PAKISTAN

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1. ENERGY, ECONOMIC AND ELECTRICITY INFORMATION

1.1. General Overview

Pakistan is situated in South Asia and it streches over 1,600 kilometres from south-west to north east. It lies between 23° and 37° north latitude and 60 ° and 76 ° east longitude. The country is a land of diversified physical features, and six major physical regions can be identified as:

1. Northern Mountains;
2. The Western off-shoots of the Himalayas;
3. Baluchistan Plateau;
4. Potowar Plateau and the Salt Range;
5. Upper and Lower Indus Plains;
6. The Thar Desert.

Similar to the diversity in physical features, Pakistan has great diversity of climate. In the northern mountains and western off-shoots of the Himalayas the winters are extremely cold and mountains remain snow covered, while the summer temperatures reach up to 52^{0}C at some places in the Baluchistan Plateau and the Lower Indus Plains.

Rainfall at most of the places in Pakistan is scanty. Nearly three fourths of Pakistan receives average annual rainfall of less than 25 cm [Ref. 1]. Pakistan is on the margin of the monsoon climate and most of the rainfall is in the months of July, August and September. Within the Indus Basin, flooding is an annual occurrence, and some parts of the Sind province are dependent on flood irrigated agriculture.

On January 1, 2003, the population of Pakistan was about 145 millions and the population density was 182 inhabitants per square kilometre (Table 1). At present, the population growth rate is about 2.1% per annum [Ref. 2].

TABLE 1: POPULATION INFORMATION

									Average Annual Growth rate (%)	
	1960*	1970*	1980*	1990*	2000*	2001*	2002*	2003*	1960 to 1980	1980 to 2003
Population (millions)**	45.0	59.7	80.2	108.2	136.0	139.1	142.1	145.1	2.9%	2.6%
Population density (inhabitants/km^2)	56.6	75.0	100.8	136.0	170.9	174.7	178.5	182.3	2.9%	2.6%
Urban population as percentage of total (%)	21.4	25.4	28.3	30.2	33.4	33.2	33.5	33.5		
Area (1000 Km^2)	796.1									

* *In this report, unless otherwise specified, years correspond to financial years (1st July – 30th June)*
** *On 1st January*
Sources: [Ref. 2]

1.1.1. Economic Indicators

During the last 42 years, Pakistan's economy has grown at an average annual rate of 6.8% (in current US$). However, due to high population growth rate, per capita Gross Domestic Product (GDP) has increased at only 3.9% per annum during the same period. The present per capita income in Pakistan is US$ 390, 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)

								Average annual growth rate (%)	
	1960	1970	1980	1990	2000	2001	2002	1960-1980	1980-2002
GDP(Million of current US $)	3,535	9,107	19,114	35,432	56,441	54,107	55,421	8.80%	4.96%
GDP (Million of constant 1990 US $)	6,353	12,210	19,534	35,432	54,484	55,820	57,835	5.78%	5.06%
GDP (Million of constant 2000 US $)	6,581	12,648	20,236	36,705	56,441	57,824	59,912	5.78%	5.06%
GDP/capita (current US $/capita)	79	153	238	327	415	389	390	5.71%	2.27%
GDP by sector (%)									
Agriculture	45.8	38.9	30.5	25.8	25.9	24.6	23.6		
Industry	15.0	20.7	22.7	22.2	20.8	21.4	21.6		
Services	39.2	40.4	46.8	51.9	53.3	54.0	54.8		

Sources: [Ref. 2]

TABLE 3: BASIC INDICATORS

Indicator	Period/year	
Average annual rate of inflation*	1980-1990	7.3%
	1990-2003	8.6%
Life expectancy at birth	2003	63 years
Literacy rate	2003	51.6%

** Measured by Consumer Price Index.*

Sources: [Ref. 2]

1.1.2. Energy Situation

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 fuelwood, agricultural and animal wastes. Pakistan does not have adequate oil reserves (Table 4) and has to import large quantities of oil to meet its energy requirements. During 2001-2002, Pakistan spent about 29.7% of its export earnings on petroleum imports [Ref. 2].

TABLE 4: ENERGY RESERVES (Exajoule)

	Estimated energy reserves on 30 June 2003					
	Solid	Liquid	Gas	Uranium	Hydro[1]	Total
Total amount in place	105	1.7	21.7		1.4	129.8

[1] *Equivalent to estimated hydropower potential of 30,000 MW by converting to energy at 50% plant factor and using 10550 GJ/GWh conversion factor from secondary energy to primary energy.*

Sources: [Ref. 3]

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 55,000-64,000 barrels per day (equivalent to about 13-22% of the country's oil consumption). Pakistan's natural gas production in year 2002-2003 amounts to

2,719 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 2002-2003 was only 3.3 million tonnes. The sectoral distribution of coal consumption is as follows: Brick kilns: 53.3%, Coke use: 22.9%, Cement: 19.6%, Power: 4.2%. 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.

During the year 2002-2003, hydropower provided 29.5% of electricity in Pakistan. Although, Pakistan has relatively high endowment of hydropower potential, only 5,046 MW (14%) has been exploited. Various mini/micro hydel 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 2.3% of electricity needs of the country in year 2003. The first plant, KANUPP, has completed its designed life and has generated over 10.7 billion KWh of electricity. KANUPP will restart in early 2004 for its extended life. The second nuclear power plant, CHASNUPP, was connected to the national grid on June 13, 2000, and has generated over 5 billion kWh of electricity upto 30 June 2003.

TABLE 5: ENERGY STATISTICS

	Exajoule								Average Growth Rate %
	1960	1970	1980	1990	2000	2001	2002	2003	1980 to 2003
Energy Supply[1]									
Total	**0.38**	**0.64**	**1.04**	**1.70**	**2.46**	**2.47**	**2.51**	**2.60**	**4.0**
Solids[2]	0.29	0.33	0.44	0.55	0.65	0.60	0.61	0.64	1.7
Liquids	0.07	0.17	0.20	0.50	0.83	0.86	0.83	0.80	6.1
Gases	0.02	0.11	0.25	0.47	0.77	0.81	0.85	0.91	5.8
Primary electricity[3]	0.01	0.03	0.16	0.18	0.21	0.20	0.22	0.25	2.1
Energy production									
Total	**0.31**	**0.49**	**0.86**	**1.29**	**1.73**	**1.71**	**1.80**	**1.90**	**3.5**
Solids[2]	0.27	0.33	0.44	0.52	0.62	0.57	0.58	0.59	1.3
Liquids	0.01	0.02	0.02	0.12	0.13	0.13	0.14	0.15	8.8
Gases	0.02	0.11	0.25	0.47	0.77	0.81	0.85	0.91	5.8
Primary electricity[3]	0.01	0.03	0.16	0.18	0.21	0.20	0.22	0.25	2.1
Net import (import-export)									
Total	**0.07**	**0.15**	**0.18**	**0.41**	**0.73**	**0.75**	**0.71**	**0.69**	**6.2**
Solids[2]	0.02	0.00	0.00	0.03	0.03	0.03	0.03	0.05	
Liquids	0.05	0.15	0.18	0.38	0.71	0.73	0.68	0.65	5.7
Gases	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Share of domestic Oil production (%)	17.7	12.4	10.4	24.1	15.3	15.3	17.5	18.4	

(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. 3&4]

1.2. Energy Policy

Up till 2000, energy sector, to a large extent, was owned and operated by the Government of Pakistan (GOP). During the last two decades, GOP formulated various policies and programs to reform the energy sector. Besides improving the efficiency of public sector institutions, policies were

made to increase the private sector participation in the development of energy sector. For the electricity sector, the GOP encouraged setting up of private sector power projects on BOO (Build-Own-Operate) basis under 1986 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.

Creation of competitive markets for energy/electricity is one of the major aims of all energy sector policies. The GOP has setup legal and institutional framework for re-structuring of energy sector entities owned by the public sector. The ultimate aim is creation of a market in which private companies will be working under the regulatory authorities to provide energy/electricity on competitive basis.

The competitive electricity market will be established in two stages:

- Single Buyer Plus (SBP) trading arrangement
- Competitive Trading Bi-lateral Contract Market (CTBCM) by July 2009 or latest by July 2012.

In view of the fact that competitive market will need sometime to evolve, the GOP announced its policy for power generation projects in 2002. This policy laid down a frame of work in which both private and public sectors will work together to expand power generation capacity required in the near future (i.e. 2005 onwards). The objectives of the policy are:

- To provide sufficient capacity for power generation at the least cost, and to avoid capacity shortfalls;
- To encourage and ensure exploitation of indigenous resources, which include renewable energy resources, human resources, participation of local engineering and manufacturing capabilities;
- To ensure that all stakeholders are looked after in the process, i.e. a win-win situation for all; and
- To be attuned to safeguarding the environment.

Private Power and Infrastructure Board (PPIB) was given the job of solicitation of bids for hydel and indigenous fuel-based projects, for which feasibility studies are already available; and to initiate feasibility study work on raw sites for exploiting indigenous as well as renewable resource. As per 2002 policy, hydel projects in the private sector will be implemented on Build-Own-Operate-Transfer (BOOT) basis. Thermal projects will be established either on BOOT or Build-Own-Operate (BOO) basis by the private sector. The basis for selection of the successful bidder in each case will be the minimum levelized tariff, either through International Competitive Bidding for solicited proposal or through negotiations.

Because, large-hydro power projects will remain the responsibility of WAPDA (a public utility), it prepared a hydro power development plan in 2000. This plan identifies additional power generation capacity that will be required in the next 5 to 25 years (2005 to 2025), and hydro power projects that can be built.

1.3. The Electricity System

1.3.1. Electricity Market

In 1997, an electricity act was passed to establish the National Electric Power Regulatory Authority (NEPRA) for regulating the provision of electric power services in a competitive market. NEPRA is responsible for grant of licenses to generation, transmission, and distribution companies. Until fully competitive market is emerged the authority will approve tariff rates and other terms and

conditions for the supply of electric power services by the generation, transmission and distribution companies.

By the end of 2002 the Power Wing of Water and Power Development Authority (WAPDA) was restructured to create the following twelve corporate entities:

- Three Thermal Power Generation Companies (GENCOs)
- Eight Distribution Companies (DISCOs)
- One National Transmission and Power Dispatch Company (NTDC); it was established in December 2002 and was given exclusive right to transmit electricity 220 KV and above in whole country excluding area of Karachi Electric Supply Corporation (KESC).

Privatization of these generation and distribution companies was to be carried out by 2001. Up till now privatization schedule of only one distribution company (FESCO) is finalized and sent to the Privatization Commission of Pakistan. Restructuring of the KESC, has also been initiated.

1.3.2. Structure of the Electricity Sector

The followings are the major stake holders in the electricity sector.

- **WAPDA (Water and Power Development Authority)**

  WAPDA has the following responsibilities:
  - Planning and execution of 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.

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

- **PAEC (Pakistan Atomic Energy Commission)**

  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 June 13, 2000.

- **IPPs (Independent Power Producers)**

Up till now private sector is involved in electricity generation only. The IPPs in operation as on 30th June 2003 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)
- Liberty Power (235 MW)
- Altern Energy (10 MW)

- **Central Power Generation Company Ltd. (CPGCL)**
- **Northern Power Generation Company (NPGC)**
- **Jamshoro Power Company Ltd. (JPCL)**
- **Lakhra Power Generation Company Ltd. (LPGCL)**
- **National Transmission and Distribution Company (NTDC)**

The NTDC is supposed to establish its four independent parts.

i. Central Power Purchasing Agency (CPPA) for the procurement of power on behalf of the ex-WAPDA DISCOs,

ii. "System Operator" to carryout the job of dispatching of plants and provision of balancing services,

iii. "Transmission Network Operator" for the operation and maintenance of the transmission system including planning, design and capacity expansion of its transmission system, generation expansion, least-cost planning and sitting of new generation facilities,

iv. Contract Registrar and Power Exchange Administrator (CRPEA) to look after bi-lateral trading contract of generation licensees with the Bulk Power Consumers (BPCs)/distribution companies.

- **Distribution Companies**

Table 6 provides the installed electricity generating capacity and transmission voltages of WAPDA, generation companies 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 2003

Utilities	Installed Capacity (MWe)				Transmission Voltage
	Thermal	Hydro	Nuclear	Total	
WAPDA	-	5,010	-	5,010	500,220,132 kV
AJKHEB*		36		36	
KESC	1,756	-	-	1,756	220,132 kV
PAEC	-	-	462	462	
IPPs	5,794	-	-	5,794	500,220,132 kV
CPGCL	1,655	-	-	1,655	
NPGC	1,876	-	-	1,876	
JPCL	904	-	-	904	
Total	12,286	5,046	462	17,793	

**Azad Jammu Kashmir Electricity Board*
Source: [Ref. 3 & 4]

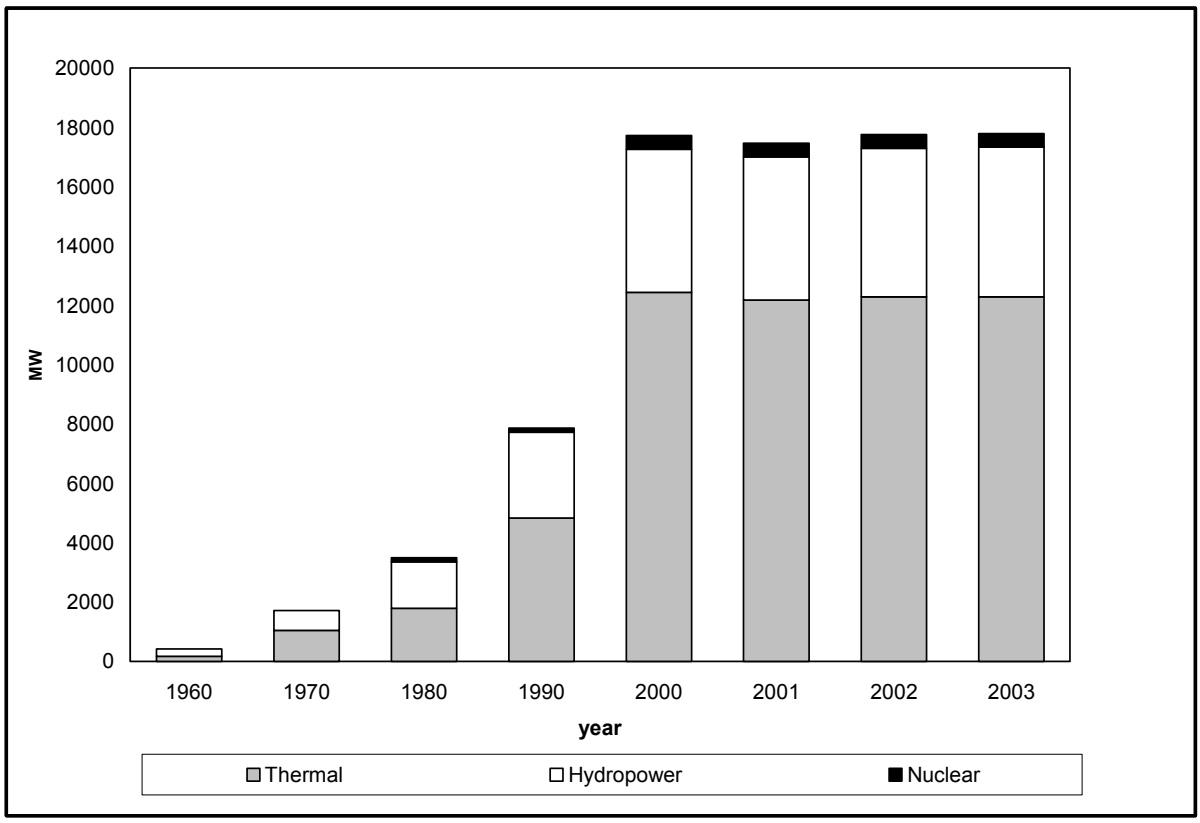

Fig. 1 Installed Generating Capacity of Electric Power on 30th June 2003

1.3.3. Decision Making Process

The National Economic Council (NEC) is the supreme 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, and approves any energy sector project to be built by the public sector. For example, any nuclear or large-hydro power project needs approval of the ECNEC.

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.

1.3.4. Main Indicators

Table 7 shows the historical electricity production and installed capacity in the country and Table 8 provides energy related ratios. Most parts of the country have both severe winter and summer as a result, there is a vide variation in electricity demand during the year. Furthermore, higher share of household sector in total electricity demand makes the peak demand more pronounced. On the other hand, high share of hydro power in total supply results in seasonal variation in supply. These variations are further effected by the regulation on water out flow from the storage dam for irrigation. Up till early 1990, there was a wide gap between the maximum demand at peak hours and the installed capacity in certain months. The hydro capacity decreases to about 3,000 MW from installed capacity of 5,046 MW when the water level in the dams gets low.

Table 9 gives weighted average generation costs of electricity by producers in year 2002. Table 10 gives power sector development plan for next twenty years prepared by NTDC.

TABLE 7: ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

	1960	1970	1980	1990	2000	2001	2002	2003	Average Annual Growth Rate (%) 1980 to 2003
Electricity production (TWh)									
Thermal	0.59	3.54	6.17	20.72	46.06	48.93	51.17	51.59	9.67
Hydro	0.51	2.92	8.72	16.93	19.29	17.19	18.94	22.35	4.18
Nuclear			*	0.29	0.40	2.00	1.8	1.74	
Total(1)	1.10	6.46	14.89	37.94	65.75	68.12	72.41	75.68	7.33
Capacity of electrical plants (GWe)									
Thermal	0.17	1.05	1.79	4.83	12.44	12.18	12.29	12.29	8.73
Hydro	0.25	0.67	1.57	2.90	4.83	4.83	5.01	5.05	5.22
Nuclear			0.14	0.14	0.14	0.46	0.46	.46	5.43
Total	0.42	1.72	3.50	7.86	17.40	17.47	17.76	17.79	7.33

(1) Electricity losses are not deducted.
** Less than 0.01 TWh*
Sources: [Ref.3, 4 and PAEC]

TABLE 8: ENERGY* RELATED RATIOS

	1960	1970	1980	1990	2000	2001	2002	2003
Energy supply per capita (GJ/capita)	8	11	13	16	18	18	18	18
Electricity generation per capita (kWh/capita)**	24	108	186	351	483	490	510	522
Electricity production/Energy production (%)	4	14	18	31	40	42	43	42
Nuclear/Total electricity (%)	-	-	***	0.8	0.6	2.9	2.5	2.3
Ratio of external dependency (%)[(1)]	18	23	18	24	30	31	28	27
Load factor of electricity plants (%)								
- Total	30	43	49	55	43	45	47	49
- Thermal	40	39	39	49	42	46	48	48
- Hydro	23	50	64	67	46	41	43	51
- Nuclear	-	-	-	24	33	49	44	43

(1) Net import / Total energy consumption
** Wood is included*
*** Self generation is not included*
**** Less than 0.1%.*
Sources: [Ref. 2, 3 &4]

TABLE 9: ELECTRICITY GENERATION COSTS IN 2001-02

	Generation (GWh)	Weighted Average Generation cost (Rs*./kWh)
WAPDA-Hydel	18,941	0.21
WAPDA-Thermal	18,684	2.50

** One US $. = Rs. 61.4258*
Sources: [Ref. 8]

TABLE 10. REQUIREMENTS OF ELECTRICITY GENERATION CAPACITY (MWe) in the years 2010, 2020 and 2025

	2010			2020			2025		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Maximum Demand (MW)	16554	16758	16895	27188	31221	33379	33842	41194	48,199
Energy Generated (GWh)	99315	100490	101351	163250	187220	200283	202946	246705	288,804

Sources: [Ref. 9]

2. NUCLEAR POWER SITUATION

2.1. Historical Development and current nuclear power organizational structure

2.1.1. Overview

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 June 13, 2000. It has a gross capacity of 325 MWe and is located at Chashma.

2.1.2. Current Organizational Chart(s)

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.

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.

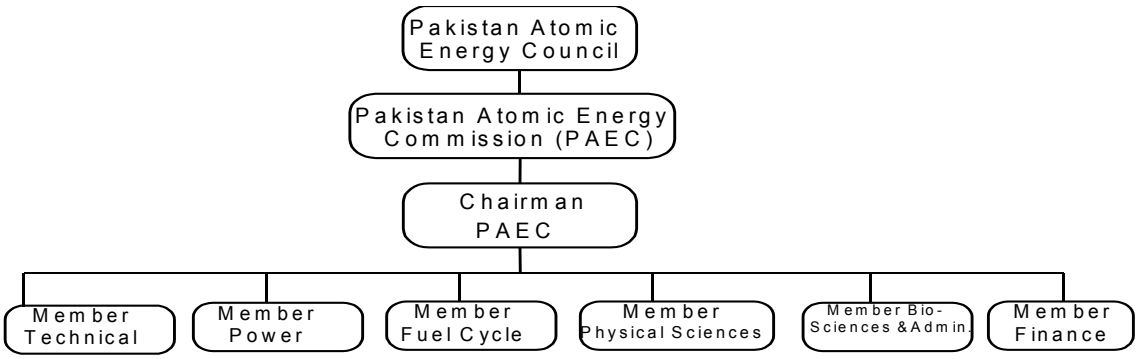

FIG. 2. Organizational Chart for National Atomic Energy Authority

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.

2.2. Nuclear Power Plants: Status and Operations

At present, nuclear power provides about 2.3% of electricity generation in the country. This power is generated by a 137 MWe PHWR, KANUPP and 325 MWe, PWR CHASNUPP. PAEC is planning to install another nuclear power plant at the CHASNUPP site. Table 11 provides the status of nuclear power plants in the country. The first nuclear power plant of Pakistan (KANUPP) completed its nominal designed life of 30 years in 2002. After long-term planning with the IAEA and CANDU Operators Group (COG), PAEC carried out a renovation programme for KANUPP in 2002 to extend its life for 15 years. Table 11 gives the major features of the NPP of Pakistan.

TABLE 11: STATUS OF NUCLEAR POWER PLANTS

Station	KANUPP	CHASNUPP 1	CHASNUPP 2
Type	PHWR	PWR	PWR
Gross Capacity	137	325	
Operator	PAEC	PAEC	PAEC
Status	In Licensing process after rehabilitation	Operational	Proposed
Reactor Supplier	CGE	CNNC	
Construction Date	01-Aug.-66	01-Aug.-93	
Criticality Date	01-Aug.-71	03-May-2000	
Grid Connection Date	18-Oct.-71	13-June-2000	
Commercial Operation Date	07-Dec.-72	15-Sept-2000	
Shutdown Date			

Source: PAEC

2.3. Supply of NPPs

Policy and Strategy

Pakistan aims at gradual indigenisation of its nuclear power program 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 and 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.

2.4 Operation of NPPs

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, PAEC has capability to operate its two nuclear power plants (KANUPP & CHASNUPP) satisfactorily. Various PAEC centres (e.g., NCNDT, PWI, PINSTECH) provide valuable backup services as required.

2.5. Fuel Cycle and Waste Management

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.

2.6 Research and Development

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/Centers

- 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 Center for Nuclear Studies)
  Bachelor, Masters and Ph.D 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.
- CHASCENT (CHASNUPP Centre for Nuclear Training)
  one year course for Engineers and Technicians

2.7. International Co-operation and Initiatives

Pakistan is an active member in various international organizations in the field of nuclear energy, and exchanges operating data regularly with IAEA, WANO and COG. The Fuel Channel Integrity Assessment Programme (FCIA) of Karachi NPP was undertaken with the help of IAEA and COG, 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 mission are eminently satisfactory. A project, "Improved Safety Features of KANUPP" is in progress under the auspices of the IAEA.

The design and safety review of CHASNUPP was carried out by an IAEA mission in 1993 and Pre OSART in March 1999. An IAEA OSART Mission of CHASNUPP is being conducted from 12–29 January 2004. PAEC shares its operating information with other Nuclear Power Plant operators, through IAEA, WANO and COG. Both the nuclear power plants KANUPP and CHASNUPP are under the IAEA Safeguards.

2.8. Human Resources Development

PAEC has been making a significant contribution in development of human resources in the field of Science and Technology in particular in application of nuclear Science and Technology. Every year young Scientists and engineers from various fields get post-graduate degrees and training in the training centers of PAEC listed in section 2.6. These trained personals also get the opportunity to get work experien ce in their relevant fields by working in the research institutes of PAEC. Especially, experience of working on research reactors and nuclear power plants is a unique opportunity for the professionals of the developing countries.

3. NATIONAL LAWS AND REGULATIONS

3.1. 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. 7]. 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 consists 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.

3.2. Main National Laws and Regulations in Nuclear Power

- 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 Reasearch 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.

4. CURRENT ISSUES AND DEVELOPMENTS ON NUCLEAR POWER

4.1. Energy Policy

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 program 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.

4.2. Privatisation and deregulation

Under the current policy, an open and competitive electivity market is to be developed in Pakistan latest by 2010. The focus of this policy is to increase private sector participation in electricity market and reduce dependence on public sector. All fossil-fuel based power projects will be developed by the private sector. Nuclear power remains in the public sector. Because all activities in the electricity market are to be under the license of NEPRA, nuclear power plants although are part of PAEC, they are registered and will be operating under the rules and regulations given in the generation license issued to them by the NEPRA.

4.3. Role of the government in the nuclear R& D

Government. of Pakistan is fully supporting all the research and development programmes of PAEC. These R&D programs encompass nuclear application in various areas including medicine, agricultural development, food, water and nuclear power.

4.4. Nuclear Energy and Climate Change

Table 11 reports electricity generation from nuclear power plants in Pakistan during last 31 years. There were two alternative sources to replace this generation - gas fired and furnace oil fired power plants. Table 11 shows GHG's emissions if this amount of electricity would have been produced by these two alternative sources.

TABLE 11: GHGS EMISSIONS AVOIDED BY NUCLEAR

Total Nuclear Generation (million kWh)	GHG Emissions (million tons)		
	Oil Steam	Gas Steam	Gas CC
14151	10.9	7.9	6.8

Hence nuclear power contributed in reduction of GHG's emissions in the range of 6.8 to 10.9 million tons during the last 31 years.

4.5. Safety and waste management issues

The Directorate of Safety (DOS) looks after the safety aspects of PAEC projects. KANUPP and CHASNUPP have their own waste management programs for disposing solid, liquid and gaseous wastes and sites for ultimate disposal of radioactive waste are being explored.

4.6. Other issues

In near future PAEC is planning to install another unit of 325 MWe at Chashma site.

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Appendix 1

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 inspector	Prefers the present system	Letter of 20 December 1988
• Supplementary agreement on provision of technical assistance by the IAEA		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 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

Appendix 2

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

National Atomic Energy Authority

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