PAKISTAN

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1. GENERAL INFORMATION

1.1. General Overview

Pakistan is situated in South Asia and it stretches over 1,600 kilometres from southwest to northeast. It lies between 23° and 37° north latitude and 60° and 76° east longitude. It is a low-income developing country and is ranked as the 160th in terms of its Gross National Product per capita among the total 204 countries whose profiles are available [Ref. 1].

On 1 January 2000, the population of Pakistan was about 136 millions and the population density was 171 inhabitants per square kilometre (Table 1). At present, the population growth rate is about 2.3% per annum.

TABLE 1. POPULATION INFORMATION[1]

	1960	1970	1980	1990	1998	1999	2000	Growth rate (%) 1980 to 2000
Population (millions) [a]	45.0	59.7	80.2	108.2	130.7	133.0	136.0	2.7
Population density (inhabitants/km²) [a]	56.6	75.0	100.8	136.0	163.3	167.1	170.9	
Urban population as percent of total	21.9	24.7	28.0	30.1	32.6	33.0	33.0	3.0
Area (1000km²)	796.1							

[a] On 1st January
Sources: [Ref. 2]

1.2. Economic Indicators

During the last 40 years, Pakistan's economy has grown at an average annual rate of 7.2% (in current US$). However, due to high population growth rate, per capita Gross Domestic Product (GDP) has increased at only 4.3% per annum during the same period. The present per capita income is US$ 419, which places the country among the low income developing economies of the world. The historical GDP statistics are shown in Table 2 and some basic indicators are given in Table 3.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

	1960	1970	1980	1990	1998	1999	2000	Growth rate (%) 1980 to 2000
GDP (millions of current US$)	3,535	9,107	19,114	35,432	57,433	58,472	57,014	5.6
GDP (millions of constant 2000 US$)	6,649	12,779	20,445	37,084	52,677	54,881	57,014	5.3
GDP per capita (current US$/capita)	79	153	238	327	442	440	419	2.7
GDP by Sector (%):								
Agriculture	45.8	38.9	30.5	25.8	25.9	25.6	25.9	
Industry	15.0	20.7	22.7	22.2	21.3	21.2	20.8	
Services	39.2	40.4	46.8	51.9	52.8	53.2	53.3	

Sources: [Ref.2]

1.3. Energy Situation

1.3.1. Energy Resources

Pakistan's commercially exploitable energy resources consist of coal, gas, oil and hydropower, and a large base of traditional fuels in the form of fuel wood, agricultural and animal wastes. Pakistan does not have adequate energy reserves (Table 4). Pakistan has to import large quantities of oil to meet

[1] In this report, unless otherwise specified, years correspond to financial years (1st July – 30th June)

its energy requirements. During 1999-2000, Pakistan spent about 31.8% of its export earnings on petroleum imports [Ref. 3].

TABLE 3. BASIC INDICATORS

Indicator	Period/year	
Average annual rate of inflation*	1980-1990	7.6%
	1990-2000	9.2%
	1980-2000	8.5%
Life expectancy at birth	2000	63 years
Literacy rate	2000	49%

* Measured by Consumer Price Index.
Sources: [Ref. 2]

TABLE 4. ESTIMATED ENERGY RESERVES

Exajoule

	Solid	Liquid	Gas	Uranium	Hydro	Total
Total amount in place (2000) [a]	79.3	1.5	20.0		1.4 [c]	102.2
Total amount in place [b]	85.8	1.3	20.6		25.3 [d]	133

[a] Country information [Ref. 4]
[b] IAEA Energy and Economic Data Base
[c] Equivalent to estimated hydropower potential of 30,000 MW by converting to energy at 50% plant factor and using 10,550 GJ/GW·h conversion factor from secondary energy to primary energy.
[d] For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 1998) by a factor of 10.

1.3.2. Energy Supplies

The energy supplies statistics are given in Table 5. For the last ten years, the indigenous oil production has been at the level of about 55,000-60,000 barrels per day (equivalent to about 13-22% of the country's oil consumption). Pakistan's natural gas production in 1999-2000 amounts to 2,245 million cubic feet per day. The incremental production from the fields under development and future gas discoveries is expected to enhance the supply.

Coal Production in 1999-2000 was only 3.2 million tonnes. The present market is confined mainly to providing fuel for brick kilns. The development of the coal mining industry in Pakistan, particularly for power generation is hampered by many constraints relating to the quality and quantity of coal, mining difficulties, organization problems and investment risks.

Hydropower is providing about 30% of electricity in Pakistan. Although, Pakistan has relatively high endowment of hydropower potential, only 4,964 MW (17%) has been exploited and about 1,450 MW capacity is under construction. Various mini/micro hydro projects are in construction or in planning phase and a number of medium and large size hydroelectric projects have been planned/proposed.

Two nuclear power plants are operating in Pakistan satisfying about 3% of electricity needs of the country in financial year 2000-2001. The first plant, KANUPP, has been kept operational since it's commissioning in 1971 and has generated about 10 billion kW·h of electricity. The second nuclear power plant, CHASNUPP, was connected to the national grid on 13 June 2000, and has been operating satisfactorily.

1.4. Energy Policy

Energy sector is regulated and to a large extent owned and operated by the Government of Pakistan (GOP). GOP has been carrying out institutional reforms in the energy sector for the last 15 years. Besides improving the efficiency of public sector institutions, policies are aimed at increasing private sector participation in the development of energy sector. In line with these objectives, in 1986, the GOP encouraged setting up of private sector power projects on BOO (Build-Own-Operate) basis

as a matter of policy, but the response was not very encouraging. The GOP announced comprehensive frameworks in 1994 and 1995 aimed at attracting private sector investments for the development of power sector. In 1998, the GOP announced a policy to increase the role of regulatory body -- National Electric Power Regulatory Authority (NEPRA) for the power producers. Various policies have also been announced for other sub sectors of the energy sector (e.g. Petroleum, etc.) in order to increase the private participation.

TABLE 5. ENERGY STATISTICS

Exajoule

								Average annual growth rate (%)
	1960	1970	1980	1990	1998	1999	2000	1980 to 2000
Energy supply								
- Total [1]	0.38	0.64	1.00	1.65	2.27	2.34	2.42	4.51
- Solids [2]	0.29	0.33	0.39	0.51	0.58	0.59	0.60	2.16
- Liquids	0.07	0.17	0.20	0.50	0.79	0.79	0.84	7.29
- Gases	0.02	0.11	0.25	0.47	0.67	0.71	0.77	5.88
- Primary electricity [3]	0.01	0.03	0.16	0.18	0.24	0.24	0.21	1.39
Energy production								
- Total	0.31	0.49	0.82	1.24	1.59	1.64	1.68	3.68
- Solids[2]	0.27	0.33	0.39	0.48	0.55	0.56	0.58	1.92
- Liquids	0.01	0.02	0.02	0.12	0.13	0.13	0.13	9.39
- Gases	0.02	0.11	0.25	0.47	0.67	0.71	0.77	5.88
- Primary electricity [3]	0.01	0.03	0.16	0.18	0.24	0.24	0.21	1.39
Net import (import – export)								
- Total	0.07	0.15	0.18	0.41	0.69	0.69	0.73	7.19
- Solids[2]	0.02	0.00	0.00	0.03	0.03	0.03	0.03	
- Liquids	0.05	0.15	0.18	0.38	0.66	0.66	0.71	6.98
- Gases	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

[1] Energy supply = Primary energy production + Net import (Import - Export).
[2] Solid fuels include coal and commercial wood.
[3] Primary electricity = Hydro + Nuclear
Sources: [Ref. 4]

When the 'Policy Framework and Package of Incentives for Private Sector Power Generation Projects in Pakistan' was announced by the GOP in March 1994, i.e. the introduction of Independent Power Producers (IPPs), the total installed capacity in the country was 10,800 MW. This capacity was insufficient to meet the demand on year round basis, particularly during low river flow periods, and it necessitated load shedding of the magnitude of 2,000 MW during peak load hours. At that time, an optimistic load projection at the rate of 8% per annum for the next 25 years gave rise to an estimated 54,000 MW additional electricity generation capacity requirement up to year 2018. Such an ambitious programme could not be financed by the GOP, and therefore, resource mobilization in the private sector was considered essential to meet these development targets.

Due to a poor response of the 1986 policy, a policy package was devised in March 1994 for attracting overseas investment as well as domestic capital for developing power projects. The lucrative terms, with a high rate of return on equity, attracted a large number of foreign investors and created a situation of surplus power in the country, since the economic growth slowed down in the following years and power demand did not grow as projected. The financial position of Water and Power Development Authority (WAPDA) was adversely affected due to high tariffs and guaranteed payments to be made to the IPPs.

The GOP revised the power policy in July 1998. This policy envisages power generation additions in future through competitive bidding for specific sites and types of plants and gives priority to indigenous fuel based (hydro and local coal) projects. Competitive bidding amongst power suppliers is likely to keep the tariff low. In the mean time efforts are being made to solve the problem of surplus power by revival of the sick industry. The present policy of the government is not to use public sector funds for power production, except for hydro generation.

2. ELECTRICITY SECTOR

2.1. Structure of the Electricity Sector

The integrated power system of Pakistan consists of two utilities, namely WAPDA and KESC. Pakistan Atomic Energy Commission (PAEC) owns nuclear power plants, which are connected to WAPDA and KESC networks. The IPPs are connected to the national grid at various locations.

- **WAPDA**

  Previously WAPDA had the following responsibilities:
  - Planning and execution of thermal and hydro electricity generation projects;
  - Execution of irrigation, water storage, and soil drainage schemes;
  - Prevention of water logging and carrying out reclamation of water logged and saline lands;
  - Flood control.

  Now the Power Wing of WAPDA has been restructured and eight distribution companies, three thermal generation companies and one transmission and distribution company have been established. However, all hydropower projects remain with the WAPDA.

- **KESC**

  - KESC is a limited company listed at Karachi Stock Exchange. Majority of its shares are held by the public sector. However, plans exist for its privatization.
  - KESC is responsible for generation, transmission and distribution of power to the city of Karachi, Uthal in Sind, and Bela district in Balochistan.

- **PAEC**

  PAEC is responsible for:
  - Nuclear power project planning and implementation;
  - Operation and maintenance of nuclear power plants;
  - PAEC owns two nuclear power plants:
    - KANUPP (Karachi Nuclear Power Plant), a 137 MWe PHWR, integrated in KESC network;
    - CHASNUPP (Chashma Nuclear Power Plant), a 325 MWe PWR connected to WAPDA grid since 13 June 2000.

- **IPPs**

  IPPs only generate electricity. Transmission and distribution is the responsibility of transmission and despatch company. The IPPs in operation as on 30th June 2000 are:
  - KAPCO (1466 MW)
  - HUBCO (1292 MW)
  - AES Pak. Gen. (365 MW)
  - Gul Ahmad Energy (136 MW)
  - Kohinoor Energy (131 MW)
  - Tapal Energy (126 MW)
  - AES Lalpir (362 MW)
  - Japan Power (135 MW)
  - Southern Electric Power (117 MW)
  - Habibullah Coastal (129 MW)
  - Fauji Kabirwala (157 MW)
  - Rousch Pakistan (412 MW)
  - Saba Power (134 MW)
  - Uch Power (586 MW)

Table 6 provides the installed electricity generating capacity and transmission voltages of the utilities and IPPs, while Figure 1 shows the installed generation capacity of the country by plant type.

TABLE 6. POWER PLANTS AND GRID OF UTILITIES ON 30TH JUNE 2000

Utilities	Installed Capacity (MWe)				Transmission Voltage
	Thermal	Hydro*	Nuclear	Total	
WAPDA	5,131	4,826	325	10,282	500,220,132 kV
KESC	1,756	-	137	1,893	220,132 kV
IPPs	5,549	-	-	5,549	500,220,132 kV
Total	12,436	4,826	462	17,724	

* A 138 MW, run of river, project has also been commissioned since March 2001.

Source: [Ref. 2 & 4]

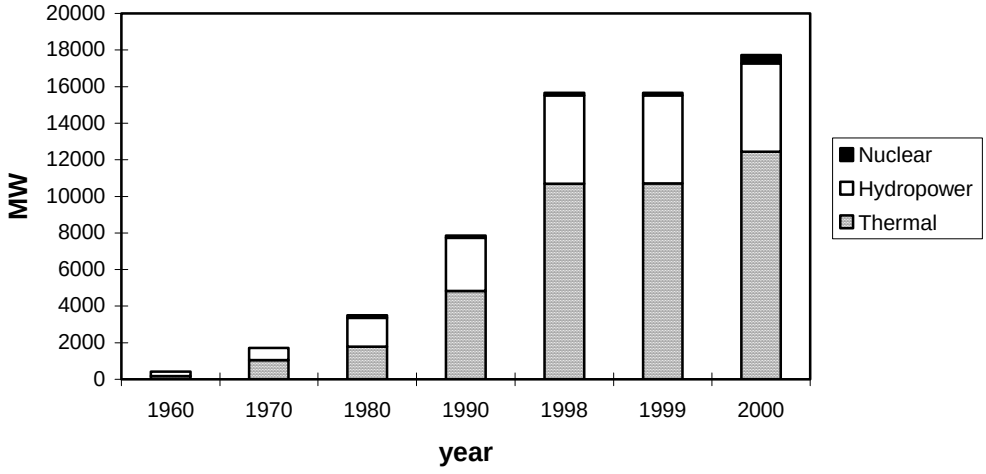

FIG. 1. Installed Generating Capacity of Electric Power on 30 June 2000

2.2. Decision Making Process

The National Economic Council (NEC) is the supreme economic body responsible for ensuring balanced development of the country. It was created in December 1962 under Article 145 of the Constitution of Pakistan. NEC is headed by the Head of the Government. Its members include some of Federal Ministers, the Governors/Chief Ministers of the provinces, and the Deputy Chairman of the Planning Commission. The Planning Commission is the chief instrument for formulating the national plans.

The Energy Wing of the Planning Commission estimates the energy demand on the basis of information obtained from all concerned entities. It integrates this information at the national level to formulate unified short and long-term national energy plans.

Within the energy sector, the nuclear power area is handled exclusively by the PAEC, which also carries out its own energy studies and makes suggestions to the Energy Wing particularly towards the development of nuclear power with a view to ensure an appropriate mix of resources for electricity generation. The Energy Wing forwards the suggestions to the NEC. The NEC has the overall control of planning and approves all plans and policies relating to electricity sector development, and makes the energy policy. The Executive Committee of the National Economic Council (ECNEC) supervises the implementation of energy policy laid down by the Government.

The Private Power and Infrastructure Board (PPIB) has been set up under the Ministry of Water and Power to assess, evaluate, and co-ordinate the private sector power generation projects.

In 1997, NEPRA was established for regulating the provision of electric power services. NEPRA is responsible for grant of licenses for generation, transmission, and distribution of electric power. It approves tariff rates and other terms and conditions for the supply of electric power services.

2.3. Main Indicators

Table 7 shows the historical electricity production and installed capacity in the country and Table 8 provides energy related ratios. The integrated power system of Pakistan (as of 30th June 2000) has an installed capacity of 17,724 MW comprising hydro, thermal (oil, gas and coal fired) and nuclear plants. The hydro capacity is season dependent, decreasing to about 3,000 MW when the water level in the dams gets low. Due to ageing, the effective generation capacity of WAPDA's thermal power plants has decreased slightly. In the past several years (before mid 1990s), the installed capacity had been insufficient to meet the demand on a year round basis. As such at different time of the year, particularly during low river flows, consumers were subjected to load shedding. The magnitude of load shedding was around 2,000 MW during 1994, which reduced the industrial growth and adversely affected the economy.

TABLE 7. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

								Average Annual Growth Rate (%)	
	1960	1970	1980	1990	1998	1999	2000	1960 to 1980	1980 to 2000
Electricity production (TW·h)									
- Total [a]	1.10	6.46	14.89	37.94	62.10	65.19	66.55	13.94	7.71
- Thermal	0.59	3.54	6.17	20.72	39.66	42.67	46.06	12.50	10.57
- Hydro	0.51	2.92	8.72	16.93	22.06	22.45	19.29	15.25	4.05
- Nuclear			[b]	0.29	0.38	0.07	1.20 [c]		
Capacity of electrical plants (GWe)									
- Total	0.42	1.72	3.50	7.86	15.66	15.66	17.73	11.15	8.45
- Thermal	0.17	1.05	1.79	4.83	10.70	10.70	12.44	12.53	10.17
- Hydro	0.25	0.67	1.57	2.90	4.83	4.83	4.83	9.55	5.79
- Nuclear			0.14	0.14	0.14	0.14	0.46 [c]	-	6.27

[a] Electricity losses are not deducted.
[b] Less than 0.01 TW·h
[c] 325 MW nuclear power plant, CHASNUPP, was connected to the national grid on 13 June 2000.
Sources: [Ref.4 & 8]

TABLE 8. ENERGY[a] RELATED RATIOS

	1960	1970	1980	1990	1998	1999	2000
Energy supply per capita (GJ/capita)	8	11	12	15	17	18	18
Electricity generation per capita (kW·h/capita)[b]	24	108	186	351	478	492	483
Electricity production/Energy production (%)	4	14	19	32	41	42	41
Nuclear/Total electricity (%)			[c]	0.8	0.6	0.11	1.6
Ratio of external dependency (%)[d]	18	23	18	25	30	30	30
Load factor of electricity plants (%)							
- Total	30	43	49	55	45	48	43
- Thermal	40	39	39	49	42	46	42
- Hydro	23	50	64	67	52	53	46
- Nuclear				24	31	6.5	42

[a] Wood is included
[b] Self generation is not included
[c] Less than 0.1%.
[d] Net import / Total energy consumption
Sources: [Ref. 2,4 & 8]

Since early 1990s, the economic growth of Pakistan has declined significantly from a level of about 6% per annum in the 1980s to a level of only 3-5% per annum. Along with this economic

decline, there have been real increases in the prices of electricity. Furthermore, there have been changes in legislation resulting in large increase in self-generating capacity installed in the industry. All these factors contributed to the slowing down of electricity demand on the grid.

The GOP is very keen for revival of economy and it has taken various measures in this regard. It is hoped that 6% economic growth will be achieved in the beginning of next decade (2010-2020).

Applied Systems Analysis Group of Pakistan Atomic Energy Commission has assessed the future electricity requirements using MAED and WASP methodologies of IAEA. For this study [Ref 5], 5% GDP growth has been assumed for the 9th Five-Year Plan (1998-2003), 5.5% for the 10th Plan period (2003-2008) and 6% thereafter up to year 2033. It has been estimated that total electricity demand will increase by 6.1% during 1998-2003, 7.0% during 2003-2008, 7.6% during 2008-2013, 7.3% during 2013-18, 7.0% during 2018-23 and 6.7% during 2023-33. The corresponding electricity generation capacities and fuel mix (determined with the help of WASP methodology of IAEA under various assumptions) are given in Table 9.

he Planning and Development Division of Government of Pakistan has also projected the electricity generation capacity requirements during preparation of 9th Five-Year Plan [Ref. 6]. However, its fuel mix is not available. Also, WAPDA has carried out a study to determine the maximum role of hydropower in energy mix of Pakistan [Ref. 7]. Projections of Planning Division and WAPDA are given in Table 9.

TABLE 9. REQUIREMENTS OF ELECTRICITY GENERATION CAPACITY IN THE YEARS 2005, 2010, 2015 AND 2020

MWe

	2005	2010	2015	2020
Projected Capacity				
Planning Division[1]	17,704-18,861	27,789-30,985	43,279-50,518	55,959 – 67,141
WAPDA[2]	20,247	26,307	39,655	-
ASAG[3]	20,559	26,780	37,771	52,375
Fuel Mix (ASAG[3])				
Hydro	6,518	8,518	12,878	15,662
Oil	7,140	6,356	8,270	9,534
Gas (including imports)	6,356	10,161	13,148	11,704
Indigenous Coal	150	750	1,950	12,750
Nuclear	395	995	1,525	2,725

1. [Ref. 6]
2. [Ref. 7]
3. [Ref. 5]

2.4. Impacts of Open Electricity Market on Nuclear Sector

In the past, the power sector in Pakistan was completely owned and operated by the GOP. Since mid 1980s, the GOP has been formulating policies to encourage private sector for electricity generation. The first policy was introduced in 1986 but the response was not very encouraging. In 1994, the GOP announced a comprehensive framework for attracting private sector investments for the development of power sector. The government adopted an aggressive strategy and a positive response from the private sector investors has been achieved. The private thermal power policy has been successful in achieving the addition of sizeable thermal capacity in the power sector. Significant progress has also been made towards the implementation of the restructuring and privitization programme of electricity utilities, particularly WAPDA. For increased use of indigenous energy resources a comprehensive hydro policy has been announced in 1995 aimed at attracting the private sector in helping GOP to exploit the hydro resource. According to the existing policy (announced in July 1998), private investors will develop power projects under the NEPRA license. NEPRA will invite offers for lowest tariff per kWh for delivered energy from private sector entrepreneurs.

In response to the first two private power policies (1986 and 1994), private investors made investments for oil and gas fired power plants. Now, in the new policy, GOP intends to promote hydro and indigenous coal-fired electricity generation for private sector. Up till now nuclear power

development is the responsibility of the Pakistan Atomic Energy Commission, which is a public sector organization. All the investments in nuclear power development are from public sector. At this stage, it is difficult to tell if the nuclear power industry would be able to attract private financing, as there are distinct features of nuclear power plants compared to other types of power plants (e.g. high capital costs, long construction period, unique safety aspects and international constraints on supply of nuclear power plants and its fuel).

3. NUCLEAR POWER SITUATION

3.1. Historical Development

Pakistan started construction of its first Nuclear Power Plant (KANUPP) in 1966 at Karachi and it was commissioned in 1971. The contract for a turnkey project of 137 MWe CANDU (PHWR) reactor was awarded to the Canadian General Electric (CGE). In 1975, Canada refused to supply fuel and spares for this plant due to nuclear non-proliferation concerns. Thereafter, Pakistan Atomic Energy Commission undertook fuel fabrication on an emergency basis and has been producing locally made fuel since 1981.

Despite the keen interest of Pakistan in building additional nuclear power plants, it took more than two decades to start construction of the second nuclear power plant due to unfavourable international environment coupled with lack of indigenous technological and industrial capabilities for independent design and construction of nuclear power plant. The construction of Pakistan's second nuclear power plant started in 1992 with the help of China National Nuclear Corporation (CNNC). The plant was connected to the national grid on 13 June 2000. It has a gross capacity of 325 MWe and is located at Chashma.

3.2. Current Policy Issues

Pakistan was among the first few developing countries to enter the field of nuclear power generation. Unfortunately, development of nuclear power in the country was constrained due to international embargoes, shortages of financial resources and insufficient technical manpower. However, this situation has improved considerably as a result of many years of a sustained and rigorous programme of training, research and development in the nuclear field. PAEC is pursuing a comprehensive plan in order to enhance its technical capability in the field of nuclear power in a manner that would gradually lead to a high degree of self-reliance. The plan aims at systematically developing local capability, in close co-operation with supplier countries, leading progressively to increase indigenous design, engineering and manufacture of nuclear power plants together with their components and fuel.

3.3. Status and Trends of Nuclear Power

At present, nuclear power provides about 3% of electricity generation in the country. This power is generated by the 137 MWe PHWR at KANUPP and the 325 MWe PWR at CHASNUPP. PAEC is planning to install another nuclear power plant at the CHASNUPP site. Table 10 provides the status of nuclear power plants in the country.

3.4. Organizational Chart

Figure 2 shows the organizational chart for the National Atomic Energy Authority of Pakistan.

Established as Pakistan Atomic Energy Committee in 1955, the Ordinance for Pakistan Atomic Energy Commission (PAEC) was promulgated by the President of Pakistan on 27th May 1965 which was later approved by the National Assembly on 21st July, 1965. PAEC was established for the promotion of peaceful uses of atomic energy in the country, the discharge of international obligations connected therewith, the execution of development projects involving nuclear power stations and matters incidental thereto.

TABLE 10. STATUS OF NUCLEAR POWER PLANTS

Station	Type	Net Capacity	Status	Operator	Reactor Supplier
CHASNUPP 1	PWR	300	Operational	PAEC	CNNC
KANUPP	PHWR	125	Operational	PAEC	CGE
CHASNUPP 2	PWR	300	Planned	PAEC	

Station	Construction Date	Criticality Date	Grid Date	Commercial Date	Shutdown Date
CHASNUPP 1	01-Aug-93	03-May-00	13-Jun-00	15-Sep-00	
KANUPP	01-Aug-66	01-Aug-71	18-Oct-71	01-Oct-72	
CHASNUPP 2					

Source: IAEA Power Reactor Information System year-end 2000.

PAEC has a Chairman and six full-time working members and three part time members, appointed by the Government of Pakistan. PAEC reports to the Pakistan Atomic Energy Council consisting of 24 members. Since the inception of PAEC, head of the Council has always been the Executive Head of the GOP.

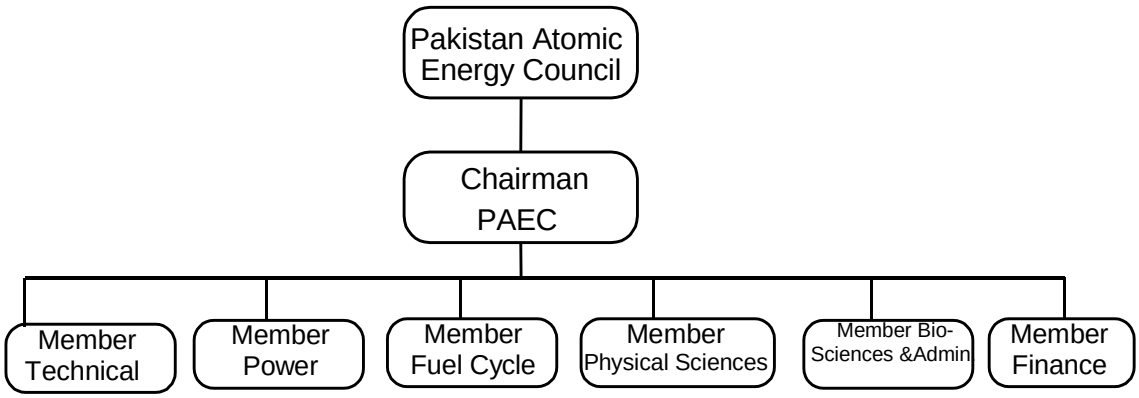

FIG. 2. Organizational Chart for National Atomic Energy Authority

The functions of the PAEC are to do all acts and things, including nuclear research work, necessary for the promotion of peaceful uses of atomic energy in the fields of agriculture, medicine and industry and for the execution of development projects including nuclear power stations and the generation of electric power. In the performance of its functioning, the Commission is guided by the instructions, if any, given to it by the GOP. PAEC may, subject to prior approval of GOP, cooperate with foreign national authority or international organization in respect of peaceful uses of atomic energy. PAEC also represents Pakistan's membership in IAEA.

4. NUCLEAR POWER INDUSTRY

4.1. Supply of Nuclear Power Plants

Policy and Strategy

Pakistan aims at gradual indigenisation of its nuclear power programme to the optimum level in order to reduce dependence on imported plant and fuel, conserve the precious foreign exchange component and lower overall cost, while raising the level of nation’s industrial and technological base.

Achievements

PAEC started nuclear power planning activities since early 1960s and has now developed expertise in energy forecasting, power plant economics and power system expansion and pre-project planning.

Design and engineering of nuclear power plant was initiated in 1980 and a formal Design & Engineering Department was set up in 1985. Over 100 engineers trained in Europe and China have actively participated in the design, design review, PSAR and FSAR preparation & review of CHASNUPP.

PAEC has already developed non-destructive testing (NDT) and quality assurance (QA) capability. The National Centre for Non Destructive Testing (NCNDT) and Pakistan Welding Institute (PWI) have been set up and PAEC has trained a large number of personnel in public and private sector.

The development of infrastructure facilities at CHASNUPP site and civil construction of all plant building/structures outside nuclear and conventional islands has been carried out by local industry. In future plants, civil works will be mostly carried out by local industry with sizable contribution in installation activities as well.

Some local manufacturing capability exists in the public and private sectors for the manufacturing of thermal power plant boiler components, heat exchangers and electrical equipment. In PAEC, efforts have been made to look after instrumentation and control, material, nuclear fuel cycle facilities and manufacture of spares for KANUPP. A Full Scope Training Simulator for CHASNUPP has also been developed by PAEC with the technical assistance of Chinese experts in addition to manufacturing of several vessels, tanks and piping, etc.

4.2. Operation of Nuclear Power Plants

PAEC is responsible for operation and maintenance of nuclear power plants in the country. KANUPP has been kept operational since its commissioning in 1971. In fact, since 1976 when Canada unilaterally abrogated the tripartite arrangement (Pakistan, Canada, IAEA) and stopped all supplies of fuel, heavy water, spare parts and technical information, Pakistan has been operating this plant under great odds. Pakistan had no other option but to develop local capabilities for making fuel and spares by itself. Now, both the nuclear power plants (KANUPP & CHASNUPP) are operating satisfactorily. Various PAEC centres (e.g., NCNDT, PWI, PINSTECH) provide valuable backup services as required.

4.3. Fuel Cycle and Waste Management Service Supply

PAEC initiated nuclear fuel cycle activities with a modest prospecting programme in early 1960s. A number of promising areas were located, some of which are presently being explored.

Uranium ore has been mined and the first ore processing plant using this indigenous ore has been in operation for some time. Essential laboratory facilities have also been set up to support the exploration and ore process development work.

Kundian Nuclear Fuel Complex (KNFC) has the facility for the fabrication of fuel for KANUPP.

Appropriate radioactive waste management systems have been designed for KANUPP and CHASNUPP to remove radioactive liquid, gaseous and solid wastes arising from the plant. These radioactive waste management systems collect, store, allow sufficient radioactive decay and process the waste through filtration, ion exchange, evaporation, solidification, vitrification and drumming.

4.4 Research and Development Activities

Research Reactor Facilities

PARR-1	Swimming Pool	10 MW	AMF, USA
PARR-2	Tank in Pool	30kW	CIAE, People's Republic of China

Research Institutes/Centres

- PINSTECH (Pakistan Institute of Nuclear Science and Technology)
  Basic/Applied Research in Physics, Chemistry, Materials, Safety, Radioisotope Applications and Radiation Protection

- PIEAS (Pakistan Institute of Engineering and Applied Sciences)
  (Formerly Centre for Nuclear Studies)
  Bachelor, Masters and PhD Degree Courses in various disciplines of Nuclear Engineering, System Engineering, Nuclear Medicine and Information Technologies

- KINPOE (Karachi Institute of Nuclear Power Engineering)
  Masters Degree in Nuclear Power Engineering, Diploma Course for Technicians

- INUP (Institute for Nuclear Power)
  Indigenization and Design of NSSS

- ICCC (Instrumentation, Control and Computers Complex)
  I & C of NPP, development of simulators, plant computer systems, etc.

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

As part of its commitment towards ensuring and continuously enhancing the operating safety of KANUPP, Pakistan is an active member in various international organizations in the field of nuclear energy, and exchanges operating data regularly. The Fuel Channel Integrity Assessment Programme (FCIA) was undertaken with the help of IAEA and Canada. An independent review of KANUPP steam generators was also carried out under contract by a Canadian utility. An IAEA seismic safety review mission inspected the plant in 1993. The findings of the above mission are eminently satisfactory. A project, “Improved Safety Features of KANUPP” is in progress under the auspices of the IAEA. This is an extension of the project “Safe Operation of KANUPP” which has been pursed in co-operation with the IAEA. The KANUPP is a member of WANO and COG.

CHASNUPP is also under the safeguards of IAEA. The design and safety review of CHASNUPP was carried out by an IAEA mission in 1993 and Pre OSART in March 1999. PAEC shares its operating information with other Nuclear Power Plant operators, through IAEA and WANO.

5. REGULATORY FRAMEWORK

5.1. Safety Authority and the Licensing Process

In Pakistan, nuclear regulatory matters are overseen by the Pakistan Nuclear Regulatory Authority (PNRA). PNRA was established through a Presidential Ordinance of 22nd January 2001 [Ref. 9]. The Authority is in the process of its formation. A Chairman and a full time member have been appointed by the Federal Government. The Authority shall consist of a Chairman, not more than two full time members and seven part time members. PNRA is empowered to devise adopt, make and enforce regulations and orders for nuclear safety and radiation protection to all types of nuclear installations and nuclear substances.

PNRA issues licences for the nuclear installations and production, storage, disposal, trade and use of nuclear substances and radioactive materials. The licence may be issued on application made to the Authority accompanied by prescribed fee, relevant information and documents, as required by regulations.

5.2. Main National Laws and Regulations

- Pakistan Nuclear Safety and Radiation Protection Regulations, 1990
- Regulations for Treatment of Food by Ionizing Radiation, 1996
- Regulations for Licensing of Nuclear Power Plant Operating Personnel, 1998
- Regulations for Licensing of Nuclear Research Reactors Operating Personnel, 1998

After the promulgation of the Pakistan Nuclear Safety and Radiation Protection Ordinance in 1984, and the Pakistan Nuclear Safety and Radiation Protection Regulations in 1990, preparation of regulatory documents started in 1990. The first document, prepared in 1990, was the "Procedure for Licensing of Nuclear Power Plants in Pakistan", which provides the basis for the licensing of nuclear power plants in Pakistan. Similarly, "Procedure for Licensing of Research Reactors in Pakistan" was prepared in 1991.

5.3. International, Multilateral and Bilateral Agreements

Pakistan became a Member State of the International Atomic Energy Agency (IAEA) in 1957 and has actively participated in virtually all of the Agency's activities. Pakistan has benefited from the IAEA's Technical Assistance and Co-operation Programme (TACP), and has also provided training to many scientists and engineers from other developing countries through TACP.

AGREEMENTS WITH THE IAEA

Project related safeguards agreements
INFCIRC No:

• /34	Research reactor	5 March 1962
• /116	Project agreements	17 June 1968
• /135	NPP Project/Canada	17 October 1969
• /239	Reprocessing Plant/France	18 March 1976
• /418	Supply of Nuclear Power Station from PR of China	24 February 1993

Unilateral safeguards submissions
INFCIRC No:

• /248	Supply of U-concentrate	2 March 1977
• /393	Supply of miniature source reactor from PR of China	10 September 1991
• Additional protocol		Not signed
• Improved procedure for designation of safeguards inspectors	prefers the present system	Letter of 20 December 1988
• Supplementary agreement on provision of technical assistance by the IAEA	Entry into force:	22 September 1994
• RCA		3 September 1987

• Agreement on privileges and Immunities with IAEA	Party	16 April 1963

Other Relevant International conventions/agreements etc.

• NPT		Non-Party
• Convention on the physical protection of nuclear material	Entry into force:	12 October 2000
• Convention on early notification of a nuclear accident	Entry into force:	12 October 1989
• Convention on assistance in the case of a nuclear accident or radiological emergency	Entry into force:	12 October 1989
• Vienna convention on civil liability for nuclear damage		Non-Party
• Joint protocol		Non-Party
• Protocol to amend the Vienna convention on civil liability for nuclear damage		Non-Party
• Convention on nuclear safety	Entry into force:	29 December 1997
• Convention on supplementary compensation for nuclear damage		Not signed
• Joint convention on the safety of spent fuel management and on the safety of radioactive waste management		Not signed (adopted 1997)
• ZANGGER Committee		Non-Member
• Nuclear export guidelines		Not adopted
• Acceptance of NUSS codes		No reply
• Partial; test-ban treaty	Signature:	14 August 1963

REFERENCES

[1] World Development Report 2000-2001, Attacking Poverty; the World Bank, Oxford University Press, 2001.

[2] Economic Survey 2000-2001 (and its earlier issues), Economic Advisor's Wing, Finance Division, Government of Pakistan, Islamabad, Pakistan.

[3] Annual Report 1999-2000, State Bank of Pakistan, Karachi, November 2000.

[4] Pakistan Energy Yearbook 2000 (and earlier issues), Hydrocarbon Development Institute of Pakistan, Ministry of Petroleum and Natural Resources, Government of Pakistan, Islamabad, Pakistan.

[5] Ahmad Mumtaz et.al., Role of Nuclear Power in Pakistan in Mitigating Greenhouse Gases Emissions: A Medium to Long Term Perspective. A Case Study of Pakistan. Progress Report of the Research Contract No. 10740, under IAEA's Co-ordinated Research Programme on "The Role of Nuclear Power and Other Energy Options in Meeting International Goals on Greenhouse Gas Emission Reductions", September 2000.

[6] Ninth Five Year Plan, Report of the Working Group for the Energy Sector, Energy Wing, Planning and Development Division, October 1997.

[7] Water Resources and Hydro Power Development Vision 2025, WAPDA, 2001.

[8] Energy Data Book, Ministry of Petroleum and Natural Resources, Government of Pakistan, 1978.

[9] The Gazette of Pakistan, Islamabad, January 22, 2001.

[10] Data & Statistics/The World Bank, www.worldbank.org/data.

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

[12] IAEA Power Reactor Information System (PRIS).

Appendix

DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

NATIONAL ATOMIC ENERGY AUTHORITY

Pakistan Atomic Energy Commission
(PAEC)
P.O. Box 1114
Islamabad
Pakistan

Tel.: +92-51-9204276
Fax: +92-51-9204908
Telex: 5725 ATCOM PK
Cable: ATOMCOM, ISLAMABAD

NATIONAL REGULATORY AUTHORITY

Pakistan Nuclear Regulatory Authority:
P.O.Box 1912
Islamabad
Pakistan

Tel +92-51-9204417
Fax: +92-51-9204112
www.pnra.gov.pk

OTHER ORGANIZATIONS

Aga Khan University — http://www.akuweb.com/

NED University of Engineering and Technology — http://www.rpi.edu/~ashrafs/ned.html

University of Karachi — http://www.kudcs.edu.pk/