNR-300 will be performed by this subsidiary of KWU (who is also the mother company of Interatom, supplier of the SNR-300).

Market Share Attained

Because of the complexities of mixed oxide fuel fabrication, in which several fabricators may be involved, and the limited nature of the market, the market share obtained by Alkem in comparison with other fabricators and the overall market is shown in the form given in Table 9.2.6. This refers to all significant mixed oxide fabrication for thermal reactors in Europe.

Comparable data for prototype fast reactors is shown in Table 9.2.7.

PLUTONIUM FUEL FABRICATION FOR THERMAL REACTORS IN EUROPE

Table 9.2.6

| Reactor Name/<br>Country | Year<br>of Fuel<br>Delivery | No. of<br>Assemblies* | Name of Supplier |              |              |
|--------------------------|-----------------------------|-----------------------|------------------|--------------|--------------|
|                          |                             |                       | Pellets          | Rods         | Assembly     |
| Obrigheim/Germany        | 1972                        | 1                     | Alkem            | Alkem        | RBU          |
|                          | 1973                        | 8                     | Alkem            | Alkem        | RBU          |
|                          | 1974                        | 4                     | Alkem            | Alkem        | RBU          |
|                          | 1975                        | 8                     | Alkem            | Alkem        | RBU          |
|                          | 1976                        | 12                    | Alkem            | Alkem        | RBU          |
| Gundremingen-A/Germany   | 1974                        | 16                    | Alkem            | Alkem        | RBU          |
|                          | 1975                        | 24                    | Alkem            | Alkem        | RBU          |
|                          | 1976                        | 24                    | Alkem            | Alkem        | RBU          |
|                          | 1977                        | 16                    | Alkem            | Alkem        | RBU          |
| Lingen/Germany           | 1970                        | 1                     | KRT              | KRT          | KRT          |
| Kahl/Germany             | 1966                        | 1                     | BNFL             | BNFL         | BNFL         |
|                          | 1968                        | 2                     | CNEN             | CNEN         | (CNEN)       |
|                          | 1969                        | 4                     | Alkem            | Alkem        | RBU          |
|                          | 1970                        | 16                    | Alkem            | Alkem        | RBU          |
|                          | 1973                        | 18                    | Alkem            | Alkem        | RBU          |
|                          | 1975                        | 18                    | Exxon            | Exxon        | Exxon        |
|                          | 1976                        | 18                    | Alkem            | Alkem        | RBU          |
|                          | 1977                        | 18                    | Alkem            | Alkem        | RBU          |
|                          | 1978                        | 18                    | Alkem            | Alkem        | RBU          |
| Sena-Chooz/France        | 1974                        | 4                     | BN               | BN/CEA       | RBU          |
|                          | 1975                        | 2                     | (BNFL)           | FBFC         | FBFC         |
| Beznau-1/Switzerland     | 1978                        | 4                     | Westinghouse     | Westinghouse | Westinghouse |
| Oskarshamn-1/Sweden      | 1974                        | 3                     | BN               | BN           | ASEA         |

Table 9.2.6 (cont.)

| Reactor Name/<br>Country | Year<br>of Fuel<br>Delivery | No. of<br>Assemblies* | Name of Supplier |              |              |
|--------------------------|-----------------------------|-----------------------|------------------|--------------|--------------|
|                          |                             |                       | Pellets          | Rods         | Assembly     |
| Dodewaard/Netherlands    | 1970                        | 2                     | BN               | BN           | BN           |
|                          | 1973                        | 4                     | BN               | BN           | BN           |
|                          | 1974                        | 7                     | BN               | BN           | BN           |
| Trino/Italy              | 1976                        | 8                     | Westinghouse     | Westinghouse | Westinghouse |
| Garigliano/Italy         | (1968)                      | 4                     | GE               | GE           | GE           |
|                          | (1968)                      | 8                     | BNFL             | BNFL         | BNFL         |
|                          | 1968                        | 4                     | BN/Alkem         | BN/Alkem     | FN           |
|                          | 1975                        | 46                    | BN               | BN           | FN           |
| Winfrith SGHWR/UK        | 1969                        | 1                     | BNFL             | BNFL         | BNFL         |
| Windscale AGR/UK         | 1963                        | 4                     | BNFL             | BNFL         | BNFL         |

\* Includes "all plutonium" rod assemblies and "island" concept assemblies.

PLUTONIUM FUEL FABRICATION FOR PROTOTYPE FAST BREEDER REACTORS IN EUROPE

Table 9.2.7

| Reactor Name/<br>Country | Year<br>of Fuel<br>Delivery | No. of<br>Assemblies* | Name of Supplier |      |          |
|--------------------------|-----------------------------|-----------------------|------------------|------|----------|
|                          |                             |                       | Pellets          | Rods | Assembly |
| SNR-300/Germany          | N/A                         | 123 (Mark Ia)*        | Alkem            | RBU  | RBU      |
|                          | 1980                        | 82 (Mark Ia)*         | BN               | BN   | BN       |
| Dounreay PFR/UK          | 1974                        | 78*                   | BNFL             | BNFL | BNFL     |
|                          | thru 1977                   | reloads               | BNFL             | BNFL | BNFL     |
| Phenix/France            | 1972                        | 120**                 | CEA              | CEA  | CEA      |
|                          | thru 1977                   | (FC: 103)<br>reloads  | CEA              | CEA  | CEA      |

\* First Core  
 \*\* First core + 17 spares

### Projection of Future Marketing Strategy

Alkem (through KWU) will continue to seek mixed oxide fabrication work both for thermal and fast reactors. It is realized that the market for thermal reactor recycle fuel will remain small for the next few years. This is primarily due to the general lack of plutonium (available plutonium stocks are generally being retained for use in FBR's) and this situation will change only if the operation at the La Hague reprocessing facility is successful. Political issues also cloud the situation.

The market for fast reactor fuel is essentially limited. It is restricted to the Prototype Fast Reactor (UK) for which BNFL will supply fuel, Phenix and Super-Phenix for which Cogema will supply most fuel and SNR-300. By virtue of the German participation in SNR-300, reloads for this reactor represent the only really potential near-term market for Alkem (the first core is already being manufactured 60% by Alkem).

### Production History

In addition to the LWR plutonium bearing fuel production indicated in Table 9.2.6, and the fabrication campaign for the SNR-300 indicated in Table 9.2.7, Alkem has also fabricated approximately 500 kg U+Pu for research reactors and R&D work.



Facility: Reaktor-Brennelement Union GmbH

Description of Operation

RBU has two facilities in the Federal Republic of Germany. They are designated as RBU-I and RBU-II in Hanau and Grosswelzheim, respectively. The combined size of these facilities is almost as large as either of the major American fabricators. Their range of activities includes all of the necessary fuel components except zircaloy tubing.

All conversion and pelletizing (except Gd-pellets) is done in RBU-I. Final assembly for PWR elements is done at RBU-I, and pellets are shipped to RBU-II for final assembly of BWR elements.

The main difference between the fabrication technology of RBU and that used in the USA is the conversion process. Whereas American fabricators rely on the ADU (ammonium diuranate) process, RBU uses the AUC (ammonium uranyl carbonate) process which they believe yields superior powder production for pelletizing and sintering.

Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The current capacities of the RBU facilities are as follows:

| Current Capacity, MTU |        |        |          |
|-----------------------|--------|--------|----------|
| Facility              | Powder | Pellet | Assembly |
| RBU-I                 | 1000   | 750    | 600      |
| RBU-II                | 0      | 10*    | 150      |

The assembly area of RBU-I is not fully utilized and is very labor intensive. More output could be achieved by expanding the number of assembly racks. The pelletizing furnaces are of the old type which require dismantling of the fire brick to replace the heating elements. This has caused significant down-time.

No expansion plans are foreseeable at this time. However, as the requirements demand further capacity, the facilities can expand with a one year lead time.

\* Pellets with absorbing material.

### Past and Present Marketing Strategy

Marketing of fuel fabrication services was initially performed by the fabricators themselves (i.e. KRT for BWR fuel and RBG for PWR fuel). Following the merger of AEG and Siemens to form KWU and of their fabrication activities to form RBU, marketing has essentially been carried out by KWU. RBU is thus an operating facility. RBU obtains all the fabrication work for the KWU reactor first cores and the reloads sold in the initial package; KWU attempts to include as many reloads in this package as possible. KWU has aggressively marketed reload fabrication services for many years. This marketing activity is divided into two groups, reloads for KWU reactors and reloads for non-KWU reactors.

The domestic market clearly represents the largest potential for KWU and with few exceptions, it has been successfully defended against outside competition - the notable exception being Exxon who has offered very low prices. Outside of the domestic market, KWU has been successful in several countries through its aggressiveness, its reputation for high quality and reliability, and the fact that it was willing to market at lower prices than on the domestic market. KWU has competed in practically all cases on the sale of fabrication services only since it does not have access to uranium except by purchase on the open market as an agent. An exception has been the sale of fabrication services in conjunction with the KWU reactors sold to Iran in which both uranium and enrichment were included as a package for the first core plus 10 reloads with 10 reloads on option. While this is not the favored mode of sale, KWU demonstrates that they are willing to compete on a similar competitive basis for each individual case.

In addition to marketing complete fabrication services, KWU has supplied partial fabrication services, such as powder production.

Market Share Attained: RBU

LWR Fuel Fabrication

Table 9.2.8  
(MTU)

Region: Domestic (FRG)

| <u>Year</u> | <u>RBU<br/>Deliveries to<br/>Germany</u> | <u>Total<br/>Deliveries<br/>to<br/>Germany</u> | <u>Total<br/>German<br/>Requirements</u> | <u>Total<br/>German<br/>Uncommitted</u> | <u>RBU<br/>Market Share<br/>of German<br/>Committed<br/>Deliveries, %</u> |
|-------------|------------------------------------------|------------------------------------------------|------------------------------------------|-----------------------------------------|---------------------------------------------------------------------------|
| pre-1978    | 1333                                     | 1523                                           | 1523                                     | 0                                       | 87.6                                                                      |
| 1978        | 67                                       | 100                                            | 100                                      | 0                                       | 67.0                                                                      |
| 1979        | 170                                      | 223                                            | 223                                      | 0                                       | 76.2                                                                      |
| 1980        | 415                                      | 565                                            | 638                                      | 73                                      | 73.5                                                                      |
| 1981        | 227                                      | 314                                            | 426                                      | 112                                     | 72.3                                                                      |
| 1982        | 296                                      | 396                                            | 584                                      | 188                                     | 74.7                                                                      |
| 1983        | 114                                      | 247                                            | 478                                      | 231                                     | 46.2                                                                      |
| 1984        | 332                                      | 363                                            | 737                                      | 374                                     | 91.5                                                                      |
| 1985        | 60                                       | 91                                             | 809                                      | 718                                     | 65.9                                                                      |
| 1986        | 190                                      | 221                                            | 671                                      | 450                                     | 86.0                                                                      |
| 1987        | 190                                      | 221                                            | 962                                      | 741                                     | 86.0                                                                      |
| 1988        | 156                                      | 156                                            | 968                                      | 812                                     | 100.0                                                                     |
| 1989        | 57                                       | 57                                             | 890                                      | 833                                     | 100.0                                                                     |
| 1990        | 91                                       | 91                                             | 991                                      | 900                                     | 100.0                                                                     |

Market Share Attained: RBU

LWR Fuel Fabrication

Table 9.2.8 (cont.)  
(MTU)

Region: Europe (non-FRG)

| <u>Year</u> | <u>RBU<br/>Deliveries</u> | <u>Total<br/>Deliveries</u> | <u>Total<br/>Requirements</u> | <u>Total<br/>Uncommitted</u> | <u>RBU<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|---------------------------|-----------------------------|-------------------------------|------------------------------|----------------------------------------------------------------|
| pre-1978    | 162                       | 2440                        | 2440                          | 0                            | 6.6                                                            |
| 1978        | 243                       | 1343                        | 1343                          | 0                            | 18.1                                                           |
| 1979        | 56                        | 1421                        | 1433                          | 12                           | 3.9                                                            |
| 1980        | 89                        | 1113                        | 1232                          | 119                          | 8.0                                                            |
| 1981        | 67                        | 875                         | 1446                          | 571                          | 7.7                                                            |
| 1982        | 19                        | 560                         | 1500                          | 940                          | 3.4                                                            |
| 1983        | 17                        | 662                         | 1830                          | 1168                         | 2.6                                                            |
| 1984        | 22                        | 864                         | 2181                          | 1317                         | 2.5                                                            |
| 1985        | 20                        | 697                         | 2397                          | 1700                         | 2.9                                                            |
| 1986        | 20                        | 563                         | 3156                          | 2593                         | 3.6                                                            |
| 1987        | 102                       | 283                         | 3109                          | 2826                         | 36.0                                                           |
| 1988        | 20                        | 237                         | 3139                          | 2902                         | 8.4                                                            |
| 1989        | 20                        | 404                         | 3954                          | 3550                         | 5.0                                                            |
| 1990        | 20                        | 194                         | 3581                          | 3387                         | 10.3                                                           |

Market Share Attained: RBU

LWR Fuel Fabrication

Table 9.2.8 (cont.)  
(MTU)

Region: International (non-FRG, non-US)

| <u>Year</u> | <u>RBU<br/>Deliveries</u> | <u>Total<br/>Deliveries</u> | <u>Requirements</u> | <u>Uncommitted</u> | <u>RBU<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|---------------------------|-----------------------------|---------------------|--------------------|----------------------------------------------------------------|
| pre-1978    | 162                       | 4849                        | 4849                | 0                  | 3.3                                                            |
| 1978        | 243                       | 1556                        | 1608                | 52                 | 15.6                                                           |
| 1979        | 43                        | 1869                        | 2161                | 292                | 2.3                                                            |
| 1980        | 179                       | 1498                        | 2030                | 532                | 11.9                                                           |
| 1981        | 187                       | 1327                        | 2388                | 1061               | 14.1                                                           |
| 1982        | 70                        | 919                         | 2621                | 1692               | 7.6                                                            |
| 1983        | 308                       | 1239                        | 3508                | 2269               | 24.9                                                           |
| 1984        | 210                       | 1396                        | 4038                | 2642               | 15.0                                                           |
| 1985        | 228                       | 1223                        | 4823                | 3600               | 18.6                                                           |
| 1986        | 207                       | 936                         | 5218                | 4282               | 22.1                                                           |
| 1987        | 171                       | 505                         | 5927                | 5422               | 33.9                                                           |
| 1988        | 89                        | 438                         | 6072                | 5634               | 20.3                                                           |
| 1989        | 88                        | 580                         | 7484                | 6904               | 15.2                                                           |
| 1990        | 88                        | 327                         | 7164                | 6837               | 26.9                                                           |

### Projection of Future Marketing Strategy

Marketing of fabrication services internationally can be expected to increase in intensity to compensate for the current slow-down in the nuclear program on the domestic market. It is known that KWU has been examining the US reload market, probably to try to offset the intense efforts being made by Exxon in Europe.

Production History: RBU  
LWR Fuel Fabrication

Table 9.2.9

| <u>YEAR</u> | <u>MTU</u> |
|-------------|------------|
| 1967        | 33         |
| 1968        | 63         |
| 1969        | 0          |
| 1970        | 65         |
| 1971        | 176        |
| 1972        | 55         |
| 1973        | 229        |
| 1974        | 85         |
| 1975        | 291        |
| 1976        | 247        |
| 1977        | 251        |

Facility: Wiederaufarbeitungsanlage Karlsruhe (WAK)

Description of Operation

The WAK reprocessing facility is operated by Gesellschaft zur Wiederaufarbeitung von Kernbrennstoffen mbH (GWK) which has become a 100% daughter of DWK as of January 1, 1979. It is a pilot reprocessing facility operating under a governmental contract to perform research and development work, including some industrial processing. Technical information for both KEWA and UNIREP is supplied in part by GWK.

The facility has been used to test the reprocessing of fuels with increasing burnup. Also, research on calcination and vitrification of waste, as well as possible terminal waste storage, is performed.

While this facility is basically a research and pilot facility, small amounts of LWR fuel are reprocessed at the site.

Capacity, Capacity Limiting Factors, Expansion Plans and New Facilities

The WAK pilot reprocessing facility has a capacity of 35 MTHM/year based on 200 operating days/year. Since this facility is essentially an R&D facility, it is not expected to be expanded for commercial use.

No new facilities are planned for GWK. However, DKW plans a large commercial reprocessing and recycle facility at Gorleben currently scheduled for the late 1980's. The date of operation of the DKW facility could well be expected to slip due to public opposition and recent governmental decisions, however. As a result, DWK (in conjunction with STEAG) has planned an intermediate spent fuel storage facility (~ 1500 MTU) at Ahaus in Northrhine-Westphalia for operation in the mid-1980's.

Past, Present and Future Marketing Strategy

The WAK reprocessing facility is a pilot research and development facility whose operation is funded by the German government. Consequently, commercial reprocessing contracts have been accepted on a limited basis, mainly to demonstrate the reprocessing technology or spent fuel with increasingly higher fuel burnups. However, this facility has no commercial marketing strategy, per se.



Market Share Attained: GWK  
LWR Fuel Reprocessing

Table 9.2.10  
(MTU)

Region: Domestic (FRG)

| <u>Year</u> | <u>GWK<br/>Commitments</u> | <u>Total<br/>Commitments</u> | <u>GWK<br/>Market Share %</u> |
|-------------|----------------------------|------------------------------|-------------------------------|
| pre-1978    | 52 (41*)                   | 301                          | 17.3                          |
| 1978        | 0                          | 93                           | 0                             |
| 1979        | 0                          | 133                          | 0                             |
| 1980        | 0                          | 205                          | 0                             |
| 1981        | 0                          | 208                          | 0                             |
| 1982        | 0                          | 202                          | 0                             |
| 1983        | 0                          | 207                          | 0                             |
| 1984        | 0                          | 230                          | 0                             |
| 1985        | 0                          | 146                          | 0                             |
| 1986        | 0                          | 39                           | 0                             |
| 1987        | 0                          | 39                           | 0                             |
| 1988        | 0                          | 68                           | 0                             |
| 1989        | 0                          | 68                           | 0                             |
| 1990        | 0                          | 39                           | 0                             |

\* Quantity actually reprocessed.

Market Share Attained: GWK  
LWR Fuel Reprocessing

Table 9.2.10 (cont.)  
(MTU)

Region: Europe (non-FRG)

| <u>Year</u> | <u>GWK<br/>Commitments</u> | <u>Total*<br/>Commitments</u> | <u>GWK<br/>Market Share, %</u> |
|-------------|----------------------------|-------------------------------|--------------------------------|
| pre-1978    | 0                          | 694                           | 0                              |
| 1978        | 0                          | 256                           | 0                              |
| 1979        | 0                          | 304                           | 0                              |
| 1980        | 0                          | 384                           | 0                              |
| 1981        | 0                          | 671                           | 0                              |
| 1982        | 0                          | 807                           | 0                              |
| 1983        | 0                          | 951                           | 0                              |
| 1984        | 0                          | 1062                          | 0                              |
| 1985        | 0                          | 1187                          | 0                              |
| 1986        | 0                          | 994                           | 0                              |
| 1987        | 0                          | 1141                          | 0                              |
| 1988        | 0                          | 1220                          | 0                              |
| 1989        | 0                          | 1320                          | 0                              |
| 1990        | 0                          | 1406                          | 0                              |

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\* Includes discharges from French and British reactors for which actual contracts do not exist.

Market Share Attained: GWK  
LWR Fuel Reprocessing

Table 9.2.10 (cont.)  
(MTU)

Region: International (non-FRG, non-US)

| <u>Year</u> | <u>GWK<br/>Commitments</u> | <u>Total*<br/>Commitments</u> | <u>GWK<br/>Market Share, %</u> |
|-------------|----------------------------|-------------------------------|--------------------------------|
| pre-1978    | 0                          | 935                           | 0                              |
| 1978        | 0                          | 428                           | 0                              |
| 1979        | 0                          | 508                           | 0                              |
| 1980        | 0                          | 681                           | 0                              |
| 1981        | 0                          | 1004                          | 0                              |
| 1982        | 0                          | 1181                          | 0                              |
| 1983        | 0                          | 1400                          | 0                              |
| 1984        | 0                          | 1453                          | 0                              |
| 1985        | 0                          | 1902                          | 0                              |
| 1986        | 0                          | 1803                          | 0                              |
| 1987        | 0                          | 1946                          | 0                              |
| 1988        | 0                          | 2066                          | 0                              |
| 1989        | 0                          | 2198                          | 0                              |
| 1990        | 0                          | 2560                          | 0                              |

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\* Includes discharges from French and British reactors for which actual contracts do not exist.

### Production History

An annual breakdown of reprocessing history is not currently available. However, from Table 9.2.10 through the end of 1977, a total of 41 MTHM has been reprocessed at the WAK facility.

## NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

### Vested Interest in Current Fuel Cycles and Reactor Technologies

The Federal Republic of Germany has an enormous vested interest by both Government and private industry in LWR's and FBR's, and in their fuel cycles. Despite the current slowdown in the nuclear program, it is intended to place significant reliance on nuclear power as a future energy source. A large program of LWR's is under construction and projected.

The FRG possesses a powerful LWR vendor and full industrial capability to supply all components and equipment. FBR's are being domestically developed and the prototype unit, SNR-300, is under construction.

In the fuel cycle, the FRG is involved from the supply of uranium through reprocessing. Large investments have been made in many sectors.

In addition, an aggressive export marketing policy has been adopted for reactors, fuel services, and technology transfers. This is viewed both as an important contribution to exports and as an extension of German commercial influence. Through many of its joint undertakings, strong commercial/political relationships are being established with many developed and developing nations.

### Current Trends in Nuclear Development Programs

For the near- to mid-term, there is a firm commitment to LWR technology. Exploitation of FBR's has commenced and a major program can be expected in the 1990's.

### 9.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

#### PROFESSIONAL LABOR FORCE PROFILE

Table 9.3.1

Available information presents the following data for 1973:

100,005 Scientists and Engineers in R&D.

KEY TECHNICAL EDUCATIONAL RESOURCES

Table 9.3.2

| <u>Institution</u>                           | <u>Location</u>        |
|----------------------------------------------|------------------------|
| Rheinisch-Westfälische Technische Hochschule | Aachen                 |
| Technische Universität Berlin                | Berlin                 |
| Ruhr-Universität Bochum                      | Bochum                 |
| Technische Universität Carolo-Wilhelmina     | Braunschweig           |
| Universität Bremen                           | Bremen                 |
| Technische Hochschule                        | Darmstadt              |
| Universität Dortmund                         | Dortmund-Eichlinghofen |
| Albert-Ludwigs-Universität                   | Freiburg im Breisgau   |
| Universität Hamburg                          | Hamburg                |
| Technische Universität                       | Hannover               |
| Universität Fridericiana Karlsruhe           | Karlsruhe              |
| Technische Universität                       | München                |
| Universität Stuttgart                        | Stuttgart              |
| Universität Trier-Kaiserslautern             | Trier                  |
| Universität Ulm                              | Ulm                    |

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 9.3.3

|                                                                                       |                            |                                                                                                        |
|---------------------------------------------------------------------------------------|----------------------------|--------------------------------------------------------------------------------------------------------|
| Gesellschaft für<br>Kernforschung MbH (GFK)                                           | Karlsruhe                  | Fast Breeders, fuel cycle,<br>safety research, nuclear<br>materials control, basic<br>research, fusion |
| Kernforschungsanlage<br>Jülich GmbH (KFA)                                             | Jülich                     | Nuclear technology (HTGR),<br>general nuclear research,<br>fusion                                      |
| Gesellschaft für Kernenergie-<br>verwertung in Schiffbau und<br>Schiffahrt MbH (GKSS) | Hamburg                    | Nuclear technology-H.S.<br>"Otto Hahn" and related<br>safety research                                  |
| Hahn-Meitner Institut für<br>Kernforschung Berlin GmbH<br>(HMI)                       | Berlin                     | Nuclear research<br>(chemistry, physics)                                                               |
| Max-Planck-Institut für<br>Plasmaphysik (IPP)                                         | Garching<br>(nr. Munich)   | Fusion and related laser<br>and plasma research data<br>processing                                     |
| Gesellschaft für Strahlen-<br>und Umweltforschung MbH<br>(GSF)                        | Neuherberg<br>(nr. Munich) | Nuclear research<br>(biology, medicine)                                                                |



KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONSTable 9.3.4

| <u>Name</u>                                            | <u>Owner</u> | <u>Location</u> | <u>Main Activities</u>                                                                       |
|--------------------------------------------------------|--------------|-----------------|----------------------------------------------------------------------------------------------|
| KWU (Kraftwerk<br>Union AG)                            | --           | Wiesens-r       | Development & design<br>of nuclear & coventional<br>power stations & steam<br>& gas turbines |
| INTERATOM<br>(Internationale Atomreak-<br>torbau GmbH) | --           | Bensberg        | Development of sodium<br>cooled fast breeder reactor                                         |
| INB (Internationale Natrium<br>Brutreaker Bau GmbH)    | --           | Gladbach        | Overall development of<br>LMFBR technology                                                   |
| ALKEM GmbH                                             | --           | Hanau           | Development and production<br>fuel elements                                                  |

## RESEARCH AND TEST REACTORS

List of ReactorsTable 9.3.5

| <u>Facility Name</u> | <u>Location</u> | <u>Owner</u>                           | <u>Constructor</u>                                          | <u>Facility Type</u>      | <u>Facility Status</u> |                |              |
|----------------------|-----------------|----------------------------------------|-------------------------------------------------------------|---------------------------|------------------------|----------------|--------------|
|                      |                 |                                        |                                                             |                           | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u>   |
| FRM                  | Garching        | GSF                                    | AMF Atomics                                                 | Research pool             | 4                      | 0              | 10/57        |
| FRG-1                | Geesthacht      | GKSS                                   | Babcock & Wilcox                                            | Research pool             | 5                      | 0              | 10/58        |
| SAR-1                | Garching        | Siemens                                | Siemens-Schuckertwerke                                      | Argonaut                  | 0                      | 0              | 6/59         |
| PR-10                | Grosswelzheim   | Max Planck Institute for Kernenergetik | AEG                                                         | Argonaut                  | 0                      | 0              | 1/61         |
| FR-2                 | Karlsruhe       | GFK                                    | Kernreaktor Bau and Betriebs Ges.                           | Heavy water-research tank | 44                     | 0              | 3/61         |
| FRJ-1 (Merlin)       | Juelich         | KFA                                    | Assoc. Elect. Ind. & John Thompson Nuclear Energy Co., Ltd. | Research pool             | 10                     | 0              | 2/62 & 11/71 |
| SUR-Munich           | Garching        | Siemens                                | Siemens-Schuckertwerke                                      | Solid homog.              | 0                      | 0              | 2/62         |
| FRJ-2 (Dido)         | Juelich         | KFA                                    | Head Wrightson Process Ltd. & AEG                           | Heavy water               | 23                     | 0              | 11/62        |
| STARK                | Karlsruhe       | GFK                                    | Siemens                                                     | Argonaut                  | 0                      | 0              | 1/63 & 6/64  |
| FRG-2                | Geesthacht      | GKSS                                   | GKSS                                                        | Research pool             | 15                     | 0              | 3/63 & 2/68  |
| SUR-Berlin           | Berlin          | HMI                                    | Siemens-Schuckertwerke                                      | Solid homog.              | 0                      | 0              | 7/63         |
| SUR-Darmstadt        | Darmstadt       | Max Planck Institute for Kernphysik    | Siemens                                                     | Solid homog.              | 0                      | 0              | 9/63         |

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

| <u>Facility Name</u>       | <u>Location</u> | <u>Owner</u>                                                                                 | <u>Constructor</u>                        | <u>Facility Type</u> | <u>Facility Status</u><br>MW(th) Status* COD |
|----------------------------|-----------------|----------------------------------------------------------------------------------------------|-------------------------------------------|----------------------|----------------------------------------------|
| ANEX                       | Geesthacht      | GKSS                                                                                         | GKSS & Interatom                          | Critical exper.      | 0 0 7/64                                     |
| SUR-Stuttgart              | Stuttgart       | Stuttgart Inst.<br>fur Kernenergetik                                                         | Siemens                                   | Solid homog.         | 0 0 10/64                                    |
| SUR-Hamburg                | Hamburg         | GKSS                                                                                         | Siemens                                   | Solid homog.         | 0 0 1/65                                     |
| Triga-II-Mainz             | Mainz           | Max Planck<br>Institute fur<br>Chemie                                                        | General Atomic Co.                        | U-Zr<br>hydride      | .10 0 8/65                                   |
| SUR-ULM                    | ULM             | Universitat<br>Ulm                                                                           | Siemens                                   | Solid homog.         | 0 0 12/65                                    |
| SUR-Karlsruhe              | Karlsruhe       | GFK                                                                                          | Siemens                                   | Solid homog.         | 0 0 3/66                                     |
| SUR-Kiel                   | Kiel            | Staatliche<br>Fachhochschule<br>fur Technik and<br>Sozialwesen<br>Abteilung Kern-<br>technik | Siemens                                   | Solid homog.         | 0 0 3/66                                     |
| Triga-I-Heidel-<br>berg    | Heidelberg      | Max Planck<br>Institute fur<br>Kernphysik                                                    | General Atomic<br>Company                 | U-Zr hydride         | .25 0 8/66                                   |
| SUR-Aachen                 | Aachen          | Technische<br>Hochschule<br>Aachen                                                           | Siemens                                   | Solid homog.         | 0 0 9/66                                     |
| SNEAK                      | Karlsruhe       | GFK                                                                                          | Siemens                                   | Crit. Exp.           | 0 0 12/66                                    |
| Adibka-1                   | Juelich         | KFA                                                                                          | Interatom and<br>Atomics<br>International | Aqu. homog.          | 0 0 3/67                                     |
| A&G Nullenergie<br>Reactor | Groszweilzheim  | Max Plank Insti.<br>fur Kernenergetik                                                        | AEC                                       | Crit. Exp.           | 0 0 6/67                                     |
| FMRB                       | Braunschweig    | Technische<br>Universite<br>Braunschweig                                                     | Deutsche Babcock<br>& Wilcox              | Research<br>pool     | 1 0 10/67                                    |

| Facility<br>Name                      | Location              | Owner                                                           | Constructor                         | Facility<br>Type                    | Facility Status  |         |               |
|---------------------------------------|-----------------------|-----------------------------------------------------------------|-------------------------------------|-------------------------------------|------------------|---------|---------------|
|                                       |                       |                                                                 |                                     |                                     | MW(th)           | Status* | COD           |
| SUR-Bremen                            | Bremen                | Ingenieur<br>Akademie der<br>Freier und<br>Hansastadt<br>Bremen | Siemens                             | Solid<br>homog.                     | 0                | 0       | 10/67         |
| SUR-Hannover                          | Hannover              | Technische<br>Universitat<br>Hannover                           | Siemens                             | Solid<br>homog.                     | 0                | 0       | 12/61         |
| FRN-Forschungs-<br>reaktor Necherberg | Neuherberg/<br>Munich | Siemens                                                         | General<br>Atomic                   | U-Zr<br>hydride                     | 1                | 0       | 8/72          |
| TRIGA-I-Hannover                      | Hannover              | Technische<br>Universitat<br>Hannover                           | General<br>Atomic                   | U-Zr<br>hydride                     | .25              | 0       | 11/72         |
| SUR-Furtwangen                        | Furtwangen            | --                                                              | Siemens                             | Solid<br>homog.                     | 0                | 0       | 6/73          |
| SUR-100                               | Furtwangen            | --                                                              | Siemens                             | Solid<br>homog.                     | 0                | 0       | 6/73          |
| Kather<br>BER-2                       | Juelich<br>Berlin     | KFA<br>HMI                                                      | --<br>Atomic Int'l                  | Crit. exp.<br>Research<br>pool      | 0<br>5           | 0<br>0  | 7/73<br>12/73 |
| (rebuilt from<br>BER-1 (Opr.1958)     |                       |                                                                 |                                     |                                     |                  |         |               |
| AVR                                   | KFA, Julich           | KFA & N. Rhein<br>Westfalen                                     | Arbeitsgemein-<br>schaft, BBC-Krupp | HTGR, highly<br>enriched U<br>Tank  | 46<br>6          | 0<br>-- | 1967<br>--    |
| WWR-5(m)                              | Rosendorf             | --                                                              | --                                  |                                     |                  |         |               |
| Triga conversion                      | Frankfurt             | Universitat<br>Frankfurt                                        | General Atomic Co.                  | Solid<br>Homog.                     | 1                | U       | --            |
| FRF                                   | Frankfurt             | Universitat<br>Institut fur<br>Kernphysik                       | Atomics Int'l                       | --                                  | --               | --      | 1958          |
|                                       | Munich                | Technical Univer-<br>sity of Munich                             | American Machine<br>& Foundry       | Pool, 90%<br>U-Al, H <sub>2</sub> O | 2.5              | --      | 1957          |
|                                       | Berlin                | Serate of the<br>Land                                           | Atomics Int'l                       | Aqa. homog.                         | 10 <sup>-5</sup> | --      | 1966          |

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

Table 9.3.6

| <u>Vendor</u> | <u>Country</u> | <u>Facility<br/>Name</u> | <u>Facility<br/>Type</u> | <u>Facility Status</u> |                |            | <u>Scope of<br/>Services</u> |
|---------------|----------------|--------------------------|--------------------------|------------------------|----------------|------------|------------------------------|
|               |                |                          |                          | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u> |                              |
| Siemens       | Austria        | SAR-GRAZ                 | Argonaut                 | .001                   | 0              | 1965       | Constructor                  |

NOTE: Refer to Table 9.3.5 for capability to provide domestic needs

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

# SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 9.3.7

FEDERAL REPUBLIC OF GERMANY-51

| Facility<br>Name                                | Location           | Facility<br>Type                                                | Capacity Status<br>MT/YR                                                                         | Status* | Year | Shareholdings                                             |
|-------------------------------------------------|--------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------|------|-----------------------------------------------------------|
| FUEL FABRICATION FOR PROTOTYPE REACTORS         |                    |                                                                 |                                                                                                  |         |      |                                                           |
| ALKEM                                           | Wolfgang/<br>Hanau | MO <sub>2</sub>                                                 | 60t                                                                                              | --      | --   | Nukem 40%<br>KWU 60%                                      |
| HOBEG                                           | Wolfgang/<br>Hanau | Spherical &<br>prismatic<br>block type fuel<br>elements for HTR | 25,000<br>elements/yr<br>for AVR<br>400,000 elements<br>for FC THTR                              | --      | --   | Nukem 100%                                                |
| FABRICATION OF FUEL ELEMENTS FOR RESEARCH & MTR |                    |                                                                 |                                                                                                  |         |      |                                                           |
| NUKEM<br>(HU)                                   | Wolfgang/<br>Hanau | Plates,<br>enrichment up<br>to 93% U <sub>235</sub>             | 25,000<br>plates/yr<br>current production<br>~10,000 plates/yr<br>(70% export:<br>NL, S, Canada) | --      | --   | DEGUSSA 45%<br>RWE 25%<br>RTZ 18%<br>Metallges.<br>AG 12% |

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

#### 9.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

##### ECONOMIC DATA PROFILE

Table 9.4.1

|                          |                  |                        |                    |
|--------------------------|------------------|------------------------|--------------------|
| GNP (Current million \$) | - 540,177 (1977) | Inflation Rate         | --- -- 3.1% (1977) |
| Exports (million \$)     | - 123,801 (1977) | Imports (million \$)   | - 106,419 (1977)   |
| Per Capita Income (\$)   | - 6,029 (1975)   | Disposable Income (\$) | - 5,922 (1975)     |
| Monetary Unit            | - Deutsche Mark  | Exchange Rate (/US\$)  | - 2.209 (5/78)     |
| Population (million)     | - 62.0 (1977)    |                        |                    |

9.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

Energy Research and Energy Technologies Program 1977-1980  
Million DM

|                                                   | <u>1977</u> | <u>1978</u> | <u>1979</u> | <u>1980</u> | <u>Total</u> |
|---------------------------------------------------|-------------|-------------|-------------|-------------|--------------|
| Nuclear Energy                                    |             |             |             |             |              |
| Research Program                                  | 1,028       | 1,086       | 1,152       | 1,170       | 4,436        |
| Investments for<br>the future Program             | 1           | 14          | 34          | 47          | 96           |
| Specifics in Program                              |             |             |             |             |              |
| Nuclear Safety Research<br>& Radiation Protection | 152         | 162         | 172         | 180         | 666          |
| Nuclear fuel cycle                                | 267         | 282         | 310         | 305         | 1,164        |
| HTR                                               | 137         | 131         | 142         | 147         | 557          |
| LMFBR                                             | 169         | 158         | 158         | 181         | 666          |
| Prototype & test<br>Reactors                      | --          | --          | --          | --          | --           |
| Controlled Nuclear<br>fusion                      | 83          | 91          | 98          | 107         | 379          |

Exchange rate (1977) = 2.36/US\$



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

Table 9.4.3

| <u>Industry<br/>University or<br/>Laboratory</u>               | <u>Program<br/>Area</u>                                                                                                                       | <u>Budget<br/>\$ (Millions)</u> | <u>Key<br/>Personnel</u> |
|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------------|
| Nuclear Research Center at<br>Karlsruhe (GfK)                  | Fast breeder, reactor<br>safety, physical pro-<br>tection, reprocessing,<br>waste conditioning,<br>final storage, super<br>conductors, fusion | --                              | --                       |
| Nuclear Research Center at<br>Jülich (KFA)                     | High temperature<br>reactors, coal<br>gasification, new<br>secondary energy systems,<br>fusion                                                | --                              | --                       |
| Research Center at<br>Geesthacht (GKSS)                        | Nuclear safety, nuclear<br>ship propulsion, off-<br>shore technology                                                                          | --                              | --                       |
| Research Center for<br>Environmental Science (GSF)             | Final storage of radio-<br>active waste, biology,<br>medicine.                                                                                | --                              | --                       |
| Plasma Physics Institute<br>of the Max Planck Society<br>(IPP) | Center of the German<br>fusion research<br>activities                                                                                         | --                              | --                       |
| Society for Reactor Safety                                     | Carries out and coordi-<br>nates reactor safety<br>R&D                                                                                        | --                              | --                       |
| Hahn-Meitner Institute for<br>Nuclear Research Berlin<br>(HMI) | Carries out nuclear<br>research in chemistry<br>and physics.                                                                                  | --                              | --                       |

Research on energy conducted at universities is focused primarily on basic problems.

#### 9.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

The German nuclear reactor industry, entirely private, includes the following companies:

| <u>COMPANY</u>                                    | <u>PROGRAMS</u>                                                                                                                      |
|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| KWU (Kraftwerk Union AG)                          | Development and design of nuclear and conventional power stations and steam and gas turbines                                         |
| INTERATOM (Internationale Atomreaktorbau GmbH)    | Development of the sodium cooled fast breeder reactor                                                                                |
| INB (Internationale Natrium-Brutreaktor Bau GmbH) | Overall development of LMFBR technology                                                                                              |
| NUKEM GmbH                                        | Conversion of enriched uranium hexafluoride to oxide, production of MTR fuel plates and uranium elements, reprocessing of spent fuel |
| ALKEM GmbH                                        | Development and production of plutonium fuel elements                                                                                |
| RBG (Reactorbrennelemente GmbH)                   | Conversion of uranium hexafluoride to uranium dioxide, production of uranium oxide fuel elements                                     |

The responsibility borne by government and industry of the back end of the fuel cycle is detailed as follows:

- 1) Industry builds and operates reprocessing plants, waste conditioning plants and interim storage facilities.
- 2) Government takes care of the necessary research and development and operates final storage facilities.
- 3) All costs arising from the implementation of the system have to be borne by the industrial partners responsible for operating nuclear power plants.

## ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 9.4.5

| <u>Name</u>                                                    | <u>Share Capital</u> | <u>Assets</u> | <u>Sales</u> |
|----------------------------------------------------------------|----------------------|---------------|--------------|
| Kraftwerk Union AG (KWU)                                       |                      |               |              |
| ALKEM GmbH                                                     |                      |               |              |
| Hochtemperaturreaktor-Brennelement<br>GmbH (HOBEG)             |                      |               |              |
| Reaktor-Brennelement<br>Union GmbH (RRU)                       |                      |               |              |
| Wiederaufarbeitungsanlage<br>Karlsruhe (WAK)                   |                      |               |              |
| Kernbrennstoff-Wiederaufarbeitungs-<br>Gesellschaft mbH (KEWA) |                      |               |              |

### 9.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Internal financing through private banks and bond issues as the utilities are privately owned and operated.

## 9.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

### 9.5.1 ENERGY POLICY - BASIC LEGISLATION

1. Atomic Energy Law (1959) regulates licensing procedures for nuclear facilities, transportation conditions for radioactive materials and other nuclear matters.
2. Radiation Protection Law.
3. Energy conservation law requires improved heat insulation and the rational use of heating installations in houses.
4. The third law on the use of hard coal by electric power stations ensures that the share of domestic coal used in generating electricity remain of sufficient volume to secure electric power supplies.
5. Energy Industry Act ensures that utilities meet the actual energy demand at favorable overall costs.
6. Law on investment aids for energy conservation measures in old buildings.
7. Various environmental protection laws.

The Second Revision of the Energy Policy Program included legislative and administrative measures in the areas of:

1. enforced information for industry and consumers
2. labelling of household machines
3. accelerated introduction of energy conservation technologies, products and processes
4. enforced use of waste heat of power stations in connection with district heating
5. additional investments for energy conservation in old buildings
6. information for consumers in the transportation area and a revised automobile tax

## 9.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

### LEGISLATIVE-PARLIAMENT

Federal laws are passed by a legislative body known as the Bundestag which is composed of 496 elected representatives. The Parliament has three committees which monitor energy activities within their jurisdiction as follows:

1. Economic matters
2. Research and technology
3. Internal affairs (including reactor safety)

The FEDERAL ASSEMBLY composed of members of the Bundestag and representatives of the member states of the Republic meets only to elect the FEDERAL PRESIDENT (Walter Scheel) who represents the Republic in international relations.

EXECUTIVE-FEDERAL CHANCELLOR (Helmut Schmidt) is elected by Parliament on the proposal of the President and heads the cabinet composed of FEDERAL MINISTERS.

The following Ministries have energy responsibilities:

| MINISTRY                     | RESPONSIBILITY                                                                                                                              | KEY INDIVIDUALS              |
|------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| Research and<br>Tech. (BMFT) | Energy R&D; advanced reactor systems, reactor safety, fuel cycle, administration of the German nuclear institutes, non-nuclear energy.      | Hans Matthofer<br>Minister   |
| Economic Affairs             | Energy policy and analysis, mineral resources, petroleum, electricity, nuclear power, coal, hydropower, stockpiling, IAEA and OECD affairs, | Hans Friderrichs<br>Minister |
| Interior (BMI)               | Safety of nuclear facilities, radiation protection, nuclear regulation, environmental affairs.                                              | Werner Maihofer<br>Minister  |

### 9.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

Dr. Hans Matthofer, Federal Minister for Research and Technology

Dr. Volker Hauff, Parliamentary State-Secretary for R&T  
(immediate political deputy to Matthofer)  
(He is in charge of establishing and implementing  
energy R&D policy and implementing energy program.)

Mr. Hans H. Haunschild, State-Secretary for R&T

Dr. Wolf-Juergen Schmidt-Kuester, Assistant Secretary  
responsible for energy, material resources, industrial  
technologies, and biological, ecological, and medical  
technologies)

Dr. M. Popp, Deputy Assistant Secretary for Energy R&T  
Dr. Daunert, Director, Office for Advanced Reactor  
Systems

Dr. Heinz Seipel, Director, Office of Reactor Safety  
R&T and LWR Technology

Mr. Krewer, Director, Office of Nuclear Fuel Cycles  
(No. 1) (responsible for U-supply and enrichment)

Dr. Hagen, Director, Office of Nuclear Fuel Cycles  
(No.2) (responsible for fuel elements, Pu  
technology, reprocessing of fuel, and radio-  
active waste disposal)

Dr. Schwarz, Acting Director, Office of Nuclear Centers

#### Nuclear Centers

Dr. Harde, Chairman of the Board, Karlsruhe Center

Dr. Karl Beckurts, Director of the Julich Center

Dr. Schopper, Director, DESY High Energy Accelerator Center

Dr. Wienecke, Director, Plasma Physics Center (near Munich)

Dr. R. Wittenzellner, Director, Radiation and Environmental  
Research Center (near Munich)

#### Ministry of Interior

Mr. Maihoffer, Federal Minister of Interior

Mr. Wilhelm Sahl, Director, Division for Nuclear Regulation

Mr. J. Pfaffelhuber, Head, Office of Radiation Law

#### Hahn-Meitner Institute

Dr. J. Erchler, Scientific and Technological Director

Dr. W. Ellerkmann, Administrative Director

### 9.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

(Continued)

#### Deutsches Atomforum

Dr. H. Mandel, President

#### Interatom

Dr. A. Brandstetter, Managing Director (responsible for nuclear reactor activities)

In establishing R&D policy, industry, trade unions, and scientists work the Federal Government, the governments of Federal States and elected members of research centers to make up a supervisory board which then determines the focal areas the research centers concentrate on.

#### 9.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

In December, 1977, the Schmidt government announced there will be no "official" moratorium of nuclear power plants, but energy preferences have swung to the use of coal with nuclear power as a last resort. The new energy program no longer contains any figures regarding nuclear capacity to be in operation in 1985; however, the appendices of the new program give a total of 24,000 MWe, which is the figure resulting of all nuclear power plants presently in operation, under construction or in the licensing phase.

The Federal government energy policy gives the following objectives:

- more energy conservation
- a smaller share for petroleum in overall supply
- priority for indigenous hard coal and lignite
- expansion of nuclear power at the rate necessary to secure electricity supply
- reduced dependence on imports by diversifying sources, concluding international agreements and engaging in international cooperation
- determined continuation of the energy research effort

#### 9.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

In April, 1977, the Government launched a comprehensive Program for Energy Research and Energy Technologies 1977-1980. The program combines and continues the two previous energy research programs, the Fourth Nuclear Program 1973-1976 and the Non-Nuclear Energy R&D Program 1974-1977.

The Government stated that the priorities in the nuclear energy sector are reactor safety, the nuclear fuel cycle and advanced reactor systems. Nuclear energy is meeting a growing proportion of demand for electric energy. At the end of 1977, just under 10,000 MW were on stream; approximately another 10,000 MW are under construction. Main R&D items are the fast breeder, high temperature gas cooled reactor, reactor safety research, reprocessing and radio-active waste management. The focal point of the fast breeder program is the 300 MW SNR-300 plant under construction at Kalkar. A strong public debate on the pros and cons of nuclear energy is currently causing considerable delays in the progress of nuclear power development.



#### 9.5.6 NUCLEAR ENERGY R&D - PRIORITIES

The priorities for energy R&D are as follows:

- more effective and rational utilization of primary and secondary energy
- future development and improvement of technologies for coal production, conversion and coal utilization
- development of the potential offered by renewable energy sources and fusion
- further development and improvement of nuclear energy for peaceful purposes

The priorities in the nuclear energy sector are reactor safety, the nuclear fuel cycle and advanced reactor systems.

The safety of light water reactors (LWR) is being further improved by detailed analyses of assumed incidents and by improving the reliability of components. Issues concerning the shutdown of nuclear energy facilities are treated together with maintenance and repair. With increasing progress in the development of advanced reactor lines, reactor safety research activities are being gradually removed from the development program and dealt with separately.

As for the nuclear fuel cycle, problems of uranium enrichment, of reprocessing of spent fuel elements as well as of handling and disposal of waste are to the fore. This sector also includes activities on nuclear safeguards.

#### 9.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

The Supreme State Authority is in charge of licensing procedures for nuclear facilities in cooperation with federal state authorities and grants both construction and operating licenses.

The applicant makes a request to the Supreme State Authority, who makes a decision to license or reject the application. Before this decision is made, many participating authorities are called in to review the request:

Federal Minister of the Interior  
Advisory Committee on Reactor Safeguards (RSK)  
Participating federal authorities  
Safety assessors (TUV, GRS)

9.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

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

Table 9.6.1

| <u>Facility Name</u>     | <u>Location</u> | <u>Utility/ Owner</u>                     | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>                               |
|--------------------------|-----------------|-------------------------------------------|---------------|----------------------------------|---------------------------|----------------|------------------------------------------|
| Mannheim I & II          | Mannheim        | Grosskraftwerk Mannheim AG                |               | Black coal/<br>Oil/Gas           | 1650                      | 0              | 1970 1971<br>(120) (65)<br>1973<br>(190) |
| Staudinger               | Hannover        | Prussenelektra Hannover                   |               | Black coal/<br>Oil/Gas           | 840                       | 0              |                                          |
| Wedel (+2 GT)            | Hamburg         | HEW, Hamburg                              |               | Black coal/<br>Oil/Gas           | 630<br>(+111)             | 0              |                                          |
| Wilhelmshaven            | Hamburg         | NWK, Hamburg                              |               | Black coal/<br>Oil/Gas           | 720                       | 0              | 1976<br>(690)                            |
| Heibronni-6              | Stuttgart       | EVS, Stuttgart                            |               | Black coal/<br>Oil/Gas           | 603                       | 0              | 1966<br>(125)                            |
| Veltheim 1               |                 | Gemeinschafts-<br>kraftwerk Weser<br>GmbH |               | Black coal/<br>Oil/Gas           | 500                       | 0              | 1970<br>(300)                            |
| Hafenkraftwerk<br>Bremen | Bremen          | Stadtwerke<br>Bremen AG                   |               | Black coal/<br>Oil/Gas           | 404                       | 0              | 1968<br>(140)                            |
| Franken II               | Nurnberg        | Grosskraftwerke<br>Franken AG<br>Nurnberg |               | Black coal/<br>Oil/Gas           | 400                       | 0              |                                          |

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

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

Table 9.6.1 (Continued)

FEDERAL REPUBLIC OF GERMANY-65

| <u>Facility<br/>Name</u>   | <u>Location</u> | <u>Utility/<br/>Owner</u>                            | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------------|-----------------|------------------------------------------------------|---------------|------------------------------------------|-------------------------------|----------------|------------|
| Neuhof                     | Hamburg         | HEW, Hamburg                                         |               | Black coal/<br>Oil/Gas                   | 399                           | 0              |            |
| Heyden                     | Hannover        | Preussenelektra<br>Hannover                          |               | Black coal/<br>Oil/Gas                   | 318                           | 0              |            |
| Altbach I & II             | Esslingen       | Neckarwerke<br>Elektr.-Vers-<br>AG, Esslingen        |               | Black coal/<br>Oil/Gas                   | 313                           | 0              |            |
| Gaisburg I &<br>(+G.T.) II | Stuttgart       | TWS Stuttgart                                        |               | Black coal/<br>Oil/Gas                   | 245<br>(+60)                  | 0              |            |
| Datteln                    | Ruhr            | VEBA Kraftwerke<br>Ruhr AG<br>Gelsenkirchen-<br>Buer |               | Black coal/<br>Oil/Gas                   | 290                           | 0              |            |
| Westerhalt                 | Ruhr            | VEBA Kraftwerke<br>Ruhr AG<br>Gelsenkirchen-<br>Buer |               | Black coal/<br>Oil/Gas                   | 270                           | 0              |            |
| Walheim                    | Esslingen       | Neckarwerke<br>Elektr.-Vers-AG<br>Esslingen          |               | Black coal/<br>Oil/gas                   | 267                           | 0              |            |

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

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

Table 9.6.1 (Continued)

| <u>Facility Name</u>               | <u>Location</u>    | <u>Utility/ Owner</u>       | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|------------------------------------|--------------------|-----------------------------|---------------|----------------------------------|---------------------------|----------------|------------|
| Leiningerwerk<br>Zolling-Angelberg | Munich             | Isar-Amperwerke AG, Munchen |               | Black coal/<br>Oil/gas           | 265                       | 0              |            |
| Herrenhausen                       | Hanover            | Stadtwerke AG               |               | Black coal/<br>Oil/gas           | 265                       | 0              |            |
| Wehrden                            | Wehrden-Volklingen | Kraftwerke Wehrden AG       |               | Black coal/<br>Oil/gas           | 230                       | 0              |            |
| Gersteinwerk                       | Dortmund           | VEW                         |               | Black coal/<br>Oil/gas           | 214                       | 0              |            |
| Oberhavel                          | Berlin             | BEWAG                       |               | Black coal/<br>Oil/gas           | 200                       | 0              |            |
| Emden I                            | Hamburg            | NWK                         |               | Black coal/<br>Oil/gas           | 195                       | 0              |            |
| Franken I                          | Nurnberg           | Grosskraftwerke Franken     |               | Black coal/<br>Oil/gas           | 195                       | 0              | 1976       |
| Munchen-Nord                       | Munich             | Stadtwerke                  |               | Black coal/<br>Oil/gas           | 180                       | 0              | 1966       |
| Stuttgart-Munster                  | Stuttgart          | TWS                         |               | Black coal/<br>Oil/gas           | 102 +<br>70 Gas           | 0              |            |

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

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

Table 9.6.1

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/ Owner</u>      | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>    |
|----------------------|-----------------|----------------------------|---------------|----------------------------------|---------------------------|----------------|---------------|
| Afferde              | Hameln          | Electrizitatswerk Wesertal |               | Black coal/<br>Oil/Gas           | 166                       | 0              |               |
| Hannover HKW         | Hannover        | Stadtwerke Hannover        |               | Black coal/<br>Oil/Gas           | 165                       | 0              |               |
| Dettingen            | Essen           | RWE Essen                  |               | Black coal/<br>Oil/Gas           | 100 +<br>55 GT            | 0              |               |
| Kassel               | Kassel          | Kraftwerk Kassel           |               | Black coal/<br>Oil/Gas           | 142                       | 0              |               |
| Flensburg            | Flensburg       | Stadtwerke Flensburg       |               | Black coal/<br>Oil/Gas           | 116                       | 0              | 1971          |
| Scholven             | Gebenkirchen    | VEBA Kraftwerke Ruhr       |               | Black Coal                       | 1,505                     | 0              |               |
| Westfalen            | Dortmund        | VEW                        |               | Black Coal                       | 672                       | 0              |               |
| Farge                | Hamburg         | NWK                        |               | Black Coal                       | 538                       | 0              |               |
| Ensdorf              | Essen           | RWE                        |               | Black Coal                       | 532                       | 0              | 1971<br>(300) |
| Aschaffenburg        | Munich          | Bayernwerk AG              |               | Black Coal                       | 514                       | 0              | 1971<br>(150) |

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

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

Table 9.6.1

| <u>Facility Name</u> | <u>Location</u>    | <u>Utility/ Owner</u>        | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------|--------------------|------------------------------|---------------|----------------------------------|---------------------------|----------------|------------|
| Lausward             | Dusseldorf         | Stadtwerke Dusseldorf        |               | Black Coal                       | 500                       | 0              |            |
| Knepper              | Gelsenkirchen      | VEBA Kraftwerk Ruhr          |               | Black Coal                       | 498                       | 0              |            |
| Reuter               | Berlin             | BEWAG                        |               | Black Coal                       | 440                       | 0              | 1969 (132) |
| Kiel                 | Kiel               | Gemeinschafts-Kraftwerk Kiel |               | Black Coal                       | 350 (320)                 |                |            |
| Mainz                | Mainz              | Kraftwerke Mainz-Wiesbader.  |               | Black Coal                       | 350                       | 0              |            |
| Rheinhafen           | Karlsruhe          | Badenwerk AG                 |               | Black Coal                       | 330                       | 0              |            |
| Duisburg             | Duisburg           | Stadtwerke Duisburg AG       |               | Black Coal                       | 316                       | 0              |            |
| Springorum           | Gelsenkirchen Buer | VEBA Kraftwerk Ruhr          |               | Black Coal                       | 300                       | 0              |            |
| Elveslingsen I       | Hagen              | Elektromark                  |               | Black Coal                       | 265                       | 0              | 1970/76    |
| Karnap               | Essen              | RWE                          |               | Black Coal                       | 250                       | 0              |            |

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

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

Table 9.6.1 (Continued)

| <u>Facility Name</u>                                         | <u>Location</u>             | <u>Utility/ Owner</u>       | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>    |               |
|--------------------------------------------------------------|-----------------------------|-----------------------------|---------------|----------------------------------|---------------------------|----------------|---------------|---------------|
| Lübeck-Siems                                                 | Hamburg                     | NWK                         |               | Black Coal                       | 215                       | 0              |               |               |
| Tiefstack                                                    | Hamburg                     | HEW                         |               | Black Coal                       | 209                       | 0              |               |               |
| Moabit                                                       | Berlin                      | BEWAG                       |               | Black Coal                       | 206                       | 0              |               |               |
| Marbach I                                                    | Stuttgart                   | EVS                         |               | Black Coal                       | 202                       | 0              |               |               |
| Flingern                                                     | Dusseldorf                  | Stadtwerke<br>Dusseldorf AG |               | Black Coal                       | 200                       | 0              |               |               |
| Kellerman                                                    | Essen                       | STEAG AG                    |               | Black Coal                       | 200                       | 0              |               |               |
| Charlottenburg                                               | Berlin                      | BEWAG                       |               | Black Coal                       | 185                       | 0              |               |               |
| Rudow                                                        | Berlin                      | BEWAG                       |               | Black Coal                       | 175                       | 0              |               |               |
| Frankfurt                                                    | Frankfurt<br>Main           | Stadtwerke<br>Frankfurt     |               | Black Coal                       | 162.8                     | 0              |               |               |
| Harpen                                                       | Dortmund                    | Harpen AG                   |               | Black Coal                       | 150                       | 0              |               |               |
| Shamrock                                                     | Gelsen -<br>kirchen<br>Buer | VEBA Kraftwerke<br>Ruhr     |               | Black Coal                       | 135                       | 0              |               |               |
| Niederausen                                                  | Essen                       | RWE                         |               | Brown Coal                       | 2,700                     | 0              | 1968<br>(300) | 1970<br>(300) |
| * O-Operational; U-Under Construction; P-Planned; S-Shutdown |                             |                             |               |                                  |                           |                | 1971<br>(300) | 1973<br>(600) |



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

Table 9.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>             | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>               |
|--------------------------|-----------------|---------------------------------------|---------------|------------------------------------------|-------------------------------|----------------|--------------------------|
| Frimmersdorf             | Essen           | RWE                                   |               | Brown Coal                               | 2,600                         | 0              | 1966 1970<br>(300) (300) |
| Weisweiler I             | Essen           | RWE                                   |               | Brown Coal                               | 2,300                         | 0              |                          |
| Neurath                  | Essen           | RWE                                   |               | Brown Coal                               | 2,100                         | 0              | 1972 1976<br>(600) (567) |
| Fortuna II &<br>III      | Essen           | RWE                                   |               | Brown Coal                               | 905                           | 0              |                          |
| Goldenberg-<br>Werk      | Essen           | RWE                                   |               | Brown Coal                               | 813                           | 0              |                          |
| Offleben                 | Helmstedt       | Braunschweig<br>Kohlen-Berg-<br>Werke |               | Brown Coal                               | 769                           | 0              | 1973<br>(325)            |
| Schwarndorf              | Munich          | Bayernwerk AG                         |               | Brown Coal                               | 700                           | 0              | 1972<br>(300)            |
| Borken                   | Hannover        | Preussenelektra                       |               | Brown Coal                               | 356                           | 0              |                          |
| Arzberg                  | Bayreuth        | BELG                                  |               | Brown Coal                               | 196                           | 0              | 1966<br>(100)            |
| Wolfersheim              | Hannover        | Preussenelektra                       |               | Brown Coal                               | 124                           | 0              |                          |

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

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

Table 9.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>     | <u>Utility/<br/>Owner</u>        | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>              |
|--------------------------|---------------------|----------------------------------|---------------|------------------------------------------|-------------------------------|----------------|-------------------------|
| Gersteinwerk             | Dortmund            |                                  |               | Gas                                      | 1680                          | 0              | 1973<br>(850)           |
| Robert Frank             | Hannover            | Preusenelektra                   |               | Gas                                      | 1121                          | 0              | 1968<br>(300)           |
| Emsland                  | Nurnberg            | Groskraftwerk<br>Franken AG      |               | Gas                                      | 835                           | 0              |                         |
| Meppen                   | Essen               | RWE                              |               | Gas                                      | 600                           | 0              |                         |
| Emden I                  | Hamburg             | NWK                              |               | Gas                                      | 530                           | 0              | 1966 1973<br>(30) (430) |
| Moorburg                 | Hamburg             | HEW                              |               | Gas                                      | 525                           | 0              | 1976<br>(500)           |
| Weltheim II              | Porta<br>Westfalica | Gemeinschafts<br>Kraftwerk Weser |               | Gas                                      | 360                           | 0              |                         |
| Huckingen                | Essen               | RWE                              |               | Gas                                      | 300                           | 0              |                         |
| Hattingen                |                     | Gemeinschaftwerk<br>Hattingen    |               | Gas                                      | 284                           | 0              |                         |
| Herdecke                 | Hagen               | ELECTIROMARK                     |               | Gas                                      | 250                           | 0              |                         |

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

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

Table 9.6.1 (Continued)

| <u>Facility Name</u> | <u>Location</u>   | <u>Utility/ Owner</u>        | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>               |
|----------------------|-------------------|------------------------------|---------------|----------------------------------|---------------------------|----------------|--------------------------|
| München-Sud          | Munich            | Stadwerke                    |               | Gas                              | 250                       | 0              | 1969 1971<br>(125) (125) |
| Arzberg              | Bayreuth          | BELG                         |               | Gas                              | 220                       | 0              |                          |
| Elveslingsen II      | Hagen             | ELECTROMARK                  |               | Gas                              | 210                       | 0              | 1971                     |
| Mehrum               | Hannover          | Braunschweig                 |               | Gas                              | 200                       | 0              | 1969<br>(100)            |
| Kirchlengern         | Herford           | EW Minden-Ravensburg         |               | Gas                              | 183                       | 0              |                          |
| Duisberg III         | Duisburg          | Stadtwerke Duisburg          |               | Gas                              | 174                       | 0              | 1966                     |
| Hastedt              | Bremen            | Stadtwerke Bremen            |               | Gas                              | 170                       | 0              | 1972<br>(170)            |
| München-Freimann HKW | Munich            | Stadtwerke München           |               | Gas                              | 162                       | 0              |                          |
| Ffm.-Hjederrad HKW   | Frankfurt am Main | Stadtwerke Frankfurt am Main |               | Gas                              | 140                       | 0              |                          |
| Schloven             | Essen             | RWE                          |               | Oil                              | 1,428                     | 0              |                          |

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

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

Table 9.6.1 (Continued)

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/ Owner</u>                        | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>               |
|----------------------|-----------------|----------------------------------------------|---------------|----------------------------------|---------------------------|----------------|--------------------------|
| Ingolstadt           | Munich          | Bayernwerk                                   |               | Oil                              | 1,100                     | 0              | 1973<br>(400)            |
| Irsching             | Munich          | Isar-Amperwerke                              |               | Oil                              | 930                       | 0              | 1969 1972<br>(150) (330) |
| Pleinting            | Munich          | Ilse-Bayernwerk<br>Energieanlagen            |               | Oil                              | 450                       | 0              | 1969 1976<br>(300) (402) |
| Moorsburg            | Hamburg         | HEW                                          |               | Oil                              | 515                       | 0              |                          |
| Lichterfelde         | Berlin          | BEWAG                                        |               | Oil                              | 450                       | 0              | 1972 1973<br>(150) (150) |
| Schilling            | Hamburg         | NWK                                          |               | Oil                              | 375                       | 0              |                          |
| Rheinhafen           | Karlsruhe       | Badenwerk AG                                 |               | Oil                              | 360                       | 0              |                          |
| Mittelsburen         | Bremen          | Bremen<br>Stadtwerke                         |               | Oil                              | 328                       | 0              |                          |
| Marbach III          | Stuttgart       | EVS                                          |               | Oil                              | 330                       | 0              |                          |
| Köln-Niehl<br>HKW    | Cologne         | Gas-Electrizitats<br>und wasserwerke<br>Köln |               | Oil                              | 315                       | 0              | 1976<br>(300)            |

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

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

Table 9.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>                    | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>    |
|--------------------------|-----------------|----------------------------------------------|---------------|------------------------------------------|-------------------------------|----------------|---------------|
| Brunsbüttel              | Hamburg         | HEW                                          |               | Oil                                      | 272                           | 0              |               |
| Altbach II               | Esslingen       | Neckarwerke<br>Elektr.-Vers.A3               |               | Oil                                      | 250                           | 0              | 1972          |
| Hafen HKW                | Hamburg         | HEW                                          |               | Oil                                      | 221                           | 0              | 1971<br>(150) |
| Charlottenburg           | Berlin          | BEWAG                                        |               | Oil                                      | 200                           | 0              | 1966<br>(78)  |
| Köln-Nord HKW            | Cologne         | Gas-Electrizitats<br>und wasserwerke<br>Köln |               | Oil                                      | 186.5                         | 0              |               |
| Altbach II               | Esslingen       | Neckarwerke<br>Elektr.-Vers. AG              |               | Oil                                      | 140                           | 0              |               |
| Lausward                 | Düsseldorf      | Stadtwerke<br>Düsseldorf                     |               | Oil                                      | 125                           | 0              |               |
| Flingern III             | Düsseldorf      | Stadtwerke<br>Düsseldorf                     |               | Oil                                      | 87.6                          | 0              |               |
| Kavernwerk<br>Säcklingen | Freiburg        | Schluchsee-<br>Werk AG<br>Freiburg           |               | Hydro                                    | 360                           | 0              |               |

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

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

Table 9.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u>                    | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>   |
|--------------------------|-----------------|----------------------------------------------|---------------|------------------------------------------|-------------------------------|----------------|--------------|
| Erzhausen                | Hannover        | Pruesenelektra<br>u. wasserkraft-<br>anlagen |               | Hydro                                    | 220                           | 0              |              |
| Witznau                  | Frieburg        | Schluchseewerk                               |               | Hydro                                    | 190                           | 0              |              |
| Eappurg                  | Nurnberg        | Groskraftwerk<br>Franken AG                  |               | Hydro                                    | 160                           | 0              |              |
| Eönkhausen               | Hagen           | ELECTROMARK                                  |               | Hydro                                    | 140                           | 0              | 1968<br>(70) |
| Waldeck                  | Hannover        | Preusenelektra                               |               | Hydro                                    | 140                           | 0              |              |
| Waldeck II               | Hannover        | Preusenelektra                               |               | Hydro                                    | 440                           | 0              | 1975         |
| Waldshut                 | Freiburg        | Schluchseewerk                               |               | Hydro                                    | 140                           | 0              |              |
| Koepchenwerk             | Essen           | RWE                                          |               | Hydro                                    | 132                           | 0              |              |
| Jochenstein              | Passau          | Donaukraftwerk<br>Jochenstein AG             |               | Hydro                                    | 132                           | 0              |              |
| Geesthacht               | Hamburg         | HEW                                          |               | Hydro                                    | 120                           | 0              |              |
| Walchensee-<br>werk      | Munich          | Bayernwerk AG                                |               | Hydro                                    | 114                           | 0              |              |

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

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

Table 9.6.1 (Continued)

| <u>Facility Name</u>   | <u>Location</u> | <u>Utility/<br/>Owner</u>            | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|------------------------|-----------------|--------------------------------------|---------------|------------------------------------------|-------------------------------|----------------|------------|
| Häusern                | Freiburg        | Schluchseewerk                       |               | Hydro                                    | 110                           | O              |            |
| Ryberg-<br>Schwörstadt | Rheinfelden     | Kraftwerk<br>Ryburg Schwör-<br>Stadt |               | Hydro                                    | 108                           | O              |            |
| Mehrum                 |                 |                                      |               | Coal/Oil                                 | 650                           | P              | 1979       |
| Schloven-Buer          |                 |                                      |               | Coal                                     | 687                           | P              | 1979       |
| Bremen-Hafen           |                 |                                      |               | Coal                                     | 300                           | P              | 1979       |
| Spandau 1              |                 |                                      |               | Coal                                     | 300                           | P              | 1980       |
| Bergkamen              |                 |                                      |               | Coal                                     | 687                           | P              | 1981       |
| Spandau 2              |                 |                                      |               | Coal                                     | 300                           | P              | 1982       |
| Gersteinwerk           |                 |                                      |               | Coal                                     | 660                           | P              | 1982       |
| Wehr                   |                 |                                      |               | P.S.<br>Hydro                            | 235                           | O              | 1976       |
| Langenproz<br>Elten    |                 |                                      |               | P.S.<br>Hydro                            | 150                           | O              | 1976       |

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

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 9.6.2

| <u>Year</u> | <u>Capacity - MWe(net)</u> |
|-------------|----------------------------|
| 1975        | 74,356                     |
| 1980        | 92,044                     |
| 1985        |                            |
| 1990        |                            |
| 1995        |                            |
| 2000        |                            |



LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 9.6.3

| <u>Facility Name</u> | <u>Location</u> | <u>Owner</u> | <u>Facility Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|----------------------|-----------------|--------------|----------------------|-------------------|----------------|
|                      | Ruhr            |              | Hard Coal Mines      | 72.80             |                |
|                      | Saar            |              | Hard Coal Mines      | 9.29              |                |
|                      | Aachen          |              | Hard Coal Mines      | 5.38              |                |
|                      | Niedersachsen   |              | Hard Coal Mines      | 1.80              |                |
|                      | Rheinland       |              | Lignite Mines        | 119.10            |                |
|                      | Helmstadt       |              | Lignite Mines        | 4.58              |                |
|                      | Hessen          |              | Lignite Mines        | 2.93              |                |
|                      | Bayern          |              | Lignite Mines        | 7.93              |                |
| Arlesried            | Bavaria         |              | Oil Field            | 1,617             | 0              |
| Darching             | Bavaria         |              | Oil Field            | 348               | 0              |

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

\*\* Coal - Million Tonnes/year; Oil- Barrels/day; Natural Gas - km<sup>3</sup>/year

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 9.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>    | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|--------------------|--------------|--------------------------|-------------------|----------------|
| Moenchsrot               | Bavaria            |              | Oil Field                | 826               | 0              |
| Others                   | Bavaria            |              | Oil Field                | 1,588             | 0              |
| Emlichheim               | Emsland            |              | Oil Field                | 3,460             | 0              |
| Geogsdorf                | Emsland            |              | Oil Field                | 8,104             | 0              |
| Meppen-Schwefingen       | Emsland            |              | Oil Field                | 1,333             | 0              |
| Ruehlermoor              | Emsland            |              | Oil Field                | 1,333             | 0              |
| Ruehlertwist             | Emsland            |              | Oil Field                | 1,667             | 0              |
| Scheerhorn               | Emsland            |              | Oil Field                | 5,207             | 0              |
| Others                   |                    |              | Oil Field                | 1,872             | 0              |
| Ploen Ost                | Schleswig-Holstein |              | Oil Field                | 4,808             | 0              |
| Preetz                   | Schleswig-Holstein |              | Oil Field                | 780               | 0              |
| Reitbrook                | Schleswig-Holstein |              | Oil Field                | 1,660             | 0              |

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

\*\* Oil - Barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 9.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>    | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|--------------------|--------------|--------------------------|-------------------|----------------|
| Others                   | Schleswig-Holstein |              | Oil Field                | 1,733             | O              |
| Eldingen                 | Hanover            |              | Oil Field                | 1,192             | O              |
| Hanbensbuettel           | Hanover            |              | Oil Field                | 7,151             | O              |
| Hardesse                 | Hanover            |              | Oil Field                | 2,405             | O              |
| Hohne                    | Hanover            |              | Oil Field                | 1,355             | O              |
| Knessebeck               | Hanover            |              | Oil Field                | 1,711             | O              |
| Leiferde                 | Hanover            |              | Oil Field                | 1,336             | O              |
| Leuben                   | Hanover            |              | Oil Field                | 846               | O              |
| Meckelfeld               | Hanover            |              | Oil Field                | 829               | O              |
| Neinhagen-Haenigsen      | Hanover            |              | Oil Field                | 668               | O              |
| Oelheim-Sued             | Hanover            |              | Oil Field                | 1,092             | O              |
| Oerrel-Wesendorf         | Hanover            |              | Oil Field                | 1,101             | O              |

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

\*\* Oil - Barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 9.6.3

| <u>Facility<br/>Name</u> | <u>Location</u>    | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|--------------------|--------------|--------------------------|-------------------|----------------|
| Ruehme                   | Hanover            |              | Oil Field                | 974               | 0              |
| Sinstorf                 | Hanover            |              | Oil Field                | 1,489             | 0              |
| Suderbruch               | Hanover            |              | Oil Field                | 751               | 0              |
| Vorhop                   | Hanover            |              | Oil Field                | 1,369             | 0              |
| Others                   | Hanover            |              | Oil Field                | 3,923             | 0              |
| Landau                   | Upper Rhine Valley |              | Oil Field                | 2,220             | 0              |
| Others                   | Upper Rhine Valley |              | Oil Field                | 242               | 0              |
| Barensburg               | Weser-Ems          |              | Oil Field                | 2,665             | 0              |
| Bockstedt                | Weser-Ems          |              | Oil Field                | 1,868             | 0              |
| Bramberge                | Weser-Ems          |              | Oil Field                | 13,934            | 0              |
| Dueste                   | Weser-Ems          |              | Oil Field                | 1,957             | 0              |
| Gross-Lessen             | Weser-Ems          |              | Oil Field                | 4,651             | 0              |

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

\*\* Oil - Barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIFELY PLANNED

Table 9.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u>                  | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|----------------------------------|--------------|--------------------------|-------------------|----------------|
| Sued-Oldenburg           | Weser-Ems                        |              | Oil Field                | 1,563             | 0              |
| Voigtei                  | Weser-Ems                        |              | Oil Field                | 1,135             | 0              |
| Wehrbleck                | Weser-Ems                        |              | Oil Field                | 1,262             | 0              |
| Others                   | Weser-Ems                        |              | Oil Field                | 3,621             | 0              |
|                          | Between Elbe and<br>Weser Rivers |              | Gas Field                | 0.335             | 0              |
| Schlochteren             | Between Weser and Ems<br>Rivers  |              | Gas Field                | 12.1              | 0              |
| Groningen                | Mouth of Ems River               |              | Gas Field                | 2.97              | 0              |
|                          | West of Ems River                |              | Gas Field                | 1.7               | 0              |
|                          | Alpine Foreland                  |              | Gas Field                | 0.76              | 0              |

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

\*\* Oil - Barrels/day; Natural Gas - km<sup>3</sup>/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 9.6.4

| <u>RESOURCE</u>                                                | <u>1985</u> | <u>2000</u> |
|----------------------------------------------------------------|-------------|-------------|
| <u>COAL</u> (million tonnes)                                   |             |             |
| Indigenous Supply                                              | 229.6       | 237.3       |
| Imports                                                        | --          | --          |
| Exports                                                        | 125.5       | 134.3       |
| <br><u>CRUDE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                              | 2.79        | 0.12        |
| Imports                                                        | 144.31      | 176.48      |
| Exports                                                        | --          | --          |
| <br><u>SHALE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                              | 0           | 0           |
| Imports                                                        |             |             |
| Exports                                                        |             |             |
| <br><u>NATURAL GAS</u> (cubic kilometers)                      |             |             |
| Indigenous Supply                                              | 19.08       | 2.28        |
| Imports                                                        | 43.12       | 62.42       |
| Exports                                                        | --          | --          |
| <br><u>URANIUM</u> (kilotonnes U <sub>3</sub> O <sub>8</sub> ) |             |             |
| Indigenous Supply                                              | .24         | .35         |
| Imports                                                        | 4.38        | 10.64       |
| Exports                                                        | 0           | 0           |

SECTION 10

FINLAND

## 10.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

### INDIGENOUS RESOURCES

Finland has no high grade fossil reserves. The figures quoted in Table 10.1.1 are for peat and are taken from the World Energy Conference Survey (ref. 1.2). Figures for other indigenous sources such as wood and industrial wastes are not available and their supply cannot be substantially increased. Peat can be exploited more intensively but its share in the total supply of energy is expected to remain small because the high cost of transportation and storage makes it economical only for local power plants.

All important sources of hydro-electric power have been harnessed and scope in this direction is therefore limited.

No geothermal or solar energy contribution is currently available or anticipated.

Small amounts of uranium reserves exist in Finland. Additional resources are possible but have not been verified by exploration.

### ENERGY SUPPLY

Solid fuel production in Finland consists entirely of peat. The quantity is given as 0.726 million tonnes (ref. 1.2) and 0.782 million tonnes (ref. 1.6). A significant percentage of indigenous energy supply results from the use of wood, liquor and waste material. This has also been included under "other fuels" in Table 10.1.2. Imports of hard coal amount to 4.646 million tonnes (ref. 1.5), 4.1 million tonnes (ref. 1.6).

No internal production of crude oil takes place, the import level being 9.622 million tonnes (ref. 1.5) and 9.81 million tonnes (ref. 1.6).

Natural gas imports were 0.73 km<sup>3</sup> in 1975 (ref. 1.5).

### PATTERNS OF ENERGY USE

Solid fuels are consumed in all sectors (except transportation), a large proportion of which is peat and wood.

Imported natural gas is used almost entirely by industry with a small percentage going to the power stations.

Industry and households are the major consumers of electricity of which approximately 33% is hydraulically generated.



## FORECASTS OF ENERGY SUPPLY AND DEMAND

Energy demand in Finland is expected to grow at an average annual rate of 1.5% to 3.3% over the period 1975-1981 while electricity demand is expected to grow by an average of 2.6% to 4.5% per year. The total forecast energy consumption figures given in Table 10.1.4 which range from  $857 \times 10^{12}$  BtU to  $1,019 \times 10^{12}$  BtU are considerably below the  $1,273 \times 10^{12}$  BtU figure put forward by the Finnish Energy Policy Commission (ref. 1.30). The Workshop on Alternative Energy Strategies (ref. 1.14) also forecasts a higher 1985 primary energy demand of  $1,132 \times 10^{12}$  BtU to  $1,407 \times 10^{12}$  BtU and an electricity demand of between 45.9 and 60.0 TWh.

The breakdown of primary energy demand into sources of supply is shown in Table 10.1.5 and correspond to the medium economic growth forecast shown in Table 10.1.4. Reference 1.30 includes an estimate of the percentage share of each energy source in the total energy supply for 1985 and the trends identified have been projected to produce the 2000 breakdown. Savings in fossil fuel consumption are aided by the import of electricity from USSR which in 2000 will supply almost 8% of the primary energy needs, but the expansion of nuclear generating capacity to perhaps 6000 MW by 2000 represents the most important new source of energy.

# INDIGENOUS ENERGY RESOURCES

Table 10.1.1

|                                     | Economically<br>Recoverable Reserves | Total Indigenous<br>Resources | Location of<br>Identified Reserves |
|-------------------------------------|--------------------------------------|-------------------------------|------------------------------------|
| Hard Coal (million tonnes)          | 0                                    | 0                             | -                                  |
| Soft Coal (million tonnes)          | 0                                    | 0                             | -                                  |
| Peat (million tonnes)               | 2,340                                | 18,000                        | Dispersed                          |
| Crude Oil (million tonnes)          | 0                                    | 0                             | -                                  |
| Shale Oil (million tonnes)          | 0                                    | 0                             | -                                  |
| Natural Gas (cubic km)              | Not Available                        | Not Available                 |                                    |
| Uranium (thousand tonnes $U_3O_8$ ) | 3.8                                  | Unknown                       | Kolari,<br>Paltamo                 |
| Hydro Power (TWh/year)              | 11.8                                 | 28.0                          | Kemijoki                           |
| Geothermal (TWh/year)               | 0                                    | 0                             |                                    |

ENERGY SUPPLY 1975

Table 10.1.2

| Resource                               | Indigenous<br>Supply | Imports |           | Exports |         |
|----------------------------------------|----------------------|---------|-----------|---------|---------|
|                                        |                      | Total   | % from US | Total   | % to US |
| Hard Coal (million tonnes)             | 0                    | 4.649   | 0         | 0       | 0       |
| Soft Coal (million tonnes)             | 0                    | 0       | 0         | 0       | 0       |
| Other Fuels                            | 4.98*                |         |           |         |         |
| Crude Oil (million tonnes)             | 0                    | 9.622   | 0         | 0       | 0       |
| Shale Oil (million tonnes)             | 0                    | 0       | 0         | 0       | 0       |
| Natural Gas (cubic km)                 | 0                    | 0.73    | 0         | 0       | 0       |
| Uranium (thousand tonnes $U_{38}O_8$ ) | 0                    | --      | 0         | 0       | 0       |
| Electricity (TWh)                      | 25.56                | 4.16    | 0         | 0.16    | 0       |

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 10.1.3

| Resource                                 | Consuming Sector            |            |                |                          | Total |
|------------------------------------------|-----------------------------|------------|----------------|--------------------------|-------|
|                                          | Household and<br>Commercial | Industrial | Transportation | Electrical<br>Generation |       |
| Coal*(million tonnes)                    | 2.61                        | 3.77       | 0              | 3.26                     | 9.64  |
| Petroleum (million tonnes)               | 3.41                        | 2.95       | 2.64           | 0.98                     | 9.98  |
| Natural Gas (cubic km)                   | 0                           | 0.63       | 0              | 0.042                    | 0.67  |
| Nuclear Power (TWh)                      | -                           | -          | -              | 0                        | 0     |
| Hydro Power (TWh)                        | -                           | -          | -              | 12.19                    | 12.19 |
| Geothermal Power (TWh)                   | -                           | -          | -              | 0                        | 0     |
| Utility Electricity<br>Distributed (TWh) | 10.23                       | 16.86      | 0.12           | 3.37                     | 30.58 |

\* Peat and wood have been included by reduction to a hard-coal equivalent

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 10.1.4

FINLAND-6

| Year | Low Economic Growth<br>2.0%                       |                      | Medium Economic Growth<br>3.0%                    |                      | High Economic Growth<br>4.0%                      |                      |
|------|---------------------------------------------------|----------------------|---------------------------------------------------|----------------------|---------------------------------------------------|----------------------|
|      | Total Primary<br>Energy<br>(10 <sup>12</sup> BtU) | Electricity<br>(TWh) | Total Primary<br>Energy<br>(10 <sup>12</sup> BtU) | Electricity<br>(TWh) | Total Primary<br>Energy<br>(10 <sup>12</sup> BtU) | Electricity<br>(TWh) |
| 1975 | 768                                               | 25.6                 | 768                                               | 25.6                 | 768                                               | 25.6                 |
| 1985 | 857                                               | 33.5                 | 934                                               | 42.2                 | 1,019                                             | 46.2                 |
| 2000 | 1,105                                             | 50.8                 | 1,384                                             | 63.8                 | 1,736                                             | 79.9                 |

# CONSUMPTION OF ENERGY RESOURCES

Table 10.1.5

| Resource             | Standard Unit                                 | Annual Consumption of<br>Standard Units |      |      | Energy Consumption<br>(10 <sup>12</sup> BtU) |      |      |
|----------------------|-----------------------------------------------|-----------------------------------------|------|------|----------------------------------------------|------|------|
|                      |                                               | 1975                                    | 1985 | 2000 | 1975                                         | 1985 | 2000 |
| Coal                 | Million Tonnes                                | 3.69                                    | 2.4  | 2.4  | 102.5                                        | 68   | 66   |
| Crude Oil            | Million Tonnes                                | 10.39                                   | 11.9 | 15.7 | 347.1                                        | 399  | 525  |
| Natural Gas          | Cubic km                                      | 0.76                                    | 0.9  | 1.1  | 27.4                                         | 34   | 39   |
| Other Fuels*         | Million Tonnes<br>Coal Equivalent             | 4.98                                    | 5.0  | 5.1  | 138.4                                        | 140  | 142  |
| Hydro Power          | TWh                                           | 12.19                                   | 12.3 | 12.3 | 138.6                                        | 140  | 140  |
| Imported Electricity | TWh                                           | 4.16                                    | 2.2  | 9.2  | 14.3                                         | 25   | 105  |
| Other Renewables     | IWh                                           | -                                       | -    | -    | -                                            | -    | -    |
| Nuclear Power        | IWh                                           | 0                                       | 11.3 | 32.3 | 0                                            | 128  | 367  |
| Uranium              | Thousand Tonnes U <sub>3</sub> O <sub>8</sub> | -                                       | 0.90 | 1.38 | -                                            | -    | -    |

\* Wood, peat, waste products and blast furnace gas

## 10.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

### COMMERCIAL NUCLEAR POWER PLANTS

Table 10.2.1

| Facility<br>Name | Utility                  | Vendor     | Facility<br>Type | Capacity<br>(MWe net) | Status* | CON      |
|------------------|--------------------------|------------|------------------|-----------------------|---------|----------|
| Loviisa-1        | Imatran Voima<br>Oy      | TEE (USSR) | PWR              | 420                   | O       | May 1977 |
| Loviisa-2        | Imatran Voima<br>Oy      | TEE (USSR) | PWR              | 420                   | U       | May 1979 |
| Okiluoto-1       | Teollisuuden<br>Voima Oy | Asea-Atom  | BWR              | 660                   | U       | Apr 1979 |
| Okiluoto-2       | Teollisuuden<br>Voima Oy | Asea-Atom  | BWR              | 660                   | U       | Aug 1980 |

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

PROJECTED NUCLEAR GENERATING CAPACITY  
MWe (net)

Table 10.2.2

| Year     | PWR  | BWR | Magnox | AGR | CANDU | Other | FBR | Firm +<br>Planned<br>Cumulative<br>Total | NAC<br>Cumulative<br>Projection |
|----------|------|-----|--------|-----|-------|-------|-----|------------------------------------------|---------------------------------|
| pre-1978 | 420  |     |        |     |       |       |     | 420                                      | 420                             |
| 1978     |      |     |        |     |       |       |     | 420                                      | 420                             |
| 1979     | 420  | 660 |        |     |       |       |     | 1500                                     | 1500                            |
| 1980     |      | 660 |        |     |       |       |     | 2160                                     | 2160                            |
| 1981     |      |     |        |     |       |       |     | 2160                                     | 2160                            |
| 1982     |      |     |        |     |       |       |     | 2160                                     | 2160                            |
| 1983     |      |     |        |     |       |       |     | 2160                                     | 2160                            |
| 1984     |      |     |        |     |       |       |     | 2160                                     | 2160                            |
| 1985     |      |     |        |     |       |       |     | 2160                                     | 2160                            |
| 1986     |      |     |        |     |       |       |     | 2160                                     | 3160                            |
| 1987     | 1000 |     |        |     |       |       |     | 2160                                     | 3160                            |
| 1988     |      |     |        |     |       |       |     | 2160                                     | 3160                            |
| 1989     |      |     |        |     |       |       |     | 2160                                     | 3160                            |
| 1990     |      |     |        |     |       |       |     | 2160                                     | 3160                            |
| 1991     |      |     |        |     |       |       |     | 2160                                     | 3160                            |
| 1992     | 500  | 500 |        |     |       |       |     | 2160                                     | 4160                            |
| 1993     |      |     |        |     |       |       |     | 2160                                     | 4160                            |
| 1994     | 500  | 500 |        |     |       |       |     | 2160                                     | 5160                            |
| 1995     |      |     |        |     |       |       |     | 2160                                     | 5160                            |
| 1996     |      |     |        |     |       |       |     | 2160                                     | 5160                            |
| 1997     |      |     |        |     |       |       |     | 2160                                     | 5160                            |
| 1998     | 500  | 500 |        |     |       |       |     | 2160                                     | 6160                            |
| 1999     |      |     |        |     |       |       |     | 2160                                     | 6160                            |
| 2000     |      |     |        |     |       |       |     | 2160                                     | 6160                            |



## NUCLEAR REACTOR VENDORS

### Overview

No nuclear reactor vendors exist in Finland or are planned.

### Nuclear Reactor Vendor Support Industries

Finnish industry is able to supply a reasonable wide range of components and equipment for nuclear reactors. Most of the more important suppliers collaborate within the Finnatom organization. Currently none of the major components can be domestically supplied and there are no plans to set up facilities for their manufacture.

## NUCLEAR FUEL CYCLE FACILITIES

### Overview

Finland possesses no nuclear fuel cycle facilities and none are currently planned.

## NUCLEAR FUEL CYCLE FACILITIES

### Vested Interests in Current Fuel Cycles and Reactor Technologies

Since there are no reactor vendors in Finland there is not a major vested interest in current reactor technology. In addition, there is no capability to supply major components. There exists an indirect interest in the LWR fuel cycle since the two Loviisa units purchased from the USSR include 20 years of enriched uranium supply for each reactor as well as reprocessing services.

### Current Trends in Nuclear Development Programs

Finland has no plans to independently develop nuclear power systems. It will continue to rely on nuclear power plants purchased abroad. Because of political considerations and close economic relationships it is likely that future purchases will also favor Swedish and USSR suppliers although the new 1,000 MWe Soviet plant being offered for the next unit is not currently regarded as having proven reliability by the utilities.

### 10.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

#### PROFESSIONAL LABOR FORCE PROFILE

Table 10.3.1

Available information presents the following data for 1973:

196,340 Scientists and Engineers  
11,819 Scientists and Engineers  
engaged in R&D

#### KEY TECHNICAL EDUCATIONAL RESOURCES

Table 10.3.2

| <u>Institution</u>                | <u>Location</u>    |
|-----------------------------------|--------------------|
| Abo Academy                       | Abo                |
| College of Joensuu                | Joensuu            |
| University of Jyvaskyla           | Jyvaskyla          |
| University of Turku               | Turku              |
| Helsinki University of Technology | Otaniemi, Helsinki |
| University of Helsinki            | Helsinki           |

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 10.3.3

| <u>Name</u>                    | <u>Location</u> | <u>Main Activities</u>                    |
|--------------------------------|-----------------|-------------------------------------------|
| Ministry of Trade and Industry | Helsinki        | responsible for funding research projects |
| Atomic Energy Commission       | Helsinki        | advises on nuclear affairs                |

Nuclear research is primarily carried out in the universities or industrial laboratories.

KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 10.3.4

| <u>Name</u>                                                                                                                                                        | <u>Owner</u> | <u>Location</u> | <u>Main Activities</u>                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|-----------------|------------------------------------------------------------------------------------------|
| Confederation of<br>Finnish Industry                                                                                                                               |              |                 | central organization<br>which deals with energy<br>R&D within industry                   |
| Finnish Industrial<br>Power Company                                                                                                                                |              |                 | electrical supply R&D<br>including nuclear.                                              |
| Finnatom<br>A. Ahlstrom Osakeyhtio<br>Oy Nokia Ab<br>Rauma-Repola Oy<br>W. Rosenlew an Co., OY<br>OY Stromberg AB<br>OY Tampelle AB<br>Valmet OY<br>OY Wartsila AB |              | Helsinki        | members of Finnatom<br>manufacture reactor<br>components and carry<br>out supporting R&D |

RESEARCH AND TEST REACTORS  
List of Reactors

Table 10.3.5

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Owner</u>                            | <u>Constructor</u> | <u>Facility<br/>Type</u> | <u>Facility Status</u> |                |            |
|--------------------------|-----------------|-----------------------------------------|--------------------|--------------------------|------------------------|----------------|------------|
|                          |                 |                                         |                    |                          | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u> |
| FIR                      | Helsinki        | Ministry of<br>Commerce and<br>Industry | 3A                 | Triga<br>MK II           | 250Kw                  | 0              | 3/62       |

\* 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 10.3.6

| <u>Vendor</u> | <u>Country</u> | <u>Facility<br/>Name</u> | <u>Facility<br/>Type</u> | <u>Facility Status</u> |                |            | <u>Scope of<br/>Services</u> |
|---------------|----------------|--------------------------|--------------------------|------------------------|----------------|------------|------------------------------|
|               |                |                          |                          | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u> |                              |

Members of the OY FINNATOM AB have supplied equipment for the Finnish subcritical assembly and the FIR research reactor.

FINLAND-17

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



SUMMARY OF FJEL SERVICES FOR RESEARCH AND TEST REACTORS

Table 10.3.7

| <u>Facility</u><br><u>Name</u> | <u>Location</u> | <u>Facility</u><br><u>Type</u> | <u>Capacity</u> <u>Status</u> |                |             |                      |
|--------------------------------|-----------------|--------------------------------|-------------------------------|----------------|-------------|----------------------|
|                                |                 |                                | <u>MT/YR</u>                  | <u>Status*</u> | <u>Year</u> | <u>Shareholdings</u> |

Not Applicable

FINLAND-18

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

#### 10.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

##### ECONOMIC DATA PROFILE

Table 10.4.1

|                          |                 |                        |                |
|--------------------------|-----------------|------------------------|----------------|
| GDP (Current million \$) | - 29,868 (1977) | Inflation Rate         | - 12.6% (1977) |
| Exports (million \$)     | - 7,677 (1977)  | Imports (million \$)   | - 7,622 (1977) |
| Per Capita Income (\$)   | - 6,305 (1977)  | Disposable Income (\$) | - 5,030 (1975) |
| Monetary Unit            | - Finnmark      | Exchange Rate (/US\$)  | - 4.20 (1977)  |
| Population (million)     | - 4.73 (1976)   |                        |                |

#### 10.4.2 GOVERNMENT NUCLEAR ENERGY R&D BUDGET

|                     |                                 |
|---------------------|---------------------------------|
|                     | <u>\$(1,000)</u><br><u>1976</u> |
| Basic Research      | 473                             |
| Safety              | 853                             |
| Siting              | 1,132                           |
| Domestic Fuel       | 105                             |
| Industrial Research | 784                             |

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

Table 10.4.3

| <u>Industry<br/>University or<br/>Laboratory</u>                             | <u>Program<br/>Area</u>                                                                                      | <u>Budget<br/>\$ (Millions)</u> | <u>Key<br/>Personnel</u>                        |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|---------------------------------|-------------------------------------------------|
| Radiation Physics<br>Laboratory                                              | Theoretical and<br>experimental reactor<br>studies, reactor<br>kinetics, reactor<br>simulators,<br>dosimetry | -                               | -                                               |
| Institute of Radiation<br>Physics                                            | Environmental<br>activity, radiation<br>protection, dosimetry                                                | -                               | K. Salimati,<br>Director                        |
| Accelerator Laboratory<br>Radiochemistry Depart-<br>ment Radiotherapy Clinic | Nuclear-spectroscopy<br>theoretical work<br>on nuclear structure                                             | -                               | L. Simons,<br>Director                          |
| State Institute for<br>Technical Research                                    | Design of special<br>instruments based on<br>physical phenomena                                              | -                               | E. Laurila,<br>Director                         |
| Helsinki University<br>Dept. of Physics                                      | Experimental nuclear<br>physics, especially<br>nuclear spectroscopy                                          | -                               | P. E. Tahvonen<br>Director                      |
| Dept. of Nuclear<br>Physics                                                  | Nuclear models,<br>elementary particles                                                                      | -                               | K. Laurikainen,<br>Director                     |
| Research Institute<br>for Theoretical<br>Physics                             | Nuclear structure,<br>nuclear matter, elemen-<br>tary particles                                              | -                               | U. Ambegaokar,<br>Director                      |
| Oulu University                                                              | Radioactivity, Autoradio-<br>graphy                                                                          | -                               | Sakari Piha,<br>Chairman                        |
| Technical University<br>of Helsinki                                          | Neutron diffraction,<br>reactor kinetics,<br>isotopes, spectroscopy                                          | -                               | Prof. O. Lokki,<br>Head of Technical<br>Physics |
| Turku University<br>Wihuri Physical Lab                                      | Nuclear magnetic resonance<br>at low temperatures,<br>elementary particles                                   | -                               | Prof. U. Hovi<br>Head                           |

#### 10.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

Private industry plays an important role in Finnish nuclear research. In general the research is directed towards practical or commercial application of Finnish industrial capability.

The important groups are:

- Confederation of Finnish Industry
- Atomic Energy Limited
- Finnish Industrial Power Company
- Finnish Nuclear Society
- OY FINNATOM AB

#### ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 10.4.5

| <u>Name</u>    | <u>Share Capital</u> | <u>Assets</u> | <u>Sales</u> |
|----------------|----------------------|---------------|--------------|
| Not Applicable |                      |               |              |

#### 10.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Finland financed the USSR supplied Loviisa reactors through its clearing arrangements with the USSR.

The Finnish electrical power utility, TVO, has, in 1978, offered a \$25 million bond issue, the proceeds from which will be used to finance construction of two nuclear plants on the coast of Finland.

## 10.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

### 10.5.1 ENERGY POLICY - BASIC LEGISLATION

Laws that are known to apply to nuclear energy are:

- Law on Atomic Energy
- Law on Radiation Protection
- Water Law
- Law on Electricity

### 10.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

Under the Finnish Constitution, political power is divided between the Parliament and the President of the Republic, with substantial powers reserved to the President.

LEGISLATIVE-a unicameral Parliament consisting of 200 members is the supreme authority in Finland. Legislation may be initiated by any member of Parliament as well as the President or the Council of State.

EXECUTIVE-power is vested in the President (Urho K. Kekkonen) who handled foreign policy, except for certain international agreements and decisions of war or peace that must be submitted to Parliament; is Commander in Chief of the armed forces and has wide decree and appointive powers. Executive power is exercised by the Council of State (Cabinet) which is made up of the Prime Minister (Martti Miettunen) and Ministers for the various departments of the central government.

Main responsibility for the Finnish energy program lies with the Ministry of Trade and Industry (Arne Berner, Minister). Within the Ministry, the Energy Department (Erkki Vaara, Director) is responsible for the development of energy policy and energy R&D.

#### OTHER PARTS OF THE ENERGY STRUCTURE

1. Ministry for Foreign Affairs, Political Division (Jussi Makinen, Head of Dept.) is charged with nuclear affairs.
2. Atomic Energy Commission (Erkki Laurila, Chairman) acts as an advisory body to the Ministry of Trade and Industry in matters relating to the atomic energy program and nuclear safety.
3. Energy Policy Advisory Committee, which is chaired by the Minister of Trade and Industry, reports to the Council of State.

### 10.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

|                                                      |                                                |
|------------------------------------------------------|------------------------------------------------|
| Council of State                                     | Martti Miettunen, Prime Minister               |
| Ministry of Trade and<br>Industry, Energy Department | Arne Berner, Minister<br>Erkki Vaara, Director |
| Ministry for Foreign Affairs,<br>Political Division  | Jussi Makinen, Head of Department.             |
| Atomic Energy Commission                             | Erkki Laurila, Chairman                        |
| Energy Policy Advisory<br>Committee                  | Arne Berner, Chairman                          |

### 10.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

The Finnish Energy Policy Commission, established as a permanent body to help create uniform and rational energy policy, performed a comprehensive energy analysis during 1976. On the basis of that work, the report "Guidelines for the Finnish Energy Policy in 1976-1985" was published in April 1977.

The aim of Finnish energy policy is to curb the rate of increase of energy imports. Efforts to attain this goal focus on energy conservation and the introduction of nuclear power.

The report recommended that a further study be undertaken to evaluate the problems, management, and financing of emergency nuclear fuel stockpiles - enriched and/or natural uraniums.

The report also urged delay (1-2 years) on any decision regarding future nuclear installations.

#### 10.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

Loviisa I, a Soviet engineered nuclear plant of 420 MW capacity began operation in 1977. The twin plant Loviisa II, also Soviet engineered, is under construction and is expected to be completed in 1979. Also under construction is a 660 MW plant being built with help from Sweden. Finnish industry has provided (and intend to continue to) heavy equipment and engineered structures for Finnish nuclear plants. Finland is designing and constructing an emergency cooling system for a plant the Soviet Union is building for Libya.

#### 10.5.6 NUCLEAR ENERGY R&D - PRIORITIES

Finnish energy R&D priorities are largely focused on nuclear energy. More than three-fourths of the 1976 Government funds for energy R&D activities are associated with the peaceful use of nuclear energy. Over half of those funds are devoted to plant siting.

#### 10.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

The utilities are state-owned companies; therefore, the government is, in essence, deeply involved in the planning, choice of vendors permitted to bid as well as of specific vendor, construction and operation. In addition, the government provides regulatory permits. (Institute for Radiation Protection gives clearance to go to 100% power.)

10.6

NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY



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

Table 10.6.1

| <u>Facility Name</u> | <u>Location</u>  | <u>Utility/ Owner</u>  | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------|------------------|------------------------|---------------|----------------------------------|---------------------------|----------------|------------|
| Imatra               |                  | Inatra Power Company   |               | Hydro                            | 156                       | 0              |            |
| Inkoo 1-3            | West of Helsinki | Inatra PC              |               | Coal                             | 750                       | 0              | 1976       |
| Naantali             | Pori             | Inatra PC              |               | Thermal                          | 375                       | 0              |            |
| Huutokoski           |                  | Inatra PC              |               | Gas                              | 180                       | 0              |            |
| Inkoo IV             | West of Helsinki | Inatra PC              |               | Coal                             | 250                       | U              |            |
| Taivalkoski          | Oulu             | Kemijoki PC            |               |                                  | 115                       | 0              |            |
| Petajaskoski         |                  | Kemijoki PC            |               |                                  | 115                       | 0              |            |
| Pirttikoski          |                  | Kemijoki PC            |               |                                  | 127                       | 0              |            |
| Seitakorva           |                  | Kemijoki PC            |               |                                  | 100                       | 0              |            |
| Pyhakoski            |                  | Oulujoki Power Company |               |                                  | 120                       |                |            |
| Lahti                | Hame             | Imatran                |               | Oil                              | 140                       | 0              | 1976       |
| Lappeenranta         | Helsinki         | Imatran                |               | Gas                              | (180)145                  | 0              | 1976       |
| Tahkoluoto           | Pori             |                        |               | Coal                             | 200                       | 0              | 1976       |

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

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 10.6.2

| <u>Year</u> | <u>Capacity - MWe(net)</u> |
|-------------|----------------------------|
| 1975        | 7,395                      |
| 1980        | 11,000                     |
| 1985        | 11,350                     |
| 1990        |                            |
| 1995        |                            |
| 2000        |                            |

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 10.6.3

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity</u> | <u>Status*</u> |
|--------------------------|-----------------|--------------|--------------------------|-----------------|----------------|
|--------------------------|-----------------|--------------|--------------------------|-----------------|----------------|

Not Applicable

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

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 10.6.4

| <u>RESOURCE</u>                                            | <u>1985</u> | <u>2000</u> |
|------------------------------------------------------------|-------------|-------------|
| <u>COAL</u> (million tonnes)                               |             |             |
| Indigenous Supply                                          | 6.41        | 6.94        |
| Imports                                                    | --          | --          |
| Exports                                                    | 4.01        | 4.54        |
| <u>CRUDE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                          | 0           | 0           |
| Imports                                                    | 11.9        | 15.7        |
| Exports                                                    | --          | --          |
| <u>SHALE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                          | 0           | 0           |
| Imports                                                    | 0.9         | 1.1         |
| Exports                                                    | --          | --          |
| <u>NATURAL GAS</u> (cubic kilometers)                      |             |             |
| Indigenous Supply                                          | 0           | 0           |
| Imports                                                    |             |             |
| Exports                                                    |             |             |
| <u>URANIUM</u> (kilotonnes U <sub>3</sub> O <sub>8</sub> ) |             |             |
| Indigenous Supply                                          | 0           | 0           |
| Imports                                                    | 0.90        | 1.38        |
| Exports                                                    | 0           | 0           |

SECTION 11

FRANCE

## 11.1 PROJECTED INDIGENOUS ENERGY RESOURCES, DEMANDS AND RELATED INFORMATION

### INDIGENOUS RESOURCES

Economically recoverable reserves of coal were stated as 458.0 million tonnes by the 1974 World Energy Conference (ref. 1.1, Appendix 2). The 1976 Survey increased this figure to 478 million tonnes (ref. 1.2, Appendix 2). Total indigenous resources increased from 1,407 million tonnes to 1,547 million tonnes over a two-year period due to the identification of additional resources. The Workshop on Alternative Energy Strategies (ref. 1.14) states recognized resources as 1,400 million tonnes with 800 million tonnes being economically recoverable. No clear definition of "economically recoverable" is given and the 1976 World Energy Survey figure has been taken.

The estimated quantity of crude oil in-place changed from 51.75 million tonnes (ref. 1.1, Appendix 3) to 52.8 million tonnes (ref. 1.2, Appendix 3). The resource is almost depleted and both the economically recoverable reserves and total indigenous resource values can be considered firm at 7.9 million tonnes.

Figures for shale oil are not available through the 1976 World Energy Survey. However, the 1974 World Energy Conference listed 237 million tonnes. Oil shale deposits are far from negligible but the environmental and financial impact are expected to contribute to postponing indefinitely the possible exploitation of this source.

Original gas in-place figures for France's natural gas were revised downwards from 327.0 km<sup>3</sup> in 1973 to 291.0 km<sup>3</sup> in 1975. This figure is more in line with the 260 km<sup>3</sup> given in reference 1.26. Proved recoverable reserves however have increased and it is now expected that all remaining of the 291.0 km<sup>3</sup> (i.e. 154 km<sup>3</sup>) can be recovered. No new resources have been identified.

Total indigenous uranium resources are about 113 thousand tonnes of U<sub>308</sub>, just over half of which is now considered economically recoverable.

Figures for hydro-power are taken from the World Energy Conference (ref. 1.2, Appendix 6). The Workshop on Alternative Energy Strategies (ref. 1.14) forecasts a production of 63 TWh by 1985, a figure that compares well with the economically recoverable reserve quoted in reference 1.2.

No figures are available for geothermal energy resources but they are expected to be very limited. Altogether new forms of energy represent only a few percent of French forecasts for 1985.

## ENERGY SUPPLY

The production of solid fuels in France in 1975 was 25.187 million tonnes (ref. 1.5). This figure compares well with that given in reference 1.6 (24.56 million tonnes). Reference 1.16 gives 22.7 million tonnes. Almost 50% of France's solid fuel requirements are imported (20 million tonnes, refs. 1.5 and 1.6). Poland, West Germany and the United States are the major sources of supply, the United States imports representing approximately 16% of the total.

Indigenous supply of crude oil is minimal (1.84 million tonnes, ref. 1.5, 1.97 million tonnes, ref. 1.6). This is to be expected bearing in mind the total reserve figure of 7.9 million tonnes. Imports amount to 106 million tonnes (refs. 1.5, 1.6) and have declined from 134.9 million tonnes in 1973. Major sources of supply are Africa and the Middle East. No oil is imported from the United States.

There is no shale oil production in France.

Production of natural gas has been steady for the period 1972-1975 at approximately 7.5 km<sup>3</sup> (ref. 1.5). Imports of 12.54 km<sup>3</sup> were required to meet the demand and these were secured principally from the Netherlands.

France has an active uranium industry, combining indigenous supply, import (primarily from Africa as U<sub>3</sub>O<sub>8</sub>) and export (primarily as enriched fuel in support of France reactor sales). A small portion (as enriched UF<sub>6</sub>) was imported from the United States.

## PATTERNS OF ENERGY USE

Industry and electrical generation represent the major sectoral demand for coal (ref. 1.6).

Petroleum is consumed in all sectors and there is a small net trade in this commodity (refs. 1.5, 1.6).

Natural gas is mainly used in the industrial and household sectors, though a significant quantity is consumed for electrical generation.

Industry and households represent the major consumers of electrical energy of which about 32% is hydraulically generated.

## FORECASTS OF ENERGY SUPPLY AND DEMAND

The energy demand forecasts for France shown in Table 11.1.4 indicate an average annual growth of total primary energy demand between 1975 and 2000 ranging from 1.8% to 3.6% and a growth of electricity demand in the same period from 3.8% to 6.7%.

Projections published by the Commission of the European Communities (ref. 1.16) forecast an energy demand of  $10,111 \times 10^{12}$  Btu (254 million tonnes oil equivalent) in 1985. The Workshop on Alternative Energy Strategies forecast a total primary energy demand of between  $7,000 \times 10^{12}$  Btu and  $9,800 \times 10^{12}$  Btu (ref. 1.14) for four different scenarios of energy conservation policy and energy prices. These forecasts cover the same range as those presented in Table 11.1.4.

The forecast breakdown of energy demand into its various sources of supply shown in Table 11.1.5 is in 1985 as presented by France to the CEC (ref. 1.16). Oil and coal are expected to continue to decline in relative importance after 1985 while the nuclear energy capacity will expand considerably. Hydro-power potential is almost fully exploited in France and there are no plans to expand the use of tidal power beyond the existing scheme at La Rance. Electricite de France are planning to develop a number of geothermal sites and it is expected that such installations could contribute approximately 1% of the total primary energy demand by 2000 (ref. 1.35).

France, as a matter of policy, is putting considerable emphasis upon nuclear energy. Installed capacity of nuclear power plants is expected to reach as much as 91,000 MW by 2000. For the higher economic growth scenario, the nuclear electricity demand in 2000 could be as high as 500 TWh.

Recent indications are that the French nuclear program is no more than about one year behind its stated schedule and that, partly in response to the situation in Iran and partly in response to the December 1978 electrical failure, the pace of the program is being accelerated further.



# INDIGENOUS ENERGY RESOURCES

Table 11.1.1

|                                                          | Economically<br>Recoverable Reserves | Total Indigenous<br>Resources | Location of<br>Identified Reserves                                |
|----------------------------------------------------------|--------------------------------------|-------------------------------|-------------------------------------------------------------------|
| Hard Coal (million tonnes)                               | 478                                  | 2,547                         | Nord, Lorraine,<br>Pas-de-Calais                                  |
| Soft Coal (million tonnes)                               | 0                                    | 0                             |                                                                   |
| Crude Oil (million tonnes)                               | 7.9                                  | 7.9                           | Aquitaine, Parentin,<br>Alsace                                    |
| Shale Oil (million tonnes)                               | Not Available                        | Not Available                 |                                                                   |
| Natural Gas (cubic km)                                   | 154                                  | 154                           | Aquitaine, Lacq                                                   |
| Uranium (thousand tonnes U <sub>3</sub> O <sub>8</sub> ) | 61.1                                 | 113.1                         | } Lozere, Cvense,<br>} Morbihan, Massif<br>} Central, Bretagne, * |
| Hydro Power (TWh/year)                                   | 61.9                                 | 270.0                         |                                                                   |
| Geothermal (TWh/year)                                    | 0                                    | 0                             | Melun                                                             |

\* Lodeve, Haute-Vienne, Cantal

# ENERGY SUPPLY 1975

Table 11.1.2

| Resource                                                 | Indigenous<br>Supply | Imports |           | Exports |         |
|----------------------------------------------------------|----------------------|---------|-----------|---------|---------|
|                                                          |                      | Total   | % from US | Total   | % to US |
| Hard Coal (million tonnes)                               | 25.187               | 20.072  | 16.39     | 1.212   | 0       |
| Soft Coal (million tonnes)                               | 0                    | 0       | 0         | 0       | 0       |
| Crude Oil (million tonnes)                               | 1.84                 | 105.994 | 0         | 0       | 0       |
| Shale Oil (million tonnes)                               | 0                    | 0       | 0         | 0       | 0       |
| Natural Gas (cubic km)                                   | 7.57                 | 12.54   | 0         | 0.1407  | 0       |
| Uranium (thousand tonnes U <sub>3</sub> O <sub>8</sub> ) | 2.0                  | 3.85    | 2.5       | 3.77    | 0       |
| Electricity (TWh)                                        | 178.51               | 8.69    | 0         | 6.27    | 0       |

PATTERNS OF ENERGY SOURCES AND USES 1975

Table 11.1.3

| Resource                                 | Consuming Sector            |            |                |                          | Total  |
|------------------------------------------|-----------------------------|------------|----------------|--------------------------|--------|
|                                          | Household and<br>Commercial | Industrial | Transportation | Electrical<br>Generation |        |
| Coal (million tonnes)                    | 6.64                        | 14.37      | 0.07           | 18.0                     | 39.08  |
| Petroleum (million tonnes)               | 27.75                       | 25.58      | 27.20          | 10.41                    | 90.94  |
| Natural Gas (cubic km)                   | 6.93                        | 7.32       | 0.01           | 2.98                     | 17.24  |
| Nuclear Power (TWh)                      | 0                           | 0          | 0              | 17.45                    | 17.45  |
| Hydro Power (TWh)                        | 0                           | 0          | 0              | 59.89                    | 59.89  |
| Geothermal Power (TWh)                   | 0                           | 0          | 0              | 0                        | 0      |
| Utility Electricity<br>Distributed (TWh) | 73.70                       | 81.96      | 6.16           | 22.43                    | 184.25 |

FORECASTS OF ANNUAL ENERGY DEMAND AND ELECTRICITY DEMAND

Table 11.1.4

| Year | Low Economic Growth<br>3.0%                       |                      | Medium Economic Growth<br>4.5%                    |                      | High Economic Growth<br>6.0%                      |                      |
|------|---------------------------------------------------|----------------------|---------------------------------------------------|----------------------|---------------------------------------------------|----------------------|
|      | Total Primary<br>Energy<br>(10 <sup>12</sup> Btu) | Electricity<br>(TWh) | Total Primary<br>Energy<br>(10 <sup>12</sup> Btu) | Electricity<br>(TWh) | Total Primary<br>Energy<br>(10 <sup>12</sup> Btu) | Electricity<br>(TWh) |
| 1975 | 6,422                                             | 178.5                | 6,422                                             | 178.5                | 6,422                                             | 178.5                |
| 1985 | 7,629                                             | 301.5                | 8,340                                             | 345.5                | 9,106                                             | 395.1                |
| 2000 | 10,028                                            | 457.7                | 12,532                                            | 643.2                | 15,611                                            | 899.5                |

# CONSUMPTION OF ENERGY RESOURCES

Table 11.1.5

| Resource         | Standard Unit                                 | Annual Consumption of<br>Standard Units |       |       | Energy Consumption<br>(10 <sup>12</sup> BtU) |      |      |
|------------------|-----------------------------------------------|-----------------------------------------|-------|-------|----------------------------------------------|------|------|
|                  |                                               | 1975                                    | 1985  | 2000  | 1975                                         | 1985 | 2000 |
| Coal             | Million Tonnes                                | 40.46                                   | 27.2  | 26.6  | 1123.6                                       | 754  | 739  |
| Crude Oil        | Million Tonnes                                | 87.48                                   | 95.6  | 124.1 | 3709.8                                       | 4056 | 5263 |
| Natural Gas      | Cubic km                                      | 19.40                                   | 25.4  | 45.3  | 696.9                                        | 913  | 1628 |
| Hydro Power      | TWh                                           | 59.89                                   | 60.6  | 61.5  | 681.2                                        | 690  | 700  |
| Tidal Power      | TWh                                           | 1.05                                    | 1.1   | 1.1   | 12.0                                         | 12   | 12   |
| Nuclear Power    | TWh                                           | 17.45                                   | 161.2 | 352.4 | 198.5                                        | 1835 | 4010 |
| Uranium          | Thousand Tonnes U <sub>3</sub> O <sub>8</sub> | 1.83                                    | 9.07  | 17.25 | -                                            | -    | -    |
| Geothermal Power | TWh                                           | -                                       | 7.0   | 15.8  | -                                            | 80   | 180  |

## 11.2 NUCLEAR HISTORY, CAPABILITY, COMMITMENT AND TRENDS

### COMMERCIAL NUCLEAR POWER PLANTS

Table 11.2.1

| Facility<br>Name | Utility | Vendor             | Facility<br>Type | Capacity<br>(MWe net) | Status* | COD      |
|------------------|---------|--------------------|------------------|-----------------------|---------|----------|
| Marcoule G2      | CEA/EdF | Soc.<br>Alsacienne | Magnox           | 39                    | 0       | Apr 1956 |
| Marcoule G3      | CEA/EdF | Soc.<br>Alsacienne | Magnox           | 39                    | 0       | May 1960 |
| Chinon-2         | EdF     | Various            | Magnox           | 210                   | 0       | Jun 1966 |
| Chinon-3         | EdF     | Various            | Magnox           | 480                   | 0       | Aug 1967 |
| St. Laurent-1    | EdF     | Various            | Magnox           | 487                   | 0       | Aug 1969 |
| St. Laurent-2    | EdF     | Various            | Magnox           | 515                   | 0       | Aug 1971 |
| Bugey-1          | EdF     | Various            | Magnox           | 540                   | 0       | Mar 1972 |
| EL-4             | CEA/EdF | GAAA               | GCHWR            | 70                    | 0       | Mar 1968 |
| Phenix           | CEA/EdF | CEA/GAAA           | LMFBR            | 233                   | 0       | Jul 1974 |
| Super-Phenix     | NERSA   | GNR/Tech.          | LMFBR            | 1200                  | U       | Jun 1983 |
| Sena-Chooz       | Sena    | ACECO/W/<br>Fram.  | PWR              | 310                   | 0       | Apr 1967 |
| Fessenheim-1     | EdF     | Framatome          | PWR              | 890                   | 0       | Jan 1978 |
| Fessenheim-2     | EdF     | Framatome          | PWR              | 890                   | 0       | Apr 1978 |
| Bugey-2          | EdF     | Framatome          | PWR              | 925                   | 0       | Nov 1978 |
| Bugey-3          | EdF     | Framatome          | PWR              | 925                   | 0       | Jan 1979 |
| Bugey-4          | EdF     | Framatome          | PWR              | 905                   | U       | Aug 1979 |
| Bugey-5          | EdF     | Framatome          | PWR              | 905                   | U       | Dec 1979 |
| Tricastin-1      | EdF     | Framatome          | PWR              | 925                   | U       | Dec 1979 |
| Gravelines-B1    | EdF     | Framatome          | PWR              | 925                   | U       | Jan 1980 |
| Dampierre-1      | EdF     | Framatome          | PWR              | 925                   | U       | Mar 1980 |

Table 11.2.1 (cont.)

| Facility<br>Name | Utility | Vendor    | Facility<br>Type | Capacity<br>(MWe net) | Status* | COD      |
|------------------|---------|-----------|------------------|-----------------------|---------|----------|
| Tricastin-2      | EdF     | Framatome | PWR              | 925                   | U       | Nov 1979 |
| Gravelines-B2    | EdF     | Framatome | PWR              | 925                   | U       | Feb 1980 |
| Dampierre-2      | EdF     | Framatome | PWR              | 925                   | U       | Apr 1980 |
| Tricastin-3      | EdF     | Framatome | PWR              | 925                   | U       | Jul 1980 |
| Gravelines-B3    | EdF     | Framatome | PWR              | 925                   | U       | Sep 1980 |
| Dampierre-3      | EdF     | Framatome | PWR              | 925                   | U       | Nov 1980 |
| Tricastin-4      | EdF     | Framatome | PWR              | 925                   | U       | Dec 1980 |
| Gravelines-B4    | EdF     | Framatome | PWR              | 925                   | U       | May 1981 |
| Dampierre-4      | EdF     | Framatome | PWR              | 925                   | U       | Jul 1981 |
| St. Laurent-B1   | EdF     | Framatome | PWR              | 925                   | U       | Mar 1981 |
| Le Blayais-1     | EdF     | Framatome | PWR              | 905                   | U       | May 1981 |
| St. Laurent-B2   | EdF     | Framatome | PWR              | 925                   | U       | Sep 1981 |
| Chinon-B1        | EdF     | Framatome | PWR              | 925                   | U       | Apr 1982 |
| Le Blayais-2     | EdF     | Framatome | PWR              | 905                   | U       | Dec 1981 |
| Chinon-B2        | EdF     | Framatome | PWR              | 925                   | U       | May 1982 |
| Le Blayais-3     | EdF     | Framatome | PWR              | 905                   | U       | Jan 1983 |
| Paluel-1         | EdF     | Framatome | PWR              | 1300                  | U       | Apr 1983 |
| Le Blayais-4     | EdF     | Framatome | PWR              | 905                   | U       | Aug 1983 |
| Paluel-2         | EdF     | Framatome | PWR              | 1300                  | U       | Nov 1983 |
| Paluel-3         | EdF     | Framatome | PWR              | 1300                  | U       | Oct 1984 |
| Cruas-1          | EdF     | Framatome | PWR              | 905                   | U       | Nov 1984 |
| Flamanville-1    | EdF     | Framatome | PWR              | 1300                  | U       | Dec 1984 |
| Paluel-4         | EdF     | Framatome | PWR              | 1300                  | U       | Mar 1985 |
| Cruas-2          | EdF     | Framatome | PWR              | 905                   | U       | Jun 1985 |
| Cruas-3          | EdF     | Framatome | PWR              | 905                   | U       | Sep 1985 |
| Cruas-4          | EdF     | Framatome | PWR              | 905                   | U       | Dec 1985 |

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

Table 11.2.1 (cont.)

| Facility<br>Name | Utility | Vendor    | Facility<br>Type | Capacity<br>(MWe net) | Status* | COD      |
|------------------|---------|-----------|------------------|-----------------------|---------|----------|
| St. Maurice      | EdF     | Framatome | PWR              | 1300                  | U       | Mar 1986 |
| Cattenom-1       | EdF     | Framatome | PWR              | 905                   | U       | Jun 1986 |
| Cattenom-2       | EdF     | Framatome | PWR              | 905                   | U       | Sep 1986 |
| EdF-39           | EdF     | Framatome | PWR              | 1300                  | U       | Dec 1986 |
| EdF-35           | EdF     | Framatome | PWR              | 1300                  | P       | Oct 1987 |
| EdF-36           | EdF     | Framatome | PWR              | 1300                  | P       | Jul 1988 |

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



PROJECTED NUCLEAR GENERATING CAPACITY  
MWe (net)

Table 11.2.2

| Year     | PWR  | BWR | Magnox | AGR | CANDU | Other | FBR  | Firm +<br>Planned<br>Cumulative<br>Total | NAC<br>Cumulative<br>Projection |
|----------|------|-----|--------|-----|-------|-------|------|------------------------------------------|---------------------------------|
| pre-1978 | 310  |     | 2310   |     |       | 70    | 233  | 2923                                     | 2923                            |
| 1978     | 2705 |     |        |     |       |       |      | 5628                                     | 5628                            |
| 1979     | 4585 |     |        |     |       |       |      | 10213                                    | 10213                           |
| 1980     | 7400 |     |        |     |       |       |      | 17613                                    | 17613                           |
| 1981     | 5510 |     |        |     |       |       |      | 23123                                    | 23123                           |
| 1982     | 1850 |     |        |     |       |       |      | 24793                                    | 24793                           |
| 1983     | 4410 |     |        |     |       |       | 1160 | 30543                                    | 30543                           |
| 1984     | 3505 |     |        |     |       |       |      | 34048                                    | 34048                           |
| 1985     | 4015 |     |        |     |       |       |      | 38063                                    | 38063                           |
| 1986     | 4410 |     |        |     |       |       |      | 42473                                    | 42473                           |
| 1987     | 2600 |     |        |     |       |       |      | 42473                                    | 45073                           |
| 1988     | 2600 |     |        |     |       |       | 1500 | 42473                                    | 49173                           |
| 1989     | 3900 |     |        |     |       |       | 1500 | 42473                                    | 54573                           |
| 1990     | 2600 |     |        |     |       |       |      | 42473                                    | 57173                           |
| 1991     | 2600 |     |        |     |       |       | 1500 | 42473                                    | 61273                           |
| 1992     | 2600 |     |        |     |       |       |      | 42473                                    | 63873                           |
| 1993     | 2600 |     |        |     |       |       | 1500 | 42473                                    | 67973                           |
| 1994     | 1300 |     |        |     |       |       |      | 42473                                    | 69273                           |
| 1995     | 1300 |     |        |     |       |       | 1500 | 42473                                    | 72073                           |
| 1996     | 2600 |     |        |     |       |       |      | 42473                                    | 74673                           |
| 1997     | 2600 |     |        |     |       |       | 1500 | 42473                                    | 78773                           |
| 1998     | 2600 |     |        |     |       |       | 1500 | 42473                                    | 82873                           |
| 1999     | 2600 |     |        |     |       |       | 1500 | 42473                                    | 86973                           |
| 2000     | 2600 |     |        |     |       |       | 1500 | 42473                                    | 91073                           |

## NUCLEAR REACTOR VENDORS

### Overview

The French Government, through the Atomic Energy Commission, the Commissariat de l'Energie Atomique (CEA), has played and continues to play a key role in the development and implementation of nuclear power in France. The CEA, which was formed in 1945, initially channelled its efforts into the design and construction of plants for the production of plutonium for military purposes, which led to the construction and operation of the Marcoule G1 graphite-moderated, air-cooled reactor in 1956.

This was followed by the construction of the Marcoule G2 and G3 units, CO<sub>2</sub>-cooled, graphite-moderated reactors designed both for plutonium and power production (39 MWe each). These reactors were the models for the subsequent first generation of commercial nuclear power plants built in France by Electricité de France (EdF), the state utility. Through 1972, approximately 2,300 MWe of gas-cooled reactors were brought into operation. These reactors were constructed by a range of different French manufacturing and supply companies using basic CEA designs. CEA itself acted as the vendor for the only export sale of the French gas-cooled line to Spain, which was brought into operation in 1972. Although the main early emphasis was on gas-cooled reactors, CEA investigated many other alternatives; LWR's, HTGR's, HWR's, and FBR's. This led to the construction, and in 1968 the operation of EL-4, a 70 MWe gas-cooled, heavy water moderated prototype power reactor; in 1967 the operation of Rapsodie, an experimental FBR; and in 1974 the operation of Phenix, a 233 MWe prototype liquid metal FBR.

To enable France to gain an understanding and experience of LWR technology, Framatome was formed in 1958, and with a Westinghouse PWR license, participated with Westinghouse and Belgian industry in the construction of the Sena reactor, a joint project of EdF and Belgian utilities. The reactor entered service in 1967. In 1970, the French Government decided to base the second generation of domestic commercial power reactors on LWR technology under license from experienced US vendors. Framatome was restructured into a stronger industrial entity with Creusot Loire, a heavy equipment manufacturer, taking a 51% share and Westinghouse 45%. The remaining 4% was held by other mechanical and electrical equipment suppliers. The other major industrial LWR competitor that emerged was Compagnie Generale d'Electricité (CGE), a major holding company controlling design and equipment suppliers such as Sogerca, Alsthom and GAAA, with a license for BWR's from General Electric. Both companies were awarded contracts by EdF and the CGE group through Sogerca was awarded with General Electric and Brown Boveri the contract for the Kaiseraugst station in Switzerland. However, the realization that the French domestic program was not large enough to support two major vendors, and the uncertainty with exports, led to the decision in 1975 to focus on the stronger of the two groups, Framatome, as the sole French LWR supplier. Framatome subsequently took over the CGE contracts for the EdF reactors. To further strengthen the French control of Framatome, the Westinghouse

shareholdings in Framatome were reduced to 15% in 1975 and CEA took a 30% interest in the company. The remaining 15% Westinghouse share will be transferred to Creusot Loire in 1982. At the same time a joint research and development program was set up by CEA, EdF, Framatome and Westinghouse through 1982 when the Westinghouse license expires. At that time it is foreseen that France will be totally self-sufficient as a PWR designer in the range 600-1,300 MWe (net). In 1974, Framateg was formed by Creusot Loire and Framatome for the management and organization of non-domestic turnkey stations.

In a further series of major industry agreements and reorganizations, the position of Creusot Loire (and thus Framatome) has been clearly defined as the single French large-size LWR supplier supported by the industrial capability of other companies outside the group. Framatome has now received orders for some 35 domestic reactors (including units of 1,300 MWe net), with others on option. Additionally, export orders have been obtained in China, Belgium, South Africa and Iran. In the latter two countries the plants are being supplied on a turnkey basis in which Framatome (and Framateg) leads a consortium including Alsthom for the electrical generation equipment.

Based on the good performance of the Phenix reactor, the CEA continued commercial FBR development and in 1976 and 1977 established with French industry, Novatome, for the commercialization, sale and supply of FBR's. Currently, Novatome is divided between the CEA (34%), Creusot Loire (51%), and Alsthom-Atlantique (15%), so that all of the major French nuclear companies were represented. In 1976, a series of FBR research, development and commercialization agreements were signed between France and Germany; on the French side by CEA and Novatome, and on the German side by Interatom and the Karlsruhe Nuclear Research Center. Further, in 1976, the NERSA utility group comprising EdF (51%); ENEL, Italy (33%); and RWE, Germany, CEGB, UK, Belgium and Dutch utilities (16%), placed the order for the 1,300 MWe Super-Phenix FBR for operation in 1983. In 1977, the Société Européenne pour la Promotion des Systemes de Reacteurs Rapides á Sodium (SERENA) was set up to market and license FBR technology. SERENA is currently owned 39% by CEA directly, 26% by Novatome, and 35% by Kenntnisverwertungsgesellschaft Schnelle Brutreaktoren (KVG). KVG is owned 51% by Interatom, 19% by Karlsruhe, 15% by Belgonucleaire (Belgium) and 15% by NERATOM (Netherlands). It is foreseen that the French shareholding in SERENA will eventually be reduced to 51% when the non-French partners gain more FBR experience. Further, agreement has been reached on the sharing of international FBR orders gained by Novatome and INB, the German-led FBR supplier consortium.

Based on its development of marine nuclear reactors, CEA has also developed a small PWR system producing up to 500 MW (thermal) for use in developing countries or for dual purposes (electricity production and desalination, etc.). Alsthom-Atlantique is responsible for the commercialization of these small reactors.

Vendor: Miscellaneous

As referenced in the section above, a wide range of French industrial companies were involved in the supply and construction of the CEA designed gas-cooled and heavy water reactors. These reactors are no longer offered on the commercial market.

Summary of Orders

Table 11.2.3

| Country | Reactor Name  | Utility  | Type   | MWe(net) | COD      |
|---------|---------------|----------|--------|----------|----------|
| France  | Marcoule G2   | CEA/EdF  | Magnox | 39       | Apr 1956 |
| France  | Marcoule G3   | CEA/EdF  | Magnox | 39       | May 1960 |
| France  | Chinon-2      | EdF      | Magnox | 210      | Jun 1966 |
| France  | Chinon-3      | EdF      | Magnox | 480      | Aug 1967 |
| France  | St. Laurent-1 | EdF      | Magnox | 487      | Aug 1969 |
| France  | St. Laurent-2 | EdF      | Magnox | 515      | Aug 1971 |
| France  | Bugey-1       | EdF      | Magnox | 540      | Mar 1972 |
| France  | EL-4          | CEA/EdF  | GCHWR  | 70       | Mar 1968 |
| Spain   | Vandellos     | Hifrensa | Magnox | 484      | May 1972 |

Vendor: Framatome

Summary of Orders

Table 11.2.4

| Country | Reactor Name   | Utility | Type | MWe(net) | COD      |
|---------|----------------|---------|------|----------|----------|
| France  | Sena-Chooz*    | Sena    | PWR  | 310      | Apr 1967 |
| France  | Fessenheim-1   | EdF     | PWR  | 890      | Jan 1978 |
| France  | Fessenheim-2   | EdF     | PWR  | 890      | Apr 1978 |
| France  | Dugey-2        | EdF     | PWR  | 925      | Nov 1978 |
| France  | Bugey-3        | EdF     | PWR  | 925      | Jan 1979 |
| France  | Bugey-4        | EdF     | PWR  | 905      | Aug 1979 |
| France  | Bugey-5        | EdF     | PWR  | 905      | Dec 1979 |
| France  | Tricastin-1    | EdF     | PWR  | 925      | Dec 1979 |
| France  | Gravelines-B1  | EdF     | PWR  | 925      | Jan 1980 |
| France  | Dampierre-1    | EdF     | PWR  | 925      | Mar 1980 |
| France  | Tricastin-2    | EdF     | PWR  | 925      | Nov 1979 |
| France  | Gravelines-B2  | EdF     | PWR  | 925      | Feb 1980 |
| France  | Dampierre-2    | EdF     | PWR  | 925      | Apr 1980 |
| France  | Tricastin-3    | EdF     | PWR  | 925      | Jul 1980 |
| France  | Gravelines-B3  | EdF     | PWR  | 925      | Sep 1980 |
| France  | Dampierre-3    | EdF     | PWR  | 925      | Nov 1980 |
| France  | Tricastin-4    | EdF     | PWR  | 925      | Dec 1980 |
| France  | Gravelines-B4  | EdF     | PWR  | 925      | May 1981 |
| France  | Dampierre-4    | EdF     | PWR  | 925      | Jul 1981 |
| France  | St. Laurent-B1 | EdF     | PWR  | 925      | Mar 1981 |
| France  | Le Blayais-1   | EdF     | PWR  | 905      | May 1981 |
| France  | St. Laurent-B2 | EdF     | PWR  | 925      | Sep 1981 |

Table 11.2.4 (cont.)

| Country   | Reactor Name  | Utility       | Type | MWe(net) | COD      |
|-----------|---------------|---------------|------|----------|----------|
| France    | Chinon-B1     | EdF           | PWR  | 925      | Apr 1982 |
| France    | Le Blayais-2  | EdF           | PWR  | 905      | Dec 1981 |
| France    | Chinon-B2     | EdF           | PWR  | 925      | May 1982 |
| France    | La Blayais-3  | EdF           | PWR  | 905      | Jan 1983 |
| France    | Paluel-1      | EdF           | PWR  | 1300     | Apr 1983 |
| France    | Le Blayais-4  | EdF           | PWR  | 905      | Aug 1983 |
| France    | Paluel-2      | EdF           | PWR  | 1300     | Nov 1983 |
| France    | Paluel-3      | EdF           | PWR  | 1300     | Oct 1984 |
| France    | Cruas-1       | EdF           | PWR  | 905      | Nov 1984 |
| France    | Flamanville-1 | EdF           | PWR  | 1300     | Dec 1984 |
| France    | Paluel-4      | EdF           | PWR  | 1300     | Mar 1985 |
| France    | Cruas-2       | EdF           | PWR  | 905      | Jun 1985 |
| France    | Cruas-3       | EdF           | PWR  | 905      | Sep 1985 |
| France    | Cruas-4       | EdF           | PWR  | 905      | Dec 1985 |
| France    | St. Maurice   | EdF           | PWR  | 1300     | Mar 1986 |
| France    | Cattenom-1    | EdF           | PWR  | 905      | Jun 1986 |
| France    | Cattenom-2    | EdF           | PWR  | 905      | Sep 1986 |
| France    | EdF-39        | EdF           | PWR  | 1300     | Dec 1986 |
| Belgium   | Tihange-1*    | SEMO          | PWR  | 870      | Aug 1975 |
| Belgium   | Doel-3**      | EBES          | PWR  | 925      | May 1980 |
| Belgium   | Tihange-2**   | Intercom      | PWR  | 925      | Nov 1980 |
| Iran      | Ahvaz-1       | Gov't of Iran | PWR  | 925      | Oct 1983 |
| Iran      | Ahvaz-2       | Gov't of Iran | PWR  | 925      | Oct 1984 |
| S. Africa | Koeberg-1     | ESCOM         | PWR  | 922      | 1983     |
| S. Africa | Koeberg-2     | ESCOM         | PWR  | 922      | 1984     |

\* With Westinghouse and Belgian industry

\*\* With Belgian industry

Capacity, Capacity-Limiting Factors, Ability to Expand, and Expansion Plans

Framatome provides a full range of design, engineering supply, and project management services for nuclear power stations on either a nuclear island or complete plant turnkey basis. There is no stated limitation in the number of plants that can be supplied on the basis of manpower and this situation is aided by the fact that EdF, Framatome's major customer, is highly oriented to the purchase of standardized units with up to four units at each site.

Through its own facilities and those of its parent company, Creusot Loire, Framatome is able to provide all its own pressure vessels, steam generators, and other major items of nuclear equipment. Creusot Loire constructed the pressure vessel for the Sena reactor in 1962-1964 in its existing workshops. Following the decision by France in 1970 to follow the LWR concept, Framatome decided to construct two new heavy nuclear component plants, one located at Le Creusot for the assembly of pressure vessels (completed in 1973) and the other at Chalon (close to Le Creusot) for the assembly of steam generators. In 1974 it was decided to construct an additional plant at Chalon for pressure vessels, steam generators and pressurizers which came into operation in 1976. The close siting of the plants within the Creusot Loire industrial complex enables them to take advantage of the steelworks, forges, rolling mills, machining shops, etc. of Creusot Loire. The current capacity for the manufacture and assembly of pressure vessels is up to 8 per year for 4-loop reactor sizes (1,300 MWe station outputs). The current capacity for the assembly of steam generators is 18-24 units per year and for pressurizers, 8 per year. Finished products are transferred by travelling cranes from inside the plant for loading onto barges for water transport or road transport. Over 30 pressure vessels have been delivered or are currently under order.

Since the French domestic program calls for less than 8 reactors of the 1,300 MWe size per year, there is clearly spare capacity for fulfilling export orders, allowing for the export orders already in hand. There are no known firm plans to expand the facilities; however, it has been stated that expansion can be easily effected if and when the market justifies it.

### Past and Present Marketing Strategy

Until the domestic French nuclear program became oriented towards PWR's and an aggressive construction program was adopted, Framatome was only able to obtain two orders, both with Westinghouse and Belgian industry and both for joint EdF and Belgian utility reactors (Sena and Tihange-1). The lack of a French domestic program and real experience did not permit Framatome to be considered as a credible vendor. Based on the large, captive French market, however, Framatome has aggressively marketed worldwide, offering plants on both a turnkey and non-turnkey basis. Although Framatome's motivation is clearly commercial, it is fully backed by the French Government (e.g. sales to Iran) and is not obviously subject to political constraints (e.g. sales to South Africa and probably to mainland China). In fact, the success of Framatome in foreign markets is considered at Government level to be an important element of French commercial and political influence in the world. In addition, Framatome through its Governmental support is able to draw on the resources of Cogema, the Government controlled fuel company (see following section), to support its efforts (e.g. supply of enriched uranium to Iran for the first 10 years of operation of the two Framatome supplied units within 10 years of options). It is not inconceivable that reprocessing contracts could also eventually be linked to reactor sales.



### Projected Future Marketing Strategy

Framatome will continue to be the sole supplier of current generation reactors (PWR's) to France. In addition, it is anticipated that it will maintain its aggressive overseas marketing policy in both developing and developed countries where the market is not held captive by domestic suppliers (e.g. U.S.A., West Germany). Framatome can now offer a 600 MWe reactor, considered an excellent size for developing countries. It is further to be expected that Framatome will be fully backed by the full weight of the French Government.

Market Share Attained: Framatome

Table 11.2.5

| Year                  | MWe<br>(net) | Domestic |        |       | Regional (non-France) |        |      | International<br>(non-France, non-US) |        |      |
|-----------------------|--------------|----------|--------|-------|-----------------------|--------|------|---------------------------------------|--------|------|
|                       |              | Com.     | Uncom. | %     | Com.                  | Uncom. | %    | Com.                                  | Uncom. | %    |
| pre-1978              | 1180         | 2987     | 0      | 10.3  | 20999                 | 0      | 4.1  | 33883                                 | 0      | 2.6  |
| 1978                  | 2705         | 2705     | 0      | 100.0 | 3199                  | 0      | 0.0  | 9754                                  | 0      | 0.0  |
| 1979                  | 4585         | 4585     | 0      | 100.0 | 7519                  | 0      | 0.0  | 12055                                 | 0      | 0.0  |
| 1980                  | 9250         | 7400     | 0      | 100.0 | 7337                  | 0      | 25.2 | 8537                                  | 220    | 21.7 |
| 1981                  | 5510         | 5510     | 0      | 100.0 | 8586                  | 0      | 0.0  | 12419                                 | 0      | 0.0  |
| 1982                  | 1850         | 1850     | 0      | 100.0 | 3093                  | 0      | 0.0  | 9161                                  | 220    | 0.0  |
| 1983                  | 6257         | 5570     | 0      | 79.2  | 3832                  | 0      | 0.0  | 9319                                  | 2087   | 19.8 |
| 1984                  | 5352         | 3505     | 0      | 100.0 | 4211                  | 0      | 0.0  | 12645                                 | 4864   | 14.6 |
| 1985                  | 4015         | 4015     | 0      | 100.0 | 6231                  | 0      | 0.0  | 12168                                 | 5468   | 0.0  |
| 1986                  | 4410         | 4410     | 0      | 100.0 | 4371                  | 4790   | 0.0  | 8883                                  | 14404  | 0.0  |
| 1987                  | 0            | 0        | 2600   | 0.0   | 3182                  | 9700   | 0.0  | 5872                                  | 16300  | 0.0  |
| 1988                  | 0            | 0        | 4100   | 0.0   | 2268                  | 10260  | 0.0  | 3118                                  | 22530  | 0.0  |
| 1989                  | 0            | 0        | 5400   | 0.0   | 1240                  | 8080   | 0.0  | 1240                                  | 20273  | 0.0  |
| 1990                  | 0            | 0        | 2600   | 0.0   | 2152                  | 8880   | 0.0  | 2152                                  | 27429  | 0.0  |
| <hr/>                 |              |          |        |       |                       |        |      |                                       |        |      |
| Total<br>thru<br>1990 | 45114        | 42537    | 14700  | 91.0  | 78220                 | 41710  | 3.5  | 141206                                | 113795 | 4.5  |

### Nuclear Reactor Vendor Support Industries

The supply of major LWR components (e.g. pressure vessels, steam generators) lies within the Framatome group (see sections above).

## NUCLEAR FUEL CYCLE FACILITIES

### Overview

France is involved in all sectors of the nuclear fuel cycle through the Government-owned CEA and private industry. In 1976, the CEA created the Compagnie Générale des Matières Nucléaires (Cogema) to undertake all commercial activities of the CEA.

France is the only European country possessing uranium reserves which can be commercially exploited at this time. Mines and mills are owned and operated by both Cogema and private companies. Both continue to be heavily involved in exploration for uranium on a worldwide basis. The major private French companies involved are Pechiney-Ugine Kuhlmann, Compagnie Française de Pétrole (these two operate through a joint venture called Minatome, formed in 1976), Mokta and Aquitaine. France has major overseas investments in current or planned uranium production including Amok Ltd., Canada (100% French); Comuf, Gabon (75% French); Cominak, Niger (34% French); Imouraren, Niger (35% French); Somair, Niger (54% French); and Rossing, S.W. Africa (10% French). Since the domestic production of uranium is not large enough to meet domestic requirements, this foreign uranium is essential to France and also provides the basis for the substantial sales of uranium to non-domestic utilities.

Société pour la Conversion de l'Uranium en Métal et en Hexafluor (Comurhex) created in 1971 is owned principally by Pechiney-Ugine Kuhlmann (51%) and Cogema (29%) and converts uranium concentrates to  $UF_4$ , sinterable  $UO_2$  powder and metal at a facility at Malvesi and produces  $UF_6$  from  $UF_4$  or concentrates at a second facility at Pierrelatte. Comurhex took over existing facilities which have subsequently been significantly expanded.

France has a large amount of experience in gaseous diffusion enrichment. The CEA commenced the construction of the Pierrelatte gaseous diffusion plant in 1960, and it was put into operation in stages between 1964 and 1967. This plant was intended for military purposes and was designed and constructed by the CEA and French industry. Ownership of Pierrelatte remains with CEA but it is now operated by Cogema. Production preference is given to military needs, excess capacity being used to produce quantities of low enriched uranium for commercial purposes. Eurodif, the French-led, multinational commercial enrichment company was formed in 1973, and in 1973, it was decided to construct a plant of some 10,000 MTSWU per year at Tricastin for full operation in 1982. The current shareholdings in Eurodif are Cogema (27.78%), Sofidif, a joint company of Cogema and the Iranian AEC (25%), Agip Nucleare, Italy (12.50%), CNEN, Italy (12.50%), ENUSA, Spain (11.11%) and Soben, Belgium (11.11%). In 1975, Coredif S.A. was formed with the aim of constructing an additional enrichment facility of 10,000 MTSWU/year capacity in the mid-to-late 1980's. The shareholdings of Coredif are Cogema (29%), Eurodif (51%) and the Iranian AEC (20%).

Fabrication of oxide fuel for LWR's is performed by Société Franco Belge de Fabrication du Combustible (FBFC), which is controlled 80% by a holding company Eurofuel, which itself is a subsidiary of Pechiney-Ugine Kuhlmann (PUK), Framatome, Westinghouse, and Creusot Loire. FBFC possesses two facilities, one in Dessel, Belgium and the other at Romans, France. Fuel for gas-graphite reactors is manufactured from metal uranium by Société Industrielle des Combustibles Nucleaires (SICN) at the Annecy facility and Compagnie pour l'Etude et la Réalisation de Combustibles Atomiques (CERCA) at Romans. Pechiney-Ugine Kuhlmann and Creusot Loire each owns a 50% share in CERCA.  $UO_2$  fuels for the small French heavy water reactors (EL3, EL4) are also manufactured by CERCA. SICN and CERCA manufacture  $UO_2$  fuel rods for the fertile regions of FBR's (e.g. Rapsodie and Phenix). Mixed oxide fabrication is carried out by the CEA in its plutonium workshops (ATPu) at Cadarache.

The first major French reprocessing plant (UP1) began operation at Marcoule in 1958 for the purpose of extracting plutonium from the fuel discharged from the G-1, -2, and -3 gas-graphite reactors. In 1967, the La Hague reprocessing plant (UP2) was brought into operation with the primary aim of reprocessing fuel from the EdF commercial gas-graphite reactors, but was later modified to accept oxide fuels. The reprocessing of oxide fuel commenced in 1976. Reprocessing of all gas-graphite fuel will be completely transferred over to Marcoule by the early 1980's, at which time La Hague will have a capacity of 800 MTU/year for oxide fuel. Additional 800 MTU/year oxide reprocessing plants are planned for 1985 (UP3A) and 1989 (UP3B). There exists at La Hague a small reprocessing plant for fuel from the Rapsodie experimental FBR and at Marcoule a pilot plant for FBR fuels.

France has a significant interest in the transportation of nuclear materials including spent fuel both through Cogema and Transnucléaire. Transnucléaire owns a 20% share in Transnuklear GmbH (Federal Republic of Germany), 50% of Transnuclear Inc. (USA) and a third share of Nuclear Transporters Ltd. (NTL). BNFL (UK) and Transnuklear are the other partners in NTL.

The main fuel cycle facilities are summarized in Table 11.2.6.

CURRENT AND PLANNED FACILITIES

Table 11.2.6

| Facility<br>Name | Location          | Facility<br>Type | MTU/YR | Capacity Status |  | Year | Shareholdings                                                                                                                                                                 |
|------------------|-------------------|------------------|--------|-----------------|--|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |                   |                  |        | Status*         |  |      |                                                                                                                                                                               |
| Langogue         | Lozere District   | U mine and mill  | 150    | 0               |  | 1977 | Compagnie Francaise des<br>Minerais d' Uranium (CFMU):<br>12.8% Cogema<br>57.2% Imetal Holding<br>15.0% Minatome (will be<br>transferred to Cogema)<br>15.0% Kali-St. Thérèse |
| Felletin         | Crense District   | U mine           |        | 0               |  |      | CFMU                                                                                                                                                                          |
| Inguiniel        | Morbihan District | U mine           |        | 0               |  |      | CFMU                                                                                                                                                                          |
| Various          | Massif Central    | U mine           |        | 0               |  |      | Cogema                                                                                                                                                                        |
| Various          | Bretagne          | U mine           |        | 0               |  |      | Cogema                                                                                                                                                                        |
| Lodeve           | S. France         | U mine           |        | U               |  | 1980 | Cogema                                                                                                                                                                        |
| Haute-Vienne     | Haute-Vienne      | U mine and mill  | 200    | U               |  | 1979 | Dong-Trieu:<br>83% Empain-Schneider<br>Group                                                                                                                                  |
|                  |                   |                  | 500    | P               |  | 1982 |                                                                                                                                                                               |
| St. Pierre       | Massif Central    | U mine and mill  | 100    | 0               |  | 1978 | Soc. Centrale de l'Uranium<br>et des Minerais et Métaux<br>Radioactifs (SCUMRA):<br>94% Minatome                                                                              |
| Forez            | Loire             | U mill           | 500    | 0               |  | 1960 | Cogema                                                                                                                                                                        |

Table 11.2.6 (cont.)

| Facility Name                   | Location     | Facility Type                    | MTU/YR                               | Capacity Status |  | Year             | Shareholdings                                                                                                  |
|---------------------------------|--------------|----------------------------------|--------------------------------------|-----------------|--|------------------|----------------------------------------------------------------------------------------------------------------|
|                                 |              |                                  |                                      | Status*         |  |                  |                                                                                                                |
| L'Ecarpiere                     | Loire        | U mill                           | 700                                  | O               |  | 1957             | SIMO:<br>9% PUK<br>51% Cogema<br>40% CDC                                                                       |
| Bessines                        | Haute-Vienne | U mill                           | 1,500                                | O               |  | 1958             | SIMO                                                                                                           |
| Lodeve                          | S. France    | U mill                           | 600                                  | U               |  | 1980             | Cogema                                                                                                         |
| Malvesi Refining Facility       | Malvesi      | UF <sub>4</sub> and U production |                                      | O               |  |                  | Comurhex:<br>51% SCUP (99.9% Pechiney-Ugine Kuhlmann)<br>39% Cogema<br>10% Imetal                              |
| Pierrelatte Conversion Facility | Pierrelatte  | UF <sub>6</sub> production       | 8,000                                | O               |  | 1977             | Comurhex                                                                                                       |
|                                 |              |                                  | 12,000                               | P               |  | 1980             |                                                                                                                |
|                                 |              |                                  | 15,000                               | P               |  | 1982             |                                                                                                                |
| Pierrelatte Enrichment Facility | Pierrelatte  | Enrichment (mainly military)     | 300-400<br>(for commercial purposes) | O               |  | 1967             | CEA                                                                                                            |
| Eurodif Enrichment Facility     | Tricastin    | Enrichment                       | 10,800                               | U               |  | full op.<br>1982 | Eurodif S.A.:<br>27.78% Cogema<br>25.00% Sofidif<br>12.50% Agip<br>12.50% CNEN<br>11.11% ENUSA<br>11.11% Soben |

Table 11.2.6 (cont.)

| Facility Name                  | Location          | Facility Type                                                                                                  | Capacity Status |         | Year    | Shareholdings                                                                                                    |
|--------------------------------|-------------------|----------------------------------------------------------------------------------------------------------------|-----------------|---------|---------|------------------------------------------------------------------------------------------------------------------|
|                                |                   |                                                                                                                | MTU/YR          | Status* |         |                                                                                                                  |
| FBFC Fuel Fabrication Facility | Dessel, Belgium   | Oxide fuel fabrication (excluding powder production)                                                           | 200 (nom.)      | 0       | 1977/78 | FBFC:<br>80% Eurofuel (51% PUK, 35% Westinghouse, 11% Creusot Loire, 3% Framatome)<br>10% MMN<br>4% Westinghouse |
|                                |                   |                                                                                                                | 200             | U       |         |                                                                                                                  |
| FBFC Fuel Fabrication Facility | Romans            | Oxide fuel fabrication                                                                                         | 200             | 0       | 1977    | FBFC                                                                                                             |
|                                |                   |                                                                                                                | 100             | U       | 1978    |                                                                                                                  |
| CERCA Facility                 | Romans            | Heavy water and gas-graphite fuel fabrication. Manufacture of fertile FBR $UO_2$ rods. (No powder production.) | ~ 20 (HWR)      | 0       | 1960's  | CERCA:<br>50% PUK<br>50% Creusot Loire                                                                           |
|                                |                   |                                                                                                                | ~ 900 (G-G)     | 0       | 1960's  |                                                                                                                  |
|                                |                   |                                                                                                                | (FBR)           | 0       |         |                                                                                                                  |
| SICN Fabrication Facility      | Annecy and Veurey | Gas-graphite fuel fabrication. Manufacture of fertile FBR $UO_2$ rods. (No powder production.)                 | ~1200 (G-G)     | 0       |         | SICN:<br>75% ALSPI<br>25% SGPM                                                                                   |
|                                |                   |                                                                                                                | (FBR)           | 0       |         |                                                                                                                  |
| Plutonium Workshops ATPu       | Cadarache         | FBR mixed oxide and oxide fuel fabrication                                                                     | 10              | 0       |         | CEA                                                                                                              |



Table 11.2.6 (cont.)

| Facility<br>Name                            | Location | Facility<br>Type                                    | Capacity Status |         |                   | Shareholdings |
|---------------------------------------------|----------|-----------------------------------------------------|-----------------|---------|-------------------|---------------|
|                                             |          |                                                     | MTU/YR          | Status* | Year              |               |
| Marcoule<br>Reprocessing<br>Facility (UP1)  | Marcoule | Reprocessing of gas-<br>graphite reactor<br>fuel    | ~1000           | O       | first<br>op. 1958 | Cogema        |
| La Hague<br>Reprocessing<br>Facility (UP2)  | La Hague | Reprocessing of gas-<br>graphite and oxide<br>fuels | 800             | O       | full<br>op. 1983  | Cogema        |
| La Hague<br>Reprocessing<br>Facility (UP3A) | La Hague | Reprocessing of oxide<br>fuel                       | 800             | P       | 1985              | Cogema        |
| La Hague<br>Reprocessing<br>Facility (UP3B) | La Hague | Reprocessing of oxide<br>fuel                       | 800             | F       | 1987              | Cogema        |

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

Facility: French Domestic Mining and Milling Operations

As shown in Table 11.2.6 domestic French uranium mining and milling operations consist of a relatively large number of small mines and a few mills. Cogema and SIMO combined operate three mills. Dong-Trieu has a mill under construction.

Few operational details are available, however, it is known that many of the mines are open-pit. Defined reserves amount to 52,000 MTU with 44,000 MTU of estimated additional resources. Approximately 81,000 MTU of these are held by Cogema.

The current domestic production capacity amounts to some 2,900 MTU/year which is expected to increase to 3,700 MTU/year by 1985 and 4,000 MTU/year by 1990.

France has produced to date some 27,400 MTU as follows:

|          |         |
|----------|---------|
| Pre-1972 | 16,600  |
| 1972     | 1,545   |
| 1973     | 1,616   |
| 1974     | 1,673   |
| 1975     | 1,742   |
| 1976     | 2,063   |
| 1977     | ~ 2,200 |
| Total    | 27,439  |

None of the domestic production has been directly sold outside of France. It is used together with the uranium obtained from French overseas projects to generally meet domestic requirements and foreign sales contracts. Dong-Trieu is the only known privately owned company to sell directly to EdF.

## Facility: Comurhex Conversion Plants

### Description of Operation

Comurhex operates two facilities. The first one, at Malvesi, produces  $UF_4$  from incoming  $U_3O_8$  concentrates.  $UF_6$  is produced from the  $UF_4$  from Malvesi at the second plant, located in Pierrelatte.

After being dissolved in nitric acid, the uranium concentrates are filtered, purified and precipitated into ammonium diuranate (A.D.U.). The A.D.U. is then calcinated to obtain  $UO_3$ . Next the  $UO_3$  is reduced to  $UO_2$  in moving bed type reactors and then fluorinated with HF to produce  $UF_4$ . The  $UF_4$  can then either be reduced to uranium metal using magnesium or calcium at Malvesi for later fabrication into fuel elements for gas-graphite reactors or trucked to the Pierrelatte plant where processing continues. Here the  $UF_4$  is combined with fluorine in flame type reactors to produce  $UF_6$ . The  $UF_6$  is crystallized in order to achieve a complete separation of conversion residual gases. Liquified  $UF_6$  is then filled in cylinders. If required, it is purified by distillation.

### Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

$UF_4$  production for the production of uranium metal has been underway at Malvesi since the early 1950's.  $UF_6$  has been produced as feed for the Pierrelatte enrichment plant since 1962.

The current capacity for the production of  $UF_6$  is 8,000 MTU/year which will be increased to 12,000 MTU/year in 1980 and 15,000 MTU/year in 1982. The exact capacity for the production of  $UF_4$  is not known but must be higher than the above figures to allow for the on-going production of uranium metal for gas-graphite reactor fuel. The capacity for uranium metal production was given as 1,750 MTU/year in 1972. Annual requirements for the gas-graphite reactors lie at around 600-700 MTU per year. Because of the fixed number of gas-graphite reactors, the production capacity for metal uranium will not be increased.

### Past and Present Marketing Strategy

Uranium metal production is primarily aimed at meeting domestic needs for uranium metal fuel and requirements for the Vandellós gas-graphite reactor in Spain. These markets are exclusive to Comurhex. Much of the early  $UF_6$  conversion business of Comurhex came about through the aggressive marketing of French uranium in the late 1960's and early 1970's since many utilities preferred to purchase  $UF_6$  directly rather than contract for conversion services separately. This has continued to provide an important vehicle for the sale of conversion services. However, since the inception of Comurhex as a business entity, conversion services have, in addition, been competitively marketed worldwide, independent of uranium sales. The production of  $UF_6$  for all French PWR's is an exclusive Comurhex market.

The market share tables shown below refer to conversion to  $UF_6$  for both domestic and foreign reactors. Not included is the additional production to  $UF_4$  for metal production for which Comurhex (and its predecessor) has a 100% historic and future market share.

Market Share Attained: Comurhex

Table 11.2.7  
(MTU UF<sub>6</sub>)

Region: Domestic (France)

| <u>Year</u> | <u>Comurhex<br/>Deliveries to<br/>France</u> | <u>Total<br/>Deliveries<br/>to<br/>France</u> | <u>Total<br/>French<br/>Requirements*</u> | <u>Total<br/>French<br/>Uncommitted**</u> | <u>Comurhex<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|----------------------------------------------|-----------------------------------------------|-------------------------------------------|-------------------------------------------|---------------------------------------------------------------------|
| pre-1978    | 9284                                         | 10279                                         | 4238                                      | 0                                         | 90.3                                                                |
| 1978        | 6810                                         | 6899                                          | 2053                                      | 0                                         | 98.7                                                                |
| 1979        | 5790                                         | 5790                                          | 2902                                      | 0                                         | 100.0                                                               |
| 1980        | 6088                                         | 6597                                          | 3356                                      | 0                                         | 92.3                                                                |
| 1981        | 3501                                         | 7011                                          | 3845                                      | 0                                         | 49.9                                                                |
| 1982        | 3366                                         | 8010                                          | 4272                                      | 0                                         | 42.0                                                                |
| 1983        | 3361                                         | 8234                                          | 6376                                      | 0                                         | 40.8                                                                |
| 1984        | 3439                                         | 8066                                          | 6307                                      | 0                                         | 42.6                                                                |
| 1985        | 3380                                         | 8066                                          | 7322                                      | 479                                       | 41.9                                                                |
| 1986        | 3381                                         | 8076                                          | 7477                                      | 479                                       | 41.9                                                                |
| 1987        | 3381                                         | 8066                                          | 9306                                      | 1639                                      | 41.9                                                                |
| 1988        | 3381                                         | 8066                                          | 8856                                      | 1363                                      | 41.9                                                                |
| 1989        | 3381                                         | 8076                                          | 9760                                      | 1971                                      | 41.9                                                                |
| 1990        | 3381                                         | 7984                                          | 10218                                     | 2458                                      | 42.3                                                                |

\* Firm + futura

\*\* Assuming all future requirements are uncommitted

Market Share Attained: Comurhex

Table 11.2.7 (cont.)  
(MTU UF6)

Region: Europe (non-France)

| <u>Year</u> | <u>Comurhex Deliveries</u> | <u>Total Deliveries</u> | <u>Requirements*</u> | <u>Uncommitted**</u> | <u>Comurhex Market Share of Committed Deliveries, %</u> |
|-------------|----------------------------|-------------------------|----------------------|----------------------|---------------------------------------------------------|
| pre-1978    | 9715                       | 41173                   | 27642                | 0                    | 23.6                                                    |
| 1978        | 4043                       | 12476                   | 7129                 | 2                    | 32.1                                                    |
| 1979        | 3118                       | 10232                   | 10024                | 813                  | 26.7                                                    |
| 1980        | 3704                       | 9552                    | 9339                 | 1495                 | 28.7                                                    |
| 1981        | 2164                       | 8173                    | 8938                 | 1245                 | 26.5                                                    |
| 1982        | 1927                       | 7468                    | 8406                 | 1499                 | 25.8                                                    |
| 1983        | 1695                       | 6573                    | 9251                 | 2942                 | 25.8                                                    |
| 1984        | 1524                       | 6461                    | 9814                 | 4343                 | 23.6                                                    |
| 1985        | 1415                       | 6510                    | 12043                | 6318                 | 21.7                                                    |
| 1986        | 398                        | 4209                    | 14797                | 8687                 | 9.5                                                     |
| 1987        | 168                        | 3313                    | 13733                | 11965                | 5.1                                                     |
| 1988        | 168                        | 3650                    | 16854                | 12814                | 4.6                                                     |
| 1989        | 168                        | 2966                    | 17288                | 13115                | 5.7                                                     |
| 1990        | 168                        | 2963                    | 18541                | 14658                | 5.7                                                     |

\* Firm + futura

\*\* Assuming all futura requirements are uncommitted

Market Share Attained: Comurhex

Table 11.2.7 (cont.)  
(MTU UF<sub>6</sub>)

Region: International (non-France, non-US)

| <u>Year</u> | <u>Comurhex<br/>Deliveries</u> | <u>Total<br/>Deliveries</u> | <u>Requirements*</u> | <u>Uncommitted**</u> | <u>Comurhex<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|--------------------------------|-----------------------------|----------------------|----------------------|---------------------------------------------------------------------|
| pre-1978    | 14319                          | 62342                       | 41331                | 0                    | 23.0                                                                |
| 1978        | 5299                           | 20060                       | 9577                 | 32                   | 26.2                                                                |
| 1979        | 4920                           | 17950                       | 14324                | 951                  | 25.2                                                                |
| 1980        | 4798                           | 15498                       | 13644                | 2230                 | 24.8                                                                |
| 1981        | 3807                           | 14434                       | 14182                | 3332                 | 26.4                                                                |
| 1982        | 4572                           | 14618                       | 14699                | 3815                 | 31.3                                                                |
| 1983        | 5064                           | 14471                       | 18408                | 7404                 | 35.0                                                                |
| 1984        | 4795                           | 14552                       | 20081                | 11863                | 33.0                                                                |
| 1985        | 4744                           | 13480                       | 21755                | 13946                | 35.2                                                                |
| 1986        | 3626                           | 9614                        | 29323                | 23590                | 37.7                                                                |
| 1987        | 3296                           | 8618                        | 27013                | 25753                | 38.2                                                                |
| 1988        | 288                            | 5947                        | 33242                | 31336                | 4.8                                                                 |
| 1989        | 289                            | 5963                        | 34929                | 35208                | 4.8                                                                 |
| 1990        | 289                            | 5260                        | 40569                | 41903                | 5.5                                                                 |

\* Firm + futura

\*\* Assuming all futura requirements are uncommitted

Production History: Comurhex

Detailed data on the production history of Comurhex is not available. It is estimated that the following quantities have been produced for commercial purposes:

Table 11.2.8  
(MTU)

| <u>Year</u> | <u>Quantity<br/>End-Product<br/>U Metal</u> | <u>Quantity<br/>End-Product<br/>UF<sub>6</sub></u> |
|-------------|---------------------------------------------|----------------------------------------------------|
| Pre-1977    | ~ 7,000                                     | ~ 14,000                                           |

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Projected Future Marketing Strategy

Domestic requirements for uranium metal and UF<sub>6</sub> will remain an exclusive market for Comurhex. Comurhex will continue to aggressively compete worldwide for UF<sub>6</sub> conversion services.

## Facility: CEA Enrichment Complex

### Description of Operation

The French CEA has been developing the gaseous diffusion process for isotope separation since 1953. In the early 1960's, the construction began on the Enrichment Complex at Pierrelatte by USSI. The first large stage of the low enrichment section was tested in 1962 and went into production in 1964. The facility reached its rated nominal capacity of around 400 MTSWU per year in 1967.

### Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The rated nominal capacity of the Pierrelatte enrichment facility is approximately 400 MTSWU. This facility is government-owned and only a portion of the capacity is available for light water reactors. The importance of this facility is expected to decline as the Eurodif enrichment complex begins to supply enriched material to light water reactors. Under this scenario, expansion of the Pierrelatte facility is not foreseen.

### Past and Present Marketing Strategy

The Pierrelatte facility was not originally intended for producing low enriched fuel for light water reactors. However, contracts exist with two Belgian (Doel-3 and Tihange-2) and one Swiss (Kaiseraugst) reactors. In these cases, production was committed from the Pierrelatte facility in order to aid Eurodif in obtaining long-term contracts. At the time of contracting, these reactors needed material before the Eurodif plant was scheduled to begin commercial production. Kaiseraugst has a long-term contract with Eurodif, and Belgium, being a partner in Eurodif, is already committed to a portion of the output.

### Market Share Attained and Production History

Only the three contracts mentioned above are committed to Pierrelatte. The amount of material (933 MTSWU) represents three first cores and two reloads with deliveries in 1978 and 1979.

### Projected Future Marketing Strategy

With the advent of the Eurodif enrichment capacity, it appears unlikely that the French will continue to meet commercial demands for enrichment services after the current contracts expire.



## Facility: Eurodif

### Description of Operation

The Eurodif plant is located in the Tricastin district of the Rhône Valley, adjacent to the existing Pierrelatte complex. Plant construction is on schedule, and the plant will reach full capacity in late 1981. Due to the construction progress of the four unit Tricastin power station, Eurodif will have to import up to 600 MWe from the French grid for startup. After the power station is fully operational, the plant should be able to supply 600-700 MWe to the grid above the enrichment plant requirements.

The enrichment plant consists of four separate buildings containing several groups of 20 diffusers each. The first building contains 14 groups of small diffusers; the second contains 20 groups of medium-size diffusers; the third has 16 groups of large diffusers; and the fourth contains 20 groups of large diffusers for a total of 1,400 groups. Buildings three and four consume three quarters of the power necessary in the diffusion operations. When fully operational, the plant will have four product removal stages.

### Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The capacity of the Eurodif enrichment facility will increase incrementally. Estimated production capacities are given as follows:

| <u>Year</u> | <u>Million SWU</u> |
|-------------|--------------------|
| 1979        | 2.8                |
| 1980        | 6.3                |
| 1981        | 8.7                |
| 1982 on     | 10.8               |

The next increment in capacity will be built by Coredif. While Coredif was set up as a new company, it will operate with Eurodif as a complex. Present plans call for a capacity of 2-4 million SWU in 1986, increasing incrementally to 10 million SWU in 1990.

### Past and Present Marketing Strategy

The capacity of the Eurodif plant is reported to be fully committed. The five partners have committed to take 90% of the output, and the remaining 10% is split between Japan, Switzerland and the Federal Republic of Germany. The small commitment to non-partners allowed Eurodif to establish itself as a commercial supplier of enrichment services. The sales to non-partners, along with the inclusion of Iran as a partner and the results of the Coredif feasibility study, probably provided the impetus to increase the plant capacity from the original 9 million SWU to 10.8 million SWU. However, the large commitment to the partners has prevented Eurodif from offering large quantities of enrichment services to non-partners.

The Italian and Spanish nuclear power programs have encountered significant delays and reductions. In addition, it now appears that the large Iranian nuclear power program will not develop as originally planned. Since these countries are partners in Eurodif and Coredif, the reductions in their nuclear power programs will affect both facilities.

Market Share Attained: Eurodif

Enrichment Services

Table 11.2.12  
(MTSWU)

Region: Domestic (France)

| <u>Year</u> | <u>Eurodif<br/>Deliveries<br/>to France</u> | <u>Total<br/>Deliveries<br/>to France</u> | <u>Total French<br/>Requirements</u> | <u>Eurodif<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|---------------------------------------------|-------------------------------------------|--------------------------------------|--------------------------------------------------------------------|
| pre-1978    | 0                                           | 2541                                      | 2559                                 | 0.0                                                                |
| 1978        | 0                                           | 1900                                      | 1753                                 | 0.0                                                                |
| 1979        | 2323                                        | 3835                                      | 2059                                 | 60.1                                                               |
| 1980        | 3498                                        | 4527                                      | 2567                                 | 77.3                                                               |
| 1981        | 3620                                        | 4591                                      | 2658                                 | 78.8                                                               |
| 1982        | 3816                                        | 4791                                      | 3603                                 | 79.6                                                               |
| 1983        | 4212                                        | 5217                                      | 4230                                 | 80.7                                                               |
| 1984        | 4037                                        | 4325                                      | 4537                                 | 93.3                                                               |
| 1985        | 2927                                        | 3155                                      | 5117                                 | 92.8                                                               |
| 1986        | 2923                                        | 3082                                      | 5391                                 | 94.8                                                               |
| 1987        | 2553                                        | 2692                                      | 5830                                 | 94.8                                                               |
| 1988        | 3637                                        | 2692                                      | 6568                                 | 94.5                                                               |
| 1989        | 6426                                        | 2452                                      | 6596                                 | 94.5                                                               |
| 1990        | 6426                                        | 2452                                      | 7128                                 | 94.5                                                               |

Market Share Attained: Eurodif

Enrichment Services

Table 11.2.12 (cont.)  
(MTSWU)

Region: Europe (non-France)

| <u>Year</u> | <u>Eurodif<br/>Deliveries</u> | <u>Total<br/>Deliveries</u> | <u>Requirements</u> | <u>Eurodif<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|-------------------------------|-----------------------------|---------------------|--------------------------------------------------------------------|
| pre-1978    | 0                             | 18498                       | 14724               | 0.0                                                                |
| 1978        | 0                             | 5590                        | 3403                | 0.0                                                                |
| 1979        | 175                           | 6466                        | 4796                | 2.7                                                                |
| 1980        | 1380                          | 7881                        | 4986                | 10.5                                                               |
| 1981        | 4240                          | 9379                        | 5379                | 18.6                                                               |
| 1982        | 2635                          | 7928                        | 6079                | 22.1                                                               |
| 1983        | 3184                          | 9358                        | 6800                | 22.6                                                               |
| 1984        | 3135                          | 9066                        | 7901                | 22.8                                                               |
| 1985        | 3710                          | 9502                        | 8844                | 26.4                                                               |
| 1986        | 3605                          | 9969                        | 10799               | 24.1                                                               |
| 1987        | 3824                          | 10050                       | 11418               | 26.1                                                               |
| 1988        | 3829                          | 9984                        | 11781               | 26.3                                                               |
| 1989        | 4204                          | 9531                        | 14081               | 28.5                                                               |
| 1990        | 4856                          | 8692                        | 13751               | 29.8                                                               |

Market Share Attained: Eurodif

Enrichment Services

Table 11.2.12 (cont.)

Region: International (non-France, non-US)

| <u>Year</u> | <u>Eurodif<br/>Deliveries</u> | <u>Total<br/>Deliveries</u> | <u>Requirements</u> | <u>Eurodif<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|-------------------------------|-----------------------------|---------------------|--------------------------------------------------------------------|
| pre-1978    | 0                             | 36756                       | 22596               | 0.0                                                                |
| 1978        | 0                             | 7131                        | 5131                | 0.0                                                                |
| 1979        | 175                           | 9504                        | 7449                | 1.8                                                                |
| 1980        | 2380                          | 11146                       | 7891                | 16.4                                                               |
| 1981        | 4230                          | 14346                       | 8662                | 24.2                                                               |
| 1982        | 4778                          | 14816                       | 10720               | 26.3                                                               |
| 1983        | 5307                          | 16934                       | 12785               | 25.0                                                               |
| 1984        | 5017                          | 16966                       | 15244               | 23.3                                                               |
| 1985        | 5700                          | 17773                       | 16634               | 25.3                                                               |
| 1986        | 5592                          | 20396                       | 19496               | 21.5                                                               |
| 1987        | 6001                          | 19680                       | 22024               | 24.4                                                               |
| 1988        | 6008                          | 18773                       | 23019               | 25.6                                                               |
| 1989        | 6382                          | 17997                       | 27786               | 27.2                                                               |
| 1990        | 6034                          | 16164                       | 27831               | 23.3                                                               |

### Future Marketing Strategy

The total capacity of the Eurodif facility is essentially committed over the long-term to the partners. However, it appears that the major portion of the Coredif facility is presently uncommitted and could be used to supply commercial enrichment services to non-partners.

The major delays in the Spanish, Italian and Iranian nuclear power programs (combined with general delays in most nations' nuclear power programs) have created a potential significant SWU oversupply. As a result, the major industrialized nations with large nuclear programs are not favorable enrichment customers. The largest available enrichment markets are with the developing countries. Presumably, Coredif and Eurodif will market in those countries in conjunction with Framatome/Cogema reactor and other fuel cycle service sales.

In addition, Eurodif plans to use the stockpiles of partner countries to fulfill long-term commitments until Coredif becomes operational.

Facility: FBFC Fuel Fabrication-Romans

Description of Operation

The facility for the fabrication of LWR fuel now under construction at Romans is located on the site of the existing LWR fuel assembly workshop of CERCA which has produced modest quantities of such fuel since the late 1960's. The LWR fuel fabrication facilities and activities of CERCA were officially integrated within FBFC in 1977.

The existing CERCA facility has the capability to manufacture PWR fuel starting from  $UO_2$  pellets. Conversion of enriched  $UF_6$  to  $UO_2$  is performed by BNFL. Pellets are manufactured either by the Dessel facility of FBFC in Belgium or are produced elsewhere in France. The new facility, which started operation in 1977, accepts enriched  $UF_6$ , converts to  $UO_2$  powder, produces pellets, manufactures rods, and assembles them into fuel bundles; i.e. it will be fully integrated. Specific details of operation are not known, but in principle should be similar to standard Westinghouse type operations. It is believed that the process for conversion of  $UF_6$  to  $UO_2$  powder is under license from BNFL.

Capacity, Capacity-Limiting Factors, Expansion Plans and New Facilities

The FBFC facility in Dessel, Belgium (see under Belgium) currently has a nominal capacity of some 200 MTU/year (excluding the production of  $UO_2$  powder from  $UF_6$ ). Expansion to 400 MTU/year is currently under way. Although published information indicates that Dessel will be expanded to 1,000 MTU/year by 1985, it is likely that it will only be expanded to the maximum corresponding to the equipment already in place or being installed (i.e. 400 MTU/year).

The original capacity of FBFC (the old CERCA facility) of 80 MTU/year (excluding powder and pellet production) was replaced by the new integrated facility of 200 MTU/year in 1977. Expansion will bring this to 300 MTU/year in 1978. The  $UF_6$  to  $UO_2$  production capacity will be around 600-700 MTU per year initially so that conversion work can be performed for the Dessel facility. Depending on the development of the market (and particularly domestic requirements), it is foreseen to expand the current total FBFC capacity to 1,000 MTU/year in 1981/82 and 1,400 MTU/year in 1983. This expansion will be effected by expanding the new facilities at the Romans site. The facility has been planned to permit simple expansion.

### Past and Present Marketing Strategy

Because of the involvement of domestic utilities and industry in the Franco-Belgian reactors Sena and Tihange-1, CERCA and MMN, the precursors of FBFC-France and -Belgium respectively, were able to obtain contracts for fuel fabrication for these reactors using Westinghouse licenses. However, large scale production, and thus importance, became possible with the inception of FBFC and the large French domestic program of PWR's. FBFC production is now principally marketed by Framatome. On the basis of the first cores and reloads supplied with reactors sold to EdF by Framatome, FBFC has become a major LWR fuel fabricator. In addition first cores and reloads have been sold by Framatome with its reactor exports to Belgium, South Africa and Iran. The latter includes 10 years of fuel fabrication services and a further 10 years of options.

Clearly the French market (and to a large extent the Belgian market) will remain for the most part captive to Framatome/FBFC. However, EdF only orders 2-3 reloads for each reactor at a time, so that FBFC must rebid each time and thus maintain a competitive position. In recent years Framatome has also competitively bid in the market outside of France for reload fuel for PWR's not originally sold by Framatome (e.g. Federal Republic of Germany, Netherlands, Sweden, Switzerland). So far no reload contracts for such reactors have been obtained. Demonstration assemblies are, however, being supplied to several reactors on a qualification basis.

Market Share Attained: FBFC

LWR Fuel Fabrication

Table 11.2.9  
(MTU)

Region: Domestic (France)

| <u>Year</u> | <u>FBFC<br/>Deliveries to<br/>France</u> | <u>Total<br/>Deliveries<br/>to<br/>France</u> | <u>Total<br/>French<br/>Requirements</u> | <u>Total<br/>French<br/>Uncommitted</u> | <u>FBFC<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|------------------------------------------|-----------------------------------------------|------------------------------------------|-----------------------------------------|-----------------------------------------------------------------|
| pre-1978    | 259                                      | 351                                           | 351                                      | 0                                       | 73.9                                                            |
| 1978        | 561                                      | 572                                           | 572                                      | 0                                       | 98.1                                                            |
| 1979        | 518                                      | 530                                           | 530                                      | 0                                       | 97.7                                                            |
| 1980        | 613                                      | 613                                           | 637                                      | 24                                      | 100.0                                                           |
| 1981        | 124                                      | 199                                           | 566                                      | 367                                     | 62.3                                                            |
| 1982        | 181                                      | 181                                           | 711                                      | 530                                     | 100.0                                                           |
| 1983        | 106                                      | 141                                           | 718                                      | 577                                     | 75.2                                                            |
| 1984        | 120                                      | 481                                           | 1169                                     | 688                                     | 24.9                                                            |
| 1985        | 205                                      | 205                                           | 1075                                     | 870                                     | 100.0                                                           |
| 1986        | 106                                      | 106                                           | 1217                                     | 1111                                    | 100.0                                                           |
| 1987        | 0                                        | 0                                             | 1209                                     | 1209                                    | 0.0                                                             |
| 1988        | 0                                        | 0                                             | 1384                                     | 1384                                    | 0.0                                                             |
| 1989        | 0                                        | 0                                             | 1354                                     | 1354                                    | 0.0                                                             |
| 1990        | 0                                        | 0                                             | 1460                                     | 1460                                    | 0.0                                                             |



Market Share Attained: FBFC

LWR Fuel Fabrication

Table 11.2.9 (cont.)  
(MTU)

Region: Europe (non-France)

| <u>Year</u> | <u>FBFC<br/>Deliveries</u> | <u>Total<br/>Deliveries</u> | <u>Requirements</u> | <u>Uncommitted</u> | <u>FBFC<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|----------------------------|-----------------------------|---------------------|--------------------|-----------------------------------------------------------------|
| pre-1978    | 146                        | 3612                        | 3612                | 0                  | 4.0                                                             |
| 1970        | 38                         | 871                         | 871                 | 0                  | 4.1                                                             |
| 1979        | 154                        | 1114                        | 1126                | 12                 | 13.8                                                            |
| 1980        | 24                         | 1065                        | 1233                | 168                | 2.3                                                             |
| 1981        | 11                         | 990                         | 1306                | 316                | 1.1                                                             |
| 1982        | 152                        | 775                         | 1373                | 869                | 19.6                                                            |
| 1983        | 39                         | 768                         | 1590                | 822                | 5.1                                                             |
| 1984        | 85                         | 746                         | 1749                | 1003               | 11.4                                                            |
| 1985        | 58                         | 583                         | 2131                | 1548               | 9.9                                                             |
| 1986        | 58                         | 678                         | 2610                | 1932               | 8.6                                                             |
| 1987        | 29                         | 504                         | 2862                | 2358               | 5.8                                                             |
| 1988        | 0                          | 393                         | 2723                | 2330               | 0.0                                                             |
| 1989        | 0                          | 461                         | 3490                | 3029               | 0.0                                                             |
| 1990        | 0                          | 285                         | 3112                | 2827               | 0.0                                                             |

Market Share Attained: FBFC

LWR Fuel Fabrication

Table 11.2.9 (cont.)  
(MTU)

Region: International (non-France, non-US)

| <u>Year</u> | <u>FBFC<br/>Deliveries</u> | <u>Total<br/>Deliveries</u> | <u>Requirements</u> | <u>Uncommitted</u> | <u>FBFC<br/>Market Share<br/>of Committed<br/>Deliveries, %</u> |
|-------------|----------------------------|-----------------------------|---------------------|--------------------|-----------------------------------------------------------------|
| pre-1978    | 146                        | 6021                        | 6021                | 0                  | 2.4                                                             |
| 1978        | 36                         | 1084                        | 1136                | 52                 | 3.3                                                             |
| 1979        | 154                        | 1562                        | 1854                | 292                | 9.9                                                             |
| 1980        | 24                         | 1460                        | 3864                | 581                | 1.6                                                             |
| 1981        | 84                         | 1444                        | 4173                | 806                | 5.8                                                             |
| 1982        | 225                        | 1134                        | 2484                | 1350               | 19.8                                                            |
| 1983        | 111                        | 1345                        | 3268                | 1923               | 8.3                                                             |
| 1984        | 185                        | 1278                        | 3606                | 2328               | 14.5                                                            |
| 1985        | 130                        | 1109                        | 4557                | 3448               | 11.7                                                            |
| 1986        | 153                        | 1051                        | 4672                | 3621               | 14.6                                                            |
| 1987        | 123                        | 726                         | 5680                | 4954               | 16.9                                                            |
| 1988        | 94                         | 594                         | 5636                | 6062               | 15.8                                                            |
| 1989        | 71                         | 637                         | 7020                | 6383               | 11.1                                                            |
| 1990        | 24                         | 418                         | 6695                | 6277               | 5.7                                                             |

### Production History

It is estimated that the following quantities of PWR fuel have been produced by both of the FBFC facilities:

Table 11.2.10  
(MTU)

| <u>Year</u> | <u>Quantity of Fuel</u> |
|-------------|-------------------------|
| 1974        | 84                      |
| 1975        | 134                     |
| 1976        | 186                     |
| <u>1977</u> | <u>123</u>              |

### Projected Future Marketing Strategy

One of the main aims will be to maintain a 100% or close to 100% share of the French and Belgian markets, which, providing FBFC remains competitive, should not prove difficult. Similar efforts will be made to sell additional reloads to other Framatome-supplied reactors. An increased effort is anticipated for sales to other countries as FBFC gains more experience and the rapidly increasing capacity improves its fuel fabrication economics.

Facility: CERCA Fuel Fabrication Plant

As described above, the LWR fuel fabrication activities of the CERCA plant at Romans were transferred to FBFC in 1977. There still exists at CERCA fuel fabrication facilities for the French heavy water reactors EL-3 and EL-4 (oxide fuel), for French gas-graphite reactors (uranium metal fuel), and for UO<sub>2</sub> fuel rods for the fertile regions of fast reactors such as Rapsodie and Phenix.

Few details are known of these operations except that each are relatively modest in size. In 1971, it was published that the nominal fabrication capacity for gas-graphite fuels was 900 MTU/year, and 20 MTU/year for heavy water reactor fuel. Since no additional units of this type have been ordered since then and since none are planned, it is unlikely that these capacities have been increased.

Historically, the facilities have basically been used to meet domestic requirements for these types of fuels. CERCA has apparently supplied all domestic requirements for heavy water reactor oxide fuel, and it is estimated that over 100 MTU has been produced. For the gas-graphite reactors and FBR's, the market is shared between CERCA and SICN; however, the split is not known. It is estimated that the two companies have produced between them 8,000-9,000 MTU of metal fuel for gas-graphite reactors, including supplies to the Vandellós reactor in Spain.

In the future, no change from this basic domestic market orientation is expected.

Facility: SICN Fuel Fabrication Plants

SICN has a plant at Annecy for the fabrication of metal fuel for gas-graphite reactors, and a production center at Veurey where oxide rods are manufactured for the fertile regions of FBR's such as Rapsodie and Phenix.

Practically no details are known. The capacity for the fabrication of metal fuels was given in 1971 as 1,200 MTU per year. It is unlikely that this has been increased.

Historically the facilities have been basically used to meet domestic requirements for these type of fuels, together with CERCA. No change in this situation is foreseen in the near future.

#### Facility: Plutonium Workshops ATPu, Cadarache

Mixed oxide fabrication capability has existed at the Cadarache Research Center of the CEA since the 1960's. PuO<sub>2</sub> from Marcoule or La Hague reprocessing plants is blended with UO<sub>2</sub> to produce the mixed oxide powder. Pellets and rods are produced. UO<sub>2</sub> rods are subcontracted to SICN or CERCA, and final assembly is done at Cadarache.

#### Capacity, Capacity-Limiting Factors, Expansion Plans and New Facilities

The mixed oxide fabrication capacity is up to three cores per year for the Rapsodie pilot FBR, (i.e. 500 kg mixed oxide) and 1 core per year for the Phenix FBR (i.e. 4 MT mixed oxide). In 1976, the facility was expanded to be able to fabricate the first core of Super-Phenix. The current capacity is estimated to be 10 MT of mixed oxide fuel per year.

#### Past and Present Marketing Strategy

For domestic mixed oxide fuel, CEA has a monopoly. There has been little international marketing of mixed oxide fuel fabrication services.

#### Market Share Attained

Because of the complexities of mixed oxide fuel fabrication, in which several fabricators may be involved, and the limited nature of the market, the market share obtained by CEA in comparison with other fabricators and the overall market is shown in the form given in Table 11.2.11. This refers to all significant mixed oxide fabrication for thermal reactors in Europe. There is currently negligible activity in this area. CEA's contribution to power production for FBR fuel is shown in Table 11.2.12.

PLUTONIUM FUEL FABRICATION FOR THERMAL REACTORS IN EUROPE

Table 11.2.11

| Reactor Name/<br>Country | Year<br>of Fuel<br>Delivery | No. of<br>Assemblies* | Name of Supplier |              |              |
|--------------------------|-----------------------------|-----------------------|------------------|--------------|--------------|
|                          |                             |                       | Pellets          | Rods         | Assembly     |
| Obrigheim/Germany        | 1972                        | 1                     | Alkem            | Alkem        | RBU          |
|                          | 1973                        | 8                     | Alkem            | Alkem        | RBU          |
|                          | 1974                        | 4                     | Alkem            | Alkem        | RBU          |
|                          | 1975                        | 8                     | Alkem            | Alkem        | RBU          |
|                          | 1976                        | 12                    | Alkem            | Alkem        | RBU          |
| Gundremingen-A/Germany   | 1974                        | 16                    | Alkem            | Alkem        | RBU          |
|                          | 1975                        | 24                    | Alkem            | Alkem        | RBU          |
|                          | 1976                        | 24                    | Alkem            | Alkem        | RBU          |
|                          | 1977                        | 16                    | Alkem            | Alkem        | RBU          |
| Lingen/Germany           | 1970                        | 1                     | KRT              | KRT          | KRT          |
| Kahl/Germany             | 1966                        | 1                     | BNFL             | BNFL         | BNFL         |
|                          | 1968                        | 2                     | CNEN             | CNEN         | (CNEN)       |
|                          | 1969                        | 4                     | Alkem            | Alkem        | RBU          |
|                          | 1970                        | 16                    | Alkem            | Alkem        | RBU          |
|                          | 1973                        | 18                    | Alkem            | Alkem        | RBU          |
|                          | 1975                        | 18                    | Exxon            | Exxon        | Exxon        |
|                          | 1976                        | 18                    | Alkem            | Alkem        | RBU          |
|                          | 1977                        | 18                    | Alkem            | Alkem        | RBU          |
|                          | 1978                        | 18                    | Alkem            | Alkem        | RBU          |
| Sena-Chooz/France        | 1974                        | 4                     | BN               | BN/CEA       | RBU          |
|                          | 1975                        | 2                     | (BNFL)           | FBFC         | FBFC         |
| Beznau-1/Switzerland     | 1978                        | 4                     | Westinghouse     | Westinghouse | Westinghouse |
| Oskarshamn-1/Sweden      | 1974                        | 3                     | BN               | BN           | ASEA         |

Table 11.2.11 (cont'd)

| Reactor Name/<br>Country | Year<br>of Fuel<br>Delivery | No. of<br>Assemblies* | Name of Supplier |              |              |
|--------------------------|-----------------------------|-----------------------|------------------|--------------|--------------|
|                          |                             |                       | Pellets          | Rods         | Assembly     |
| Dodewaard/Netherlands    | 1970                        | 2                     | BN               | BN           | BN           |
|                          | 1973                        | 4                     | BN               | BN           | BN           |
|                          | 1974                        | 7                     | BN               | BN           | BN           |
| Trino/Italy              | 1976                        | 8                     | Westinghouse     | Westinghouse | Westinghouse |
| Garigliano/Italy         | (1968)                      | 4                     | GE               | GE           | GE           |
|                          | (1968)                      | 8                     | BNFL             | BNFL         | BNFL         |
|                          | 1968                        | 4                     | BN/Alkem         | BN/Alkem     | FN           |
|                          | 1975                        | 46                    | BN               | BN           | FN           |
| Winfrith SGHWR/UK        | 1959                        | 1                     | BNFL             | BNFL         | BNFL         |
| Windscale AGR/UK         | 1963                        | 4                     | BNFL             | BNFL         | BNFL         |

\* Includes "all plutonium" rod assemblies and "island" concept assemblies.



PLUTONIUM FUEL FABRICATION FOR PROTOTYPE FAST BREEDER REACTORS IN EUROPE

Table 11.2.12

| Reactor Name/<br>Country | Year<br>of Fuel<br>Delivery | No. of<br>Assemblies* | Name of Supplier |      |          |
|--------------------------|-----------------------------|-----------------------|------------------|------|----------|
|                          |                             |                       | Pellets          | Rods | Assembly |
| SNR-300/Germany          | N/A                         | 123 (Mark Ia)*        | Alkem            | RBU  | RBU      |
|                          | 1980                        | 82 (Mark Ia)*         | BN               | BN   | BN       |
| Dounreay PFR/UK          | 1974                        | 78*                   | BNFL             | BNFL | BNFL     |
|                          | thru 1977                   | reloads               | BNFL             | BNFL | BNFL     |
| Phenix/France            | 1972                        | 120**                 | CEA              | CEA  | CEA      |
|                          | thru 1977                   | (FC: 103)<br>reloads  | CEA              | CEA  | CEA      |

\* First Core  
 \*\* First core + 17 spares

### Projected Future Marketing Strategy

Unless plutonium recycle in thermal reactors is adopted in France (which does not appear to be the current trend), it is unlikely that CEA will make any significant efforts in this direction.

The market for fast reactor fuel is essentially limited. It is restricted to the Prototype Fast Reactor for which BNFL will supply fuel, Rapsodie, Phenix and Super-Phenix for which CEA will supply most fuel, and SNR-300 for which Alkem and Belgonucléaire will supply fuel.

## Facility: Marcoule Reprocessing Plant

### Description of Operation

The UP1 reprocessing facility at Marcoule began operation in 1958 with a capacity of approximately 900 tonnes per year. This plant was originally used to reprocess fuel from the Marcoule G1, G2 and G3 reactors for the French military program. Later, the facility was upgraded to about 1,000 tonnes per year capacity.

Both chemical and mechanical decanning techniques may be used to feed the dissolvers. The chemical extraction process used is the PUREX process producing uranium diuranate and either plutonium metal or oxide. Cesium and strontium are recovered from the waste stream which is then vitrified or cast in bitumen.

The UP1 facility is currently used to reprocess much of the Magnox fuel discharged in the French nuclear power program. However, some of this fuel will be reprocessed at La Hague until 1981. After that time, Marcoule will be the sole site for reprocessing of Magnox fuel.

### Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

The present capacity of the UP1 reprocessing facility is approximately 1,000 tonnes per year. The capacity of the plant appears sufficient to meet Magnox fuel reprocessing requirements in France. Therefore, it is doubtful at this time that the facility will be further expanded, and no new Magnox fuel reprocessing plant is foreseen.

### Past, Present and Future Marketing Strategy

As in the past, the UP1 facility will continue to reprocess domestic fuel from the gas-graphite reactors. No change is foreseen in this policy.

### Market Share Attained and Production History

Both UP1 and UP2 (La Hague) have reprocessed Magnox reactor fuel. The amount processed by each plant is unknown. However, these plants have 100% of the domestic market plus spent fuel from the Vandellós gas-graphite reactor in Spain. It is estimated that a total of 3,000-4,000 MTHM of Magnox fuel has been reprocessed to date.

## Facility: La Hague Irradiated Fuel Reprocessing Center

### Description of Operation

The La Hague Center is the site of the UP2 and planned UP3 reprocessing facilities. Construction of UP2 began in 1961 and industrial operation began January 1, 1967. When constructed, the UP2 facility was intended for the reprocessing of gas-graphite reactor fuel. However, as the French nuclear program developed and it was evident that France would rely on oxide fuel, a new section called "High Activity Oxide (HAO)" was added in 1976 to accommodate high burnup oxide fuel.

The UP2 facility uses a TBP solvent extraction process (PUREX). The main separation stages (fission products, uranium and plutonium) are repeated in several extraction cycles. In the UP2 facility, the maximum number of cycles is:

- metal fuel
  - 2 cycles for uranium
  - 3 cycles for plutonium
- oxide or mixed oxide fuel
  - 3 cycles for uranium
  - 4 cycles for plutonium

After purification, the plutonium is processed into oxide form and then to metal (optional).

Until 1981, UP2 will be used to alternately reprocess Magnox (350 tonnes/year) and LWR fuel (150 tonnes/year). Then it will be solely devoted to the reprocessing of oxide fuel with Magnox fuel reprocessed at Marcoule.

### Capacity, Capacity-Limiting Factors, Expansion Plans, and New Facilities

After start-up, UP2 has been slowly increasing capacity and is scheduled to reach full capacity of 800 tonnes per year in 1983. Further expansion of this facility is not planned. However, plans exist to construct two new facilities, UP3A and UP3B, at La Hague. These plants will have a capacity of 800 tonnes per year each and are expected to begin operation in 1985 and 1989. New contracts have been successfully negotiated to provide the commitment and front money necessary to proceed with the construction of these facilities.

### Past and Present Marketing Strategy

BNFL was the first organization to provide promise of large scale commercial reprocessing. Along with the multi-national Eurochemic organization, BNFL captured the majority of the reprocessing market prior to the restart-up accident in 1973. At that time, politics were such that it was uncertain when BNFL could get another plant operational. The Eurochemic plant was shut down in 1974, and it became apparent that France, with the oxide headend UP2 plant beginning operation in 1976, was the only country able to offer near-term commercial reprocessing.

France then began to aggressively market reprocessing services. Domestic requirements would take precedence over other contracts, but France fully intended to be an international supplier. Since that time, France has been very successful in gaining reprocessing contracts, and even succeeded in obtaining half of the 3,200 MTU contract with Japan that BNFL had been negotiating.

Market Share Attained: Cogema

LWR Fuel Reprocessing

Table 11.2.12  
(MTU)

Region: Domestic (France)

| <u>Year</u> | <u>Cogema<br/>Commitments</u> | <u>Total<br/>French<br/>Commitments*</u> | <u>Cogema<br/>Market Share<br/>of Committed<br/>Requirements, %</u> |
|-------------|-------------------------------|------------------------------------------|---------------------------------------------------------------------|
| pre-1978    | 71                            | 71                                       | 100                                                                 |
| 1978        | 0                             | 0                                        | 100                                                                 |
| 1979        | 12                            | 12                                       | 100                                                                 |
| 1980        | 72                            | 72                                       | 100                                                                 |
| 1981        | 121                           | 121                                      | 100                                                                 |
| 1982        | 321                           | 321                                      | 100                                                                 |
| 1983        | 490                           | 490                                      | 100                                                                 |
| 1984        | 594                           | 594                                      | 100                                                                 |
| 1985        | 695                           | 695                                      | 100                                                                 |
| 1986        | 741                           | 741                                      | 100                                                                 |
| 1987        | 887                           | 887                                      | 100                                                                 |
| 1988        | 987                           | 987                                      | 100                                                                 |
| 1989        | 1109                          | 1109                                     | 100                                                                 |
| 1990        | 1178                          | 1178                                     | 100                                                                 |

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\* Firm contracts do not exist, but fuel from French LWR's will be reprocessed by Cogema.

Market Share Attained: Cogema

LWR Fuel Reprocessing

Table 11.2.12 (cont.)  
(MTU)

Region: Europe (non-France)

| <u>Year</u> | <u>Cogema<br/>Commitments</u> | <u>Total<br/>Commitments*</u> | <u>Cogema<br/>Market Share<br/>of<br/>Commitments, %</u> |
|-------------|-------------------------------|-------------------------------|----------------------------------------------------------|
| pre-1978    | 257 (71**)                    | 675                           | 38.1                                                     |
| 1978        | 204                           | 256                           | 79.7                                                     |
| 1979        | 215                           | 292                           | 73.6                                                     |
| 1980        | 261                           | 312                           | 83.7                                                     |
| 1981        | 516                           | 550                           | 93.8                                                     |
| 1982        | 484                           | 486                           | 99.6                                                     |
| 1983        | 451                           | 461                           | 97.8                                                     |
| 1984        | 459                           | 468                           | 98.1                                                     |
| 1985        | 482                           | 492                           | 98.0                                                     |
| 1986        | 251                           | 253                           | 99.2                                                     |
| 1987        | 251                           | 254                           | 98.8                                                     |
| 1988        | 231                           | 233                           | 99.1                                                     |
| 1989        | 211                           | 211                           | 100.0                                                    |
| 1990        | 195                           | 228                           | 85.5                                                     |

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\* Includes discharges from British reactors for which actual contracts do not exist.

\*\* Actually reprocessed.

Market Share Attained: Cogema

LWR Fuel Reprocessing

Table 11.2.12 (cont.)  
(MTU)

Region: International (non-France, non-US)

| <u>Year</u> | <u>Cogema<br/>Commitments</u> | <u>Total<br/>Commitments*</u> | <u>Cogema<br/>Market Share<br/>of<br/>Commitments, %</u> |
|-------------|-------------------------------|-------------------------------|----------------------------------------------------------|
| pre-1978    | 257 (71**)                    | 916                           | 28.1                                                     |
| 1978        | 217                           | 428                           | 50.7                                                     |
| 1979        | 352                           | 496                           | 71.0                                                     |
| 1980        | 411                           | 609                           | 67.5                                                     |
| 1981        | 666                           | 883                           | 75.4                                                     |
| 1982        | 649                           | 860                           | 75.5                                                     |
| 1983        | 641                           | 910                           | 70.4                                                     |
| 1984        | 609                           | 859                           | 70.9                                                     |
| 1985        | 682                           | 1207                          | 56.5                                                     |
| 1986        | 451                           | 1062                          | 42.5                                                     |
| 1987        | 451                           | 1059                          | 42.6                                                     |
| 1988        | 451                           | 1079                          | 41.8                                                     |
| 1989        | 431                           | 1089                          | 39.6                                                     |
| 1990        | 550                           | 1382                          | 39.8                                                     |

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\* Includes discharges for British reactors for which actual contracts do not exist.

\*\* Actually reprocessed.



### Production History

Until early 1978, the UP2 facility had been operating on an "experimental" campaign basis. Two HAO campaigns have been undertaken. Fourteen tonnes of fuel from the Muehleberg reactor were reprocessed in 1976, and the second campaign, beginning in November, 1977, has reprocessed approximately forty-one tonnes of fuel from Stade. The third campaign is now underway.

### Future Marketing Strategy

Cogema will continue to aggressively market reprocessing services throughout the world. BNFL is presently the only real competitor, and the THORP plant is not scheduled for operation until the late 1980's. Therefore, Cogema will probably maintain a marketing edge, although BNFL is obtaining contracts for future services.

In addition, there is an indication that Cogema may link reprocessing services to other fuel cycle services (i.e. enrichment) to add some leverage to its total marketing efforts.

## NUCLEAR DEVELOPMENT OUTLOOK SUMMARY

### Vested Interest in Current Fuel Cycles and Reactor Technologies

France has an enormous vested interest by both Government and private industry in existing Magnox reactors, LWR's and FBR's, and in their fuel cycles. There is a stated national goal to drastically restrict oil imports and place massive reliance on nuclear power as a future energy source. A large program of LWR's is under construction and projected.

France possesses a powerful LWR vendor and full industrial capability to supply all components and equipment. FBR's have been domestically developed and the first large commercial unit is under construction.

In the fuel cycle, France is involved from the supply of uranium through reprocessing. Massive investments have been made in all sectors and France possesses the only operating oxide reprocessing plant of significance in the world. Reprocessing and the use of plutonium in FBR's is being implemented.

In addition to being domestically self-sufficient, France is adopting an aggressive marketing policy abroad for reactors, fuel services, and technology transfers. This is viewed both as an important contribution to exports and as an extension of French commercial influence. Through many of its joint undertakings, strong commercial-political relationships are being established with many developed and developing nations.

### Current Trends in Nuclear Development Programs

For the near- to mid-term, there is a firm commitment to LWR technology. Commercial exploitation of FBR's has commenced and a full program will be implemented in the 1990's.

### 11.3 NUCLEAR TECHNOLOGY CAPABILITY AND RESOURCES

#### PROFESSIONAL LABOR FORCE PROFILE

Table 11.3.1

Available information presents the following data for 1972:

300,786 Engineers, architects, and  
Scientists

#### KEY TECHNICAL EDUCATIONAL RESOURCES

Table 11.3.2

| <u>Institution</u>                                    | <u>Location</u>    |
|-------------------------------------------------------|--------------------|
| Université de Provence                                | Marseille          |
| Université d' Aix Marseille II                        | Marseille          |
| Université de Bordeaux I                              | Talence            |
| Université technologique de Compiègne                 | Compiègne          |
| Université scientifique et medicale                   | Grenoble           |
| Université des Sciences et Techniques                 | Villeneuve d' Ascq |
| Université Claude Bernard                             | Lyon               |
| Université des Sciences et Techniques<br>du Languedoc | Montpellier        |
| Université de Nancy I                                 | Nancy              |
| Université de Nantes                                  | Nantes             |
| Université de Nice                                    | Nice               |
| Université Paris VI                                   | Paris              |
| Université de Paris-Sud                               | Orsay              |
| Université Louis Pasteur                              | Strasbourg         |
| Université Paul Sabatier                              | Toulouse           |
| Institut national polytechnique de Grenoble           | Grenoble           |
| Institut national polytechnique de Nancy              | Nancy              |

KEY GOVERNMENTAL NUCLEAR RESEARCH ORGANIZATIONS

Table 11.3.3

| <u>Name</u>                                    | <u>Location</u>                        | <u>Main Activities</u>                                                                                                                                                                                                                                                    |
|------------------------------------------------|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Saclay Centre d'Etudes Nucleaires (CEN-S)      | Gif-sur-Yvette                         | Largest nuclear research center in France, with over 3,000 scientists, engineers, and skilled workers. Activities are in fuels, moderators, isotope separation, activation analysis, radioisotope production, reactor physics, solid state physics, electronics, biology. |
| Fontenay-aux-Roses (CEN-FAR)                   | Chatillon                              | Radiation monitoring, health physics, liquid metal coolants, ore processing, uranium refining, fusion. Staff of about 1,100.                                                                                                                                              |
| Grenoble Centre d' Etudes                      | Grenoble                               | Fundamental research, ion plasmas, heat transfer. Staff of 2,000.                                                                                                                                                                                                         |
| Cadarache Centre d' Etudes Nucleaires (CEN-CA) | St. Paul les Durance<br>(B. du Rehone) | Fast reactors. Staff of over 2,000.                                                                                                                                                                                                                                       |

# KEY PRIVATE NUCLEAR RESEARCH ORGANIZATIONS

Table 11.3.4

| <u>Name</u> | <u>Owner</u> | <u>Location</u> | <u>Main Activities</u> |
|-------------|--------------|-----------------|------------------------|
|-------------|--------------|-----------------|------------------------|

Nuclear research in France is predominately controlled by the CEA. R&D in private companies is almost completely directed towards commercial development and application. The CEA supports these activities through strong technology transfer programs. In 1972, Technicatome was formed as a joint subsidiary of CEA and EDF to take over all previous CEA beginning activities. In 1975, CEA purchased 30% of Framatome from Westinghouse. A four party R&D agreement was established between CEA, EDF, Framatome and Westinghouse. The R&D effort is totally in the area of large PWRs, funded at FR 90 million per year through 1982.

Other development work is undertaken by Framatome on pressure vessels, Jeumont-Sebneider on main coolant pumps and control rod drives, FBFC in fuel fabrication, Eurodif/Coredif in enrichment and Comurhex in UF<sub>6</sub> conversion.

RESEARCH AND TEST REACTORS  
List of Reactors

Table 11.3.5

| <u>Facility Name</u> | <u>Location</u>                     | <u>Owner</u> | <u>Constructor</u> | <u>Facility Type</u>                           | <u>Facility Status</u> |                |            |
|----------------------|-------------------------------------|--------------|--------------------|------------------------------------------------|------------------------|----------------|------------|
|                      |                                     |              |                    |                                                | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u> |
| Peggy                | Cadarache Nuclear Center, Cadarache | CEA          | CEA                | Pool, 93% U, H <sub>2</sub> O                  | 0.001                  | 0              | 1961       |
| Eole                 | Cadarache                           | CEA          | CEA                | tank, variable enrichment, D <sub>2</sub> O    | 0.01                   | 0              | 1965       |
| Chaudiere            | Cadarache                           | CEA          | CEA                | PWR, enriched UO <sub>2</sub>                  | 100                    | 0              | 1975       |
| Isis                 | Saclay Research Center, Saclay      | CEA          | CEA & PROSIR       | pool, 93% U, H <sub>2</sub> O                  | 0.1                    | 0              | 1966       |
| EL-3                 | Saclay                              | CEA          | CEA                | tank, 1.35% U, D <sub>2</sub> O                | 20                     | 0              | 1957       |
| EL-2                 | Saclay                              | CEA          | CEA                | tank, nat U, D <sub>2</sub> O, CO <sub>2</sub> | 2                      | S              | 1952/65    |
| EL-1                 | Fontenay-aux-Roses Research Centre  | CEA          | CEA                | tank, nat U, D <sub>2</sub> O                  | 0.15                   | 0              | 1948       |
| Osiris               | Saclay                              | CEA          | CEA                | pool, 93% U, H <sub>2</sub> O                  | 70                     | 0              | 1966       |
| Proserpire           | Saclay                              | CEA          | CEA                | Agu, homogeneous, Pu, H <sub>2</sub> O         | 10-6                   | 0              | 1958       |

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

RESEARCH AND TEST REACTORS  
List of Reactors

Table 11.3.5 (Continued)

| <u>Facility<br/>Name</u>              | <u>Location</u>                       | <u>Owner</u>           | <u>Constructor</u>   | <u>Facility<br/>Type</u>                             | <u>Facility Status</u> |                |                |
|---------------------------------------|---------------------------------------|------------------------|----------------------|------------------------------------------------------|------------------------|----------------|----------------|
|                                       |                                       |                        |                      |                                                      | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u>     |
| Ulysse                                | Saclay                                | CEA                    | CEA & Auxil-<br>Atom | Argonaut, 90%<br>U-Al, graphite,<br>H <sub>2</sub> O | 0.1                    | 0              | 1961           |
| Alecto                                | Saclay                                | CEA                    | CEA                  | Aqu, homo-<br>geneous, U &<br>Pu, H <sub>2</sub> O   | 10 <sup>-6</sup>       | S              | 1961/65        |
| Alize                                 | Saclay                                | CEA                    | CARATOM              | tank, variable<br>fuel, H <sub>2</sub> O             | 10 <sup>-6</sup>       | S              | 1959/67        |
| Aquilon                               | Saclay                                | CEA                    | CEA                  | tank, nat. U,<br>D <sub>2</sub> O                    | 10 <sup>-6</sup>       | S              | 1956/67        |
| Triton                                | Fontenay-aux-Roses<br>Research Centre | CEA                    | Indatom              | pool, 20% U,<br>H <sub>2</sub> O                     | 0.0001                 | 0              | 1959           |
| Minerve                               | Fontenay-aux-Roses<br>Research Centre | CEA                    | Indatom              | pool, 20% U,<br>H <sub>2</sub> O                     | 0.0001                 | 0              | 1959           |
| Strasbourg-<br>Cronenbourg            | Strasbourg                            | Univ. of<br>Strasbourg | CEA                  | Argonaut,<br>90% U-Al,<br>graphite, H <sub>2</sub> O | 0.0001                 | 0              | 1966           |
| Rapsodie<br>(Rapsodie-<br>Fortissimo) | Cadarache                             | CEA                    | EURATOM-CEA          | Prototype fast<br>breeder, 60%<br>U & Pu, Na         | 41                     | 0              | 1967<br>(1970) |

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

## RESEARCH AND TEST REACTORS

List of ReactorsTable 11.3.5 (Continued)

| <u>Facility Name</u> | <u>Location</u>                    | <u>Owner</u> | <u>Constructor</u> | <u>Facility Type</u>                                         | <u>Facility Status</u> |                |                                           |
|----------------------|------------------------------------|--------------|--------------------|--------------------------------------------------------------|------------------------|----------------|-------------------------------------------|
|                      |                                    |              |                    |                                                              | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u>                                |
| Harmonie             | Cadarache                          | CEA          | Belgonucleaire     | fast reactor experiment, 93% U, air                          | .002                   | 0              | 1965                                      |
| Masurca              | Cadarache                          | CEA          | Belgonucleaire     | fast reactor experiment, 30% U, 25% Pu in U-Pu-Fe alloy, air | .001                   | 0              | 1966                                      |
| Azur                 | Cadarache                          | CEA          | DPN-CEA            | pool, variable fuel, H <sub>2</sub> O                        | negligible             | 0              | 1962                                      |
| Marius               | Cadarache                          | CEA          | CEA                | nat. U, graphite                                             | 0.001                  | 0              | 1960<br>(Marcoule)<br>1965<br>(Cadarache) |
| Cesar                | Cadarache                          | CEA          | CEA                | 0.96% U, graphite, CO <sub>2</sub>                           | 0.01                   | 0              | 1964                                      |
| Cabri                | Cadarache                          | CEA          | CEA                | pool, 90% U, H <sub>2</sub> O                                | transcient             | 0              | 1963                                      |
| Nereide              | Fontenay-aux-Roses Research Centre | CEA          | CEA                | pool, 20% U, H <sub>2</sub> O                                | 0.6                    | 0              | 1960                                      |

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



## RESEARCH AND TEST REACTORS

List of ReactorsTable 11.3.5 (Continued)

| <u>Facility<br/>Name</u>      | <u>Location</u> | <u>Owner</u>                                | <u>Constructor</u>                          | <u>Facility<br/>Type</u>            | <u>Facility Status</u> |                |            |
|-------------------------------|-----------------|---------------------------------------------|---------------------------------------------|-------------------------------------|------------------------|----------------|------------|
|                               |                 |                                             |                                             |                                     | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u> |
| Grenoble High<br>Flux Reactor | Grenoble        | Max von Laue-<br>Paul Langevin<br>Institute | Max von Laue-<br>Paul Langevin<br>Institute | tank, 93% U,<br>D <sub>2</sub> O    | 60                     | 0              | 1971       |
| Melusine                      | Grenoble        | CEA                                         | Indatom                                     | pool, 93% U-A1,<br>H <sub>2</sub> O | 8                      | 0              | 1958       |
| Siloe                         | Grenoble        | CEA                                         | CEA & Indatom                               | pool, 93% U,<br>H <sub>2</sub> O    | 30                     | 0              | 1963       |
| Siloette                      | Grenoble        | CEA                                         | CEA & Indatom                               | pool, 93% U,<br>H <sub>2</sub> O    | 0.1                    | 0              | 1964       |
| Pegase                        | Cadarache       | CEA                                         | CEA                                         | tank, 93% U,<br>H <sub>2</sub> O    | 35                     | 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 11.3.6

| <u>Vendor</u> | <u>Country</u> | <u>Facility<br/>Name</u> | <u>Facility<br/>Type</u>    | <u>Facility Status</u> |                |            | <u>Scope of<br/>Services</u> |
|---------------|----------------|--------------------------|-----------------------------|------------------------|----------------|------------|------------------------------|
|               |                |                          |                             | <u>MW(th)</u>          | <u>Status*</u> | <u>COD</u> |                              |
| GAAA          | Italy          | ESSOR                    | Tank                        | 40                     | 0              | 1967       | Constructor                  |
| --            | Israel         | IRR-2<br>(Dimona)        | Nat.-U.<br>D <sub>2</sub> O | 26                     | 0              | --         | Constructor                  |

France has complete indigenous capability to design, manufacture, construct, operate, and maintain research reactors within CEA. See Table 11.3.5 for listing of domestically constructed research reactors.

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

SUMMARY OF FUEL SERVICES FOR RESEARCH AND TEST REACTORSTable 11.3.7

| Facility<br>Name                               | Location  | Facility<br>Type                                                         | Capacity Status                                                     |         |      | Shareholdings                             |
|------------------------------------------------|-----------|--------------------------------------------------------------------------|---------------------------------------------------------------------|---------|------|-------------------------------------------|
|                                                |           |                                                                          | MT/YR                                                               | Status* | Year |                                           |
| CERCA                                          | Romans    | Fabrication<br>of fuel ele-<br>ments for<br>research<br>& MTR            | 12,000<br>plates/yr<br>current production<br>~10,000 plates/yr      | 0       | --   | Creusot-Loire 50%<br>PUK 48%<br>Others 2% |
| <u>FUEL FABRICATION FOR PROTOTYPE REACTORS</u> |           |                                                                          |                                                                     |         |      |                                           |
| SICN                                           | Veurey    | Ass. for fast<br>reactors                                                | 100 ass./yr                                                         | 0       | --   | ALSPI-SO EZ 75%                           |
|                                                |           | Ass. for the<br>blanket                                                  | 20 ass./yr                                                          | 0       | --   | SGN 25%                                   |
|                                                | Annecy    | Metallic uranium<br>fuel for GG UO <sub>2</sub><br>fuel                  | 1,200 t/yr<br>50 t/yr                                               | 0       | --   | --                                        |
| CEA                                            | Cadarache | MO <sub>2</sub> for recycle elements<br>MO <sub>2</sub> for fast breeder | 15 t/yr<br>~5.5 t Pu eq./yr<br>(Rapsodie, Phenix<br>& Super Phenix) | 0       | --   | CEA (Gov.) 100%                           |
| CORHAT                                         |           | Fuel for HTR                                                             | --                                                                  | --      | --   | --                                        |

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

#### 11.4 ECONOMIC RESOURCES FOR NUCLEAR POWER DEVELOPMENT

##### ECONOMIC DATA PROFILE

Table 11.4.1

|                          |                  |                        |                 |
|--------------------------|------------------|------------------------|-----------------|
| GDP (Current million \$) | - 409,600 (1977) | Inflation Rate         | - 9% (1977)     |
| Exports (million \$)     | - 65,200 (1977)  | Imports (million \$)   | - 67,500 (1977) |
| Per Capita Income (\$)   | - 7,660 (1977)   | Disposable Income (\$) | - 5,700 (1977)  |
| Monetary Unit            | - Franc          | Exchange Rate (/US\$)  | 4.60 (1977)     |
| Population (million)     | - 52.8 (1977)    |                        |                 |

11.4.2 GOVERNMENTAL NUCLEAR ENERGY R&D BUDGET

|                       | <u>Francs (Millions)</u> |             |
|-----------------------|--------------------------|-------------|
|                       | <u>1976</u>              | <u>1977</u> |
| Total Energy          | 1,900                    | 2,080       |
| Total Nuclear         | 1,403                    | 1,460       |
| <u>Nuclear</u>        |                          |             |
| Fusion                | 76                       | 70          |
| CNRS                  | 140                      | (1)         |
| Subsidiary<br>R&D     | -                        | 170         |
| Reactor R&D           |                          |             |
| FBR                   | -                        | 536         |
| LWR                   | -                        | 213         |
| GCR                   | -                        | 77          |
| Other                 | -                        | 34          |
|                       | -                        | 860         |
| Isotope<br>Separation | -                        | 200         |
| Reprocessing          | -                        | 115         |
| Fabrication           |                          | 13          |
| Reactor Safety        | -                        | (2)         |

(1) increased in 1977, amount unknown

(2) remainder, amount unknown

The CEA nuclear program for 1979 includes:

Million

- \$ 51.7 - enrichment r&d and its industrial application
- 220.4 - basic research
- 99.4 - safeguards and security systems
- 114.6 - nuclear-related activities in such areas as  
chemistry and biology
- 47.1 - auxiliary operations such as multinational  
projects and documentation

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

Table 11.4.3

| <u>Industry<br/>University or<br/>Laboratory</u> | <u>Program<br/>Area</u>                                                                | <u>Budget<br/>\$ (Millions)</u> | <u>Key<br/>Personnel</u> |
|--------------------------------------------------|----------------------------------------------------------------------------------------|---------------------------------|--------------------------|
| Saclay Research<br>Center                        | radioactivation<br>analysis, spent<br>fuel studies,<br>radioisotopes<br>production     |                                 |                          |
| Fontenay Nuclear<br>Research Center              | radiometallurgy,<br>radiochemistry,<br>radiological<br>protection<br>controlled fusion |                                 |                          |
| Grenoble Nuclear<br>Research Center              | measurement,<br>analysis and<br>irradiation<br>studies                                 |                                 |                          |
| Cadarache Nuclear<br>Research Center             | fast neutron<br>system development,<br>production out<br>testing of nuclear<br>fuel    |                                 |                          |

\*Almost all French nuclear R&D is performed by the government (CEA).  
Main CEA laboratories are Saclay, Fontenay-aux-Roses, Grenoble, and  
Cadarache.

#### 11.4.4 ROLE OF PRIVATE INDUSTRY IN NUCLEAR ENERGY R&D

Private industry is predominately oriented towards application development of technology (gained either through CEA, R&D or license) to commercial PWR power plants, fuel supply, and reprocessing. While not often having a controlling interest, CEA (either directly or through COGEMA) usually is a shareholder in the major French nuclear suppliers.

ECONOMIC PROFILE OF REACTOR VENDORS AND FUEL CYCLE FACILITIES

Table 11.4.5

| <u>Name</u>                              | <u>Share Capital</u>                                                                                         | <u>Assets</u> | <u>Sales</u> |
|------------------------------------------|--------------------------------------------------------------------------------------------------------------|---------------|--------------|
| Framatome<br>(LWR Vendor)                | 51%-Creusot Loire<br>30%-CEA<br>15%-Westinghouse<br>4%-Jeumont-Schneider<br>Spie-Batignolles<br>Merlin Gerin |               |              |
| Novatome<br>(FBR Vendor)                 | 40%-Creusot Loire<br>30%-CEA<br>30%-Alsthom-Atlantique                                                       |               |              |
| Coredif<br>(enrichment)                  | 51%-Eurodif<br>29%-Cogema<br>20%-AEOL (Iran)                                                                 |               |              |
| Eurodif<br>(enrichment)                  | 27.78%-Cogema<br>25%-Sofidif<br>12.5%-CNEN<br>12.5%-AGIP<br>11.11%-SOPEN<br>11.11%-Eurpresa N. del U.        |               |              |
| Eurofuel<br>(fuel)                       | 3.5%-Westinghouse<br>11%-Framatome<br>51%-PUK<br>3%-Creusot Loire                                            |               |              |
| FBFC<br>(fuel)                           | 60%-Eurofuel<br>24%-MMN<br>16%-Westinghouse                                                                  |               |              |
| Comurhex<br>(UF <sub>6</sub> Conversion) | 39%-Cogema<br>10%-St. Gobain<br>51%-PUK (indirectly)                                                         |               |              |



#### 11.4.6 MODE OF FINANCING OF NUCLEAR POWER PLANTS

Electricité de France (EdF) is the national electric utility. All financing of nuclear power plants is thus governmental.

France provides excellent financing terms in order to support reactor and fuel export sales.

In October, 1978, EdF arranged a loan from an international banking group led by France's state-controlled Credit Lyonnais. This \$600 million loan will help finance the utility's construction of nuclear power plants.

## 11.5 GOVERNMENT COMMITMENT AND ROLE IN NUCLEAR POWER DEVELOPMENT

### 11.5.1 ENERGY POLICY - BASIC LEGISLATION

1. Compagnie Francaise des Petroles (CFP) formed to manage French interest in Turkish Petroleum Company and serve as arm of government in developing a national oil policy. Government now owns only 35 percent, CFP established 1924.
2. Parliament passed Loi Poincare in 1928 which laid foundation for the administrative structure of the petroleum industry. Government monopoly established for oil imports into French territory.
3. Commissariat a l'Energie Atomique (CEA) created in 1945.
4. Law of April 8, 1946, nationalized production, transportation, and distribution of natural gas under Gaz de France.
5. Decree covering the building of reactors passed 1963, modified 1973.
6. Central service on the safety of nuclear installations, which reports to the Ministry of Industry and Research, established 1973.
7. Government-owned company, Entreprise de Recherches et d'Activites Petrolieres (ERAP) formed 1966.
8. Decree dealing with effluents of radioactive gases and their control passed 1974.
9. Decree dealing with radioactive liquid effluents and their control passed 1974.
10. Establishment of Interministerial Committee on Nuclear Security, 1975. Committee reports to the Prime Minister.
11. CEA authorized to organize commercial fuel cycle activities into a private subsidiary, COGEMA, in August 1975.
12. Procedures outlined for public review of proposed sites of public utilities, either fossil fuel or nuclear, established 1976.
13. Energy Conservation Agency created (Agence pour les Economies d'Energie) 1976.
14. Interministerial Council on Nuclear Export Policy established September 1976, chaired by President of the Republic.
15. Council for Information on Electronuclear Energy established November 10, 1977, chaired by the Minister for Health & Family-Simone Veil.
16. Creation of new energy administration within Ministry of Industry, July, 1978, headed by Francois de Wissocq.

#### 11.5.2 GOVERNMENTAL STRUCTURE FOR NUCLEAR ENERGY POLICY AND R&D

Parliament-controls civil, fiscal, electoral, penal, labor, amnesty and budget matters.

President-controls all other areas. Appoints Prime Minister.

Cabinet-appointed by Prime Minister.

Planning Council-chaired by President and includes Prime Minister, Finance Minister, and Labor Minister. Responsible to make basic decision on energy policy, define mid-and long-term energy progress, and implement decisions via staff of Fuel Year Plan.

Within the Ministry of Industry has been created a Department of Energy and Raw Materials. Under this department the following offices and agencies will be drawn:

- motor fuels
- gas
- electricity
- coal
- energy conservation
- alternate energy sources
- geological and mineral services
- solar energy
- EdF
- Gaz de France
- Charbonnages de France
- major oil companies

### 11.5.3 ORGANIZATION FOR IMPLEMENTATION OF NUCLEAR ENERGY POLICY AND R&D

PLANNING COUNCIL-chaired by President and makes principal decisions on overall energy policy. Implements decisions through the staff of the Five Year Plan and Ministry of Industry and Research.

#### MINISTRY OF INDUSTRY AND RESEARCH

Delegation Generale a l'Energie-Proposes measures on current energy needs and supplies, directs the Commissariat a l'Energie Atomique (CEA).

The Ministry is also assisted by various advisory bodies, the most important are:

1. Advisory Committee on Research and Development on Energy
2. Advisory Commission on Energy
3. The Commission on the Production of Electricity by Nuclear Power

COMMISSARIAT A L'ENERGIE (CEA)-responsible for coordinating all nuclear energy programs. CEA structure is as follows: General direction by an Administrator, senior technical advice by a High Commissioner and general policy developed by a Senior Central Staff.

Operational units include:

Military Application

Nuclear Materials and fuel cycle through COGEMA (Compagnie Generale Des Matieres Nucleaires)

COGEMA also involved in:

United Reprocessors (UK, FRG, France)

Institute of Fundamental Research

Institute of Safety and Protection

Industrial Nuclear Application through:

Technicatome (small reactors)

Framatome (PWR)

Novatome (LMFBR and HTGR)

#### 11.5.4 NUCLEAR ENERGY POLICY AND OBJECTIVES

1. Improvement of existing LWR technology.
2. Introduction of the FBR on a commercial basis by 1985-90.
3. Diversification and security of imported fuel supply.

The Council on Nuclear Export Policy presented policy guidelines in 1976.

1. Since nuclear energy represents a competitive energy source necessary for development, France will remain prepared to contribute to the implementation of peaceful use of nuclear energy.
2. France intends to keep full command of its nuclear export policies in accordance with relevant international agreements.
3. France does not favor proliferation of nuclear arms and will itself reinforce safeguards through its nuclear export policy.
4. France will assure the security of nuclear fuel supplies for plants it has sold and will meet the legitimate needs of others for access to nuclear technologies.
5. The Government of France is of the opinion that it is necessary that all suppliers of nuclear equipment, materials and technologies avoid proliferation of nuclear arms through commercial competition.
6. France is prepared to discuss these problems with supplying and/or receiving countries engaged in substantial nuclear programs.

#### 11.5.5 NUCLEAR ENERGY R&D - STATUS AND OUTLOOK

Continued heavy LWR development and installation efforts combined with growing efforts to commercialize the LMFBR in the early 1980's. Continuing and growing efforts on fusion, pointed towards post-2000.

#### 11.5.6 NUCLEAR ENERGY R&D - PRIORITIES

Nuclear energy receives more than 75% of total energy R&D budget. Priorities are: LMFBR, enrichment, LWR, HTGR.

Nuclear energy is expected to satisfy most domestic needs in the mid-term future.

#### 11.5.7 ROLE OF GOVERNMENT IN NUCLEAR FACILITIES CONSTRUCTION AND OPERATION

Framatome (30% CEA) - Sole French large LWR reactor supplier  
EdF (100% government) - Sole French electric utility  
Institut de Surete et - (Within CEA) responsible for  
Protection regulatory matters

While French industrial firms supply much of the reactor equipment, the government is primarily responsible for all power reactor planning, construction, operation, and regulation.

11.6 NON-NUCLEAR ENERGY FACILITIES AND FUEL SUPPLY

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

Table 11.6.1

| <u>Facility Name</u> | <u>Location</u>         | <u>Utility/ Owner</u> | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>                            |
|----------------------|-------------------------|-----------------------|---------------|----------------------------------|---------------------------|----------------|---------------------------------------|
| Porcheville B        |                         | EDF                   |               | Oil                              | 2,340                     | 0              | 1968/1973/<br>1974/1975               |
| Le Havre             | Seine                   | EDF                   |               | Oil/Coal                         | 1,420                     | 0              | 1968/1973                             |
| Ambes                | South West<br>(Gironde) | EDF                   |               | Oil                              | 1,227                     | 0              | 1959/1960/<br>1971/1972/<br>1974      |
| Martiques<br>Ponteau |                         | EDF                   |               | Oil                              | 1,000                     | 0              | 1971/1972/<br>1973/1974               |
| Vitry                |                         | EDF                   |               | Oil/Coal                         | 1,120                     | 0              | 1966/1970/<br>1971                    |
| Blenod               | Moselle                 | EDF                   |               | Coal/Oil                         | 1,000                     | 0              | 1963/1966/<br>1968/1969               |
| Loire-sur-<br>Rhône  | Lyonnais                | EDF                   |               | Oil                              | 1,000                     | 0              | 1965/1968/<br>1970/1971               |
| Cordemais            | Nantes                  | EDF                   |               | Oil                              | 1,955                     | 0              | 1970/1976                             |
| Bouchain             | N. France               | EDF                   |               | Oil/Gas                          | 565                       | 0              | 1970/1971                             |
| Chevire              | Anjou                   | EDF                   |               | Oil/Gas                          | 811                       | 0              | 1953/1954/<br>1955/1958/<br>1968/1969 |

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



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

Table 11.6.1 (Continued)

| <u>Facility Name</u> | <u>Location</u>  | <u>Utility/ Owner</u> | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>          |
|----------------------|------------------|-----------------------|---------------|----------------------------------|---------------------------|----------------|---------------------|
| Emile-Huchet         |                  | Coal Board            |               |                                  | 776                       | 0              | 1x240 1973          |
| Pont-Sur-Sambre      | Flandre          | EEF                   |               | Coal/Gas                         | 484                       | 0              | 1961/1962/1967      |
| Dunkerque            | Flandre          | EDF                   |               | Oil                              | 468                       | 0              | 1962/1963/1969      |
| Montereau            | Loiret           | EDF                   |               | Oil/Gas                          | 734                       | 0              | 1959/1960/1964/1965 |
| La Maxe              |                  | EDF                   |               | Coal/Oil                         | 490                       | 0              | 1971                |
| Vaires               | Paris            | EDF                   |               | Coal/Oil                         | 490                       | 0              | 1962/1966           |
| Artix                | Pyrenees         | EDF                   |               | Gas                              | 369                       | 0              | 1959/1960/1961      |
| Hornaing             |                  | Coal Board            |               |                                  | 474                       | 0              | 3rd set 240 MW 1970 |
| Gardanne             | Bouches du Rhone | Coal Board            |               |                                  | 400                       | 0              |                     |
| Porcheville A        |                  | EDF                   |               | Coal                             | 468                       | 0              | 1956/1957           |
| Creil                | Brittany         | EDF                   |               | Coal/Oil                         | 468                       | 0              | 1955/1956           |

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

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

Table 11.6.1 (Continued)

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/ Owner</u> | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u>              |
|----------------------|-----------------|-----------------------|---------------|----------------------------------|---------------------------|----------------|-------------------------|
| Richemont            | Normandy        | Steel Corp.           |               | 384                              |                           | 0              |                         |
| Ansereuilles         |                 | EDF                   |               | Coal/Oil                         | 468                       | 0              | 1959/1964/<br>1965      |
| Champagne            |                 | EDF                   |               | Oil/Coal                         | 490                       | 0              | 1961/1965               |
| Saint-Ouen           | Paris           | EDF                   |               | Oil/Gas                          | 500                       | 0              | 1963/1966               |
| Beautor              |                 | EDF                   |               | Coal/Oil                         | 351                       | 0              | 1957/1958               |
| Lucy III             |                 | Coal Board            |               |                                  | 248                       | 0              | 1971                    |
| Courieres            |                 | Coal Board            |               |                                  | 234                       | 0              |                         |
| Violaines            |                 | Coal Board            |               |                                  | 234                       | 0              |                         |
| Yainville            |                 | EDF                   |               | Oil                              | 334                       | 0              | 1950/1952/<br>1958/1959 |
| Strasbourg II        | Alsace          | EDF                   |               | Coal/Oil                         | 234                       | 0              | 1959                    |
| Albi                 | Tarn            | EDF                   |               | Coal                             | 250                       | 0              | 1969                    |
| Pont-de-Cleux        |                 | Elec-Chimie           |               |                                  | 166                       | 0              |                         |

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

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

Table 11.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u> | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>         |
|--------------------------|-----------------|---------------------------|---------------|------------------------------------------|-------------------------------|----------------|--------------------|
| Grosblieders-<br>straff  | Lorraine        | Coal Board                |               |                                          | 220                           | 0              |                    |
| Arjuzanx                 | Gascogne        | EDF                       |               | Lignite                                  | 227                           | 0              | 1960/1961          |
| Chalon II                |                 | EDF                       |               | Coal/Cil                                 | 234                           | 0              | 1956/1959          |
| Gennevilliers<br>II      | Paris           | EDF                       |               | Oil                                      | 325                           | 0              | 1949/1950/<br>1955 |
| Arrighi                  |                 | EDF                       |               | Oil                                      | 222                           | 0              | 1953/1955          |
| Le Bec                   |                 | Coal Board                |               |                                          | 125                           | 0              |                    |
| Comines II               | Flanders        | EDF                       |               | Coal                                     | 117                           | 0              | 1950/1951          |
| Harnes                   |                 | Coal Board                |               |                                          | 110                           | 0              |                    |
| Herseange                |                 | Steel Corp.               |               |                                          | 123                           | 0              |                    |
| Dechy                    | Flanders        | Coal Board                |               |                                          | 110                           | 0              |                    |
| Aramon                   |                 | EDF                       |               | Oil                                      | 1,370                         | U              | 1977               |
| Arc-Isere                | Alps            |                           |               | Hydro                                    | 480                           | U              | 1979               |
| Caderousse               |                 | CNR                       |               | Hydro                                    | 156                           | 0              | 1975               |

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

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

Table 11.6.1 (Continued)

| <u>Facility Name</u> | <u>Location</u> | <u>Utility/ Owner</u> | <u>Vendor</u> | <u>Facility Type (Fuel Type)</u> | <u>Capacity (MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|----------------------|-----------------|-----------------------|---------------|----------------------------------|---------------------------|----------------|------------|
| Montezic             |                 |                       |               | Hydro                            | 920                       | U              | 1981-82    |
| La Coche             | Alps            |                       |               | Hydro                            | 160                       | U              | 1976-78    |
| Bollene              | Rhone (Alps)    | CNR                   |               | Hydro                            | 314                       | 0              |            |
| Chateauneuf-du-Rhone | Alps            | CNR                   |               | Hydro                            | 285                       | 0              |            |
| Genissiat            | Rhone (Alps)    | CNR                   |               | Hydro                            | 405                       | 0              |            |
| Beaucaire            | Provence        | CNR                   |               | Hydro                            | 208                       | 0              | 180 MW 197 |
| Logis-Neuf           |                 | CNR                   |               | Hydro                            | 210                       | 0              |            |
| Beauchastel          |                 | CNR                   |               | Hydro                            | 223                       | 0              |            |
| Bourg-les-Valences   |                 | CNR                   |               | Hydro                            | 190                       | 0              | 1968       |
| Fessenheim           | Alsace          | EDF                   |               | Hydro                            | 166                       | 0              |            |
| Avignon-Sauveterre   | Rhone           | CNR                   |               | Hydro                            | 169                       | 0              | 1973       |
| Brommat              |                 | EDF                   |               | Hydro                            | 412                       | 0              | 1975       |
| Ottmarsheim          | Alsace          | EDF                   |               | Hydro                            | 156                       | 0              |            |

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

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

Table 11.6.1 (Continued)

| <u>Facility<br/>Name</u>      | <u>Location</u> | <u>Utility/<br/>Owner</u> | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u> |
|-------------------------------|-----------------|---------------------------|---------------|------------------------------------------|-------------------------------|----------------|------------|
| Rhinau                        | Alsace          | EDF                       |               | Hydro                                    | 161                           | 0              |            |
| Kembs                         | Alsace          | EDF                       |               | Hydro                                    | 145                           | 0              |            |
| Marckolsheim                  | Alsace          | EDF                       |               | Hydro                                    | 156                           | 0              |            |
| Strasbourg                    | Alsace          | EDF                       |               | Hydro                                    | 130                           | 0              | 1971/1970  |
| Saint-Esteve                  | Roussilon       | EDF                       |               | Hydro                                    | 145                           | 0              |            |
| Oraison                       |                 | EDF                       |               | Hydro                                    | 187                           | 0              |            |
| Vogelran                      |                 | EDF                       |               | Hydro                                    | 130                           | 0              |            |
| Gerstheim                     |                 | EDF                       |               | Hydro                                    | 130                           | 0              | 46 MW 1968 |
| Villarodin-<br>Combe-D'Avieux |                 | EDF                       |               | Hydro                                    | 482                           | 0              | 1968/1969  |
| La Bathie-<br>Roseland        | Alps            | EDF                       |               | Hydro                                    | 522                           | 0              |            |
| Malgovert                     | Isere (Alps)    | EDF                       |               | Hydro                                    | 297                           | 0              |            |
| Gervans                       |                 | CNR                       |               | Hydro                                    | 116                           | 0              | 1972/1971  |
| Saint-Chamas                  | Gascogne        | EDF                       |               | Hydro                                    | 153                           | 0              | 1966       |

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

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

Table 11.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u> | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>                 |
|--------------------------|-----------------|---------------------------|---------------|------------------------------------------|-------------------------------|----------------|----------------------------|
| Sisteron                 | Devance         | EDF                       |               | Hydro                                    | 228                           | 0              | 1976                       |
| Serre-Poncon             | Devance         | EDF                       |               | Hydro                                    | 338                           | 0              |                            |
| Rance                    | Rance Estuary   | EDF                       |               | Hydro                                    | 240                           | 0              | 50 MW 1966                 |
| Le Chastang              | Dordogne        | EDF                       |               | Hydro                                    | 269                           | 0              |                            |
| L'Aigle                  |                 | EDF                       |               | Hydro                                    | 208                           | 0              |                            |
| Monteynard               | Alps            | EDF                       |               | Hydro                                    | 323                           | 0              |                            |
| Montpezat                | Guyenne         | EDF                       |               | Hydro                                    | 130                           | 0              |                            |
| Pragneres                |                 | EDF                       |               | Hydro                                    | 156                           | 0              |                            |
| Curbans                  |                 | EDF                       |               | Hydro                                    | 139                           | 0              | 1966                       |
| La Saussaz II            |                 | EDF                       |               | Hydro                                    | 140                           | 0              |                            |
| Randens                  |                 | EDF                       |               | Hydro                                    | 124                           | 0              |                            |
| Pied-de-Borne            |                 | EDF                       |               | Hydro                                    | 109                           | 0              |                            |
| Hermillon                |                 | EDF                       |               | Hydro                                    | 114                           | 0              | 1974                       |
| Rhine                    |                 | EDF                       |               | Hydro                                    | 760                           | 0              | 360 MW 1975<br>360 MW 1976 |

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

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

Table 11.6.1 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Utility/<br/>Owner</u> | <u>Vendor</u> | <u>Facility<br/>Type<br/>(Fuel Type)</u> | <u>Capacity<br/>(MWe net)</u> | <u>Status*</u> | <u>COD</u>                |
|--------------------------|-----------------|---------------------------|---------------|------------------------------------------|-------------------------------|----------------|---------------------------|
| Bort                     |                 | EDF                       |               | Hydro                                    | 196                           | O              |                           |
| Eosson                   | Alps            | ESA                       |               | Hydro                                    | 176                           | O              | 112 MW 1973<br>64 MW 1972 |
| Le Pouget                | Languedoc       | EDF                       |               | Hydro                                    | 124                           | O              |                           |
| Maregis                  |                 | SNCF                      |               | Hydro                                    | 148                           | O              |                           |
| Sarrans                  | Auvergne        | EDF                       |               | Hydro                                    | 114                           | O              |                           |
| Carling                  |                 | EDF                       |               | Coal                                     | 600                           | P              | 1982                      |
| Peage de<br>Roussillon   |                 |                           |               | Hydro                                    | 160                           | O              | 1977                      |
| Chautagne                |                 |                           |               | Hydro                                    | 110                           | P              | 1980                      |
| Moustiers                |                 |                           |               | Hydro                                    | 200                           | P              | 1982                      |

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

SUMMARY OF ENERGY GENERATION FACILITIES IN EXISTENCE AND PLANNED

Table 11.6.2

| <u>Year</u> | <u>Capacity - MWe(net)</u> |
|-------------|----------------------------|
| 1975        | 49,200                     |
| 1980        | 68,444                     |
| 1985        | 79,499                     |
| 1990        |                            |
| 1995        |                            |
| 2000        |                            |



LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 11.6.3

| <u>Facility<br/>Name</u> | <u>Location</u>    | <u>Owner</u>              | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|--------------------|---------------------------|--------------------------|-------------------|----------------|
|                          | Nord-Pas-de-Calais | Charbonnages de<br>France | Coal Field               | 9.01              | 0              |
|                          | Lorraine           | Charbonnages de<br>France | Coal Field               | 9.06              | 0              |
|                          | Centre-Midi        | Charbonnages de<br>France | Coal Field               | 1.184             | 0              |
| Aquitaine                |                    | Charbonnages de<br>France | Coal Field               | 0.424             | 0              |
| Auvergne                 |                    | Charbonnages de<br>France | Coal Field               | 1.446             | 0              |
| Blazny                   |                    | Charbonnages de<br>France | Coal Field               | 0.836             | 0              |
| Cevennes                 |                    | Charbonnages de<br>France | Coal Field               | 0.375             | 0              |
| Dauphine                 |                    | Charbonnages de<br>France | Coal Field               | 0.554             | 0              |
| Loire                    |                    | Charbonnages de<br>France | Coal Field               | 1.604             | 0              |

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

\*\* Coal - Million Tonnes/year

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 11.6.3 (Continued)

| <u>Facility Name</u> | <u>Location</u> | <u>Owner</u>           | <u>Facility Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|----------------------|-----------------|------------------------|----------------------|-------------------|----------------|
| Provence             |                 | Charbonnages de France | Coal Field           |                   | 0              |
| Various              | Alsace          |                        | Oil Field            |                   | S              |
| Cazaux               | Aquitaine Basin | Esso Rep               | Oil Field            | 4,540             | 0              |
| Lavergne             | Aquitaine Basin | Esso Rep               | Oil Field            | 710               | 0              |
| Lugos                | Aquitaine Basin | Esso Rep               | Oil Field            | 606               | 0              |
| Mimizan              | Aquitaine Basin | Esso Rep               | Oil Field            | 237               | 0              |
| Mothes               | Aquitaine Basin | Esso Rep               | Oil Field            | 457               | 0              |
| Parentis             | Aquitaine Basin | Esso Rep               | Oil Field            | 6,557             | 0              |
| Others               | Aquitaine Basin | Esso Rep               | Oil Field            | 119               | 0              |
| Castera-Lou          | Aquitaine Basin | SNPA                   | Oil Field            | 292               | 0              |
| Lacq Sup             | Aquitaine Basin | SNPA                   | Oil Field            | 1,075             | 0              |
| Montastruc           | Aquitaine Basin | SNPA                   | Oil Field            | 1,963             | 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 11.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Owner</u>    | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|-----------------|-----------------|--------------------------|-------------------|----------------|
| Others                   | Aquitaine Basin | SNPA            | Oil Field                | 13                | O&S            |
| Coulommès                | Paris Basin     | Petrorep        | Oil Field                | 761               | 0              |
| Saint-Martin             | Paris Basin     | Shell Francaise | Oil Field                | 395               | 0              |
| Others                   | Paris Basin     | SNPA            | Oil Field                | 4                 | O&S            |
| Brie                     | Paris Basin     | SNPA            | Oil Field                | 234               | 0              |
| Chailly                  | Paris Basin     | SNPA            | Oil Field                | 466               | 0              |
| Chateaurenard            | Paris Basin     | SNPA            | Oil Field                | 408               | 0              |
| Chuelles                 | Paris Basin     | SNPA            | Oil Field                | 391               | 0              |
| Courtenay                | Paris Basin     | SNPA            | Oil Field                | 320               | 0              |
| Grandville               | Paris Basin     | SNPA            | Oil Field                | 228               | 0              |
| St. Firmin               | Paris Basin     | SNPA            | Oil Field                | 806               | 0              |
| Villemer                 | Paris Basin     | SNPA            | Oil Field                | 290               | O&S            |

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

\*\* Oil - Barrels/day

LISTING OF FUEL SUPPLY FACILITIES IN EXISTENCE AND FIRMLY PLANNED

Table 11.6.3 (Continued)

| <u>Facility<br/>Name</u> | <u>Location</u> | <u>Owner</u> | <u>Facility<br/>Type</u> | <u>Capacity**</u> | <u>Status*</u> |
|--------------------------|-----------------|--------------|--------------------------|-------------------|----------------|
| Others                   | Languedoc       |              | Oil Field                |                   | S              |
| Lower Lacq               | Aquitaine Basin | SNPA         | Gas Field                | 7.28              | 0              |
| Meillon + Others         | Aquitaine Basin |              |                          |                   |                |
| St. Marcet,<br>Proupiary | Aquitaine Basin | ERAP         | Gas Field                | 0.8               | 0              |
| Auzas                    | Aquitaine Basin |              |                          |                   |                |
| Valampaulieres           | Jura Basin      | SNPA         | Gas Field                | 0.0025            | 0              |

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

\*\* Oil - Barrels/day; Natural Gas - km<sup>3</sup>/year

PROJECTIONS OF ENERGY SUPPLIES, IMPORTS AND EXPORTS

Table 11.6.4

| <u>RESOURCE</u>                                            | <u>1985</u> | <u>2000</u> |
|------------------------------------------------------------|-------------|-------------|
| <u>COAL</u> (million tonnes)                               |             |             |
| Indigenous Supply                                          | 16.40       | 9.69        |
| Imports                                                    | 10.80       | 16.91       |
| Exports                                                    | --          | --          |
| <u>CRUDE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                          | 0.28        | 0.04        |
| Imports                                                    | 95.32       | 124.06      |
| Exports                                                    | --          | --          |
| <u>SHALE OIL</u> (million tonnes)                          |             |             |
| Indigenous Supply                                          | 0           | 0           |
| Imports                                                    |             |             |
| Exports                                                    |             |             |
| <u>NATURAL GAS</u> (cubic kilometers)                      |             |             |
| Indigenous Supply                                          | 9.00        | 4.64        |
| Imports                                                    | 16.40       | 40.66       |
| Exports                                                    | --          | --          |
| <u>URANIUM</u> (kilotonnes U <sub>3</sub> O <sub>8</sub> ) |             |             |
| Indigenous Supply                                          | 4.4         | 6.5         |
| Imports                                                    | 4.7         | 10.8        |
| Exports**                                                  | 0           | 0           |

\*\* Exports will be in support of French reactor and fuel sales, and will be from non-France deposits.