STATUS AND POTENTIAL OF NUCLEAR ENERGY IN PAKISTAN

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ABSTRACT

Pakistan is an energy resource-deficient country which is heavily dependent on imported energy, while its per capita energy consumption level is still very low. Energy and electricity needs have been growing rapidly and these trends are expected to continue in the coming years. In order to reduce its reliance on imported energy, Pakistan needs to make use of nuclear power on a large scale. This paper discusses the limitations of indigenous energy resources in coping with the future requirements of electricity and compares the cost economics of nuclear power with that of electricity generation based on imported oil and coal. It then describes the efforts being made in the country to make use of nuclear power in a self-reliant manner.

1. INTRODUCTION

Pakistan is now passing through an energy-intensive phase of socio-economic development and will need large amounts of energy and electricity in the coming years in order to meet its developmental goals. Inspite of about 20 fold increase in total commercial energy consumption and some 130 times increase in electricity supply over the last four decades, the level of energy consumption in Pakistan is still very low compared to the world norms. With the present annual per capita consumption of commercial energy and electricity being around 0.25 Ton of Oil Equivalent (TOE) and 350 KWH respectively, this level corresponds to about half the average for the developing countries, one-seventh of the world average and one-twentieth of the average for the industrialised countries.

Not only Pakistan has an extremely low level of energy consumption, it is also very poor in terms of availability of energy resources. The per capita availability of fossil fuel reserves in Pakistan is only 5 TOE as compared to the world average of 151 TOE and 11 TOE in the oil importing developing countries. As a

result, the country has to meet about one-third of its energy requirements and three-quarters of oil requirements through imports resulting in serious balance of payment difficulties due to high cost of energy imports.

Electric power is a key component of the energy sector and has been claiming around 80% of the total public sector development outlays for this sector. Despite a 100 fold increase in power generation capacity over the last four decades, the supply of electricity, in Pakistan, is still unable to keep pace with the demand. The peak electricity demand has been exceeding supply capability by about 25% for the last five years, necessitating load-shedding of 800-1200 MW. Apart from causing inconvenience to the general public, these power shortages are estimated to be resulting in a reduction of annual gross domestic product by about 2%, with a loss of about $ 350 million per annum in industrial value added and an estimated $75 million per annum reduction in the country's exports of manufactured goods [1]. This is notwithstanding the fact that since 1978 the power generation requirements have been increasingly met

through the use of oil resulting in increased oil imports. Inspite of the relatively low prices of oil since 1986 the oil import bill has been draining some 25 to 40 percent of the country's hard earned foreign exchange through exports. There is thus an urgent need to formulate a well considered long-term plan to cope with the future requirements of energy and electricity that does not commit the country to a massive dependence upon imported energy. In this paper we discuss the limitations of our indigenous resources of fossil fuels and hydro power in meeting the requirements of electricity over the next two decades. The paper also provides an outline of the present status and future plans for nuclear power development in the country.

2. FUTURE REQUIREMENTS OF POWER GENERATION CAPACITY

The demand for electricity in the country has been growing very rapidly: In spite of load sheddings the consumption of electricity grew at about 9% per annum during the 1970s and 10% per annum during the 1980s [2]. The present installed power generation capacity in Pakistan is 8,500 MW, comprising hydel: 39%, oil and gas: 59%, coal: 0.2% and nuclear: 1.8%. Assuming the success

of government's drive for energy conservation and reduction of transmission and distribution losses, it is estimated that, for a medium pace of economic development (6% p.a. growth of gross domestic product), the requirements of installed capacity will increase to about 20,000 MW by the year 2000 and to around 45,000 MW by the year 2010. These projections are in good agreement with those made by WAPDA and the Planning Commission.

3. SUPPLY POTENTIAL OF DOMESTIC FOSSIL FUEL AND HYDRO RESOURCES

Natural Gas: Our known recoverable reserves of natural gas now amount to about 400 million TOE. The present annual production is around 11 million TOE meeting about 36% of total energy requirements. How meagre are these gas reserves can be judged from the fact that even if the production were to be held constant at the present level, they would last hardly for about 38 years. However, if the production were to increase around 10% per annum (as is envisaged for the 7th Plan period), our known gas reserves will all be exhausted within a matter of next 17 years. The irony is that inspite of considerable increase in the pace of petroleum

exploratory activity over the last 10 years, the new additions to gas reserves have not been sufficient even to compensate for the cumulative production of gas during this period.

At present about 2,850 MW of thermal capacity is either exclusively based on gas or is dual fired and uses gas or oil, depending on the availability of gas. About one third of the total gas production is being used in the power sector. The government is cognizant of the fact that natural gas is a valuable feedstock and a preferred fuel for use by households and commercial sector and that the country's known gas reserves have been depleting faster than the rate of new reserves addition. Accordingly, it has decided to restrict the use of high quality gas for power generation to the present level and to allow addition of gas-fired capacity only if based on low quality, dormant gas fields. As such, the available gas supplies would not be able to support more than 2500-3000 MW of capacity in the year 2000 and beyond unless some major new discoveries are made.

Oil: The recent estimates of known recoverable oil reserves in Pakistan amount to only 25 million tons. The present annual production is about 2.5 million TOE, which covers about one-fourth of the oil requirements of the country. Although, in recent years there has been a considerable increase in exploratory activity and the results have been quite encouraging, still the present level of exploratory effort is too low to lead anywhere close to self sufficiency in oil in the foreseeable future. As such, the oil based power generation will continue to be fueled by imported oil over the next two decades.

Coal: According to recent estimates the proven reserves of coal in the country amount to 500 million tons equivalent to 165 million TOE. If all these reserves were to be allocated to power generation, they would at best be able to support the life time (30 years) operation of about 3500 MW power generation capacity. However, our coal reserves are of extremely poor quality with 3-6% sulphur, 16-21% ash and 27-32% moisture. As such they are unsuitable for most industrial applications and power generation using the conventional coal burning

techniques. WAPDA is now building three 50 MW coal fired plants that will burn the indigenous coal using the fluidised bed combustion technology. However, On the basis of the present situation of domestic coal reserves and their development problems, it would not be realistic to expect more than 1000 MW power generation capacity based on indigenous coal by the year 2000 and some 3000 MW by 2010. As for the use of imported coal, shortage of port handling capacity and high cost of in-land coal transportation are two major constraints that will restrict its widespread use for power generation in Pakistan.

Hydro Power: Of an estimated 27,000 MW potential of the identified hydro power sites in Pakistan, only 2,900 MW has so far been developed (Tarbela: 1750 MW, Mangla: 800 MW, Warsak: 240 MW, other small plants: 110 MW). Work is now in progress on extension of Tarbela (by 1728 MW) and Mangla (by 200 MW) and on the planning and construction of some low head hydel plants (500 MW). Construction of some large new dams is also planned. Among them, Kalabagh dam (3600 MW) is at the final stages of planning but, due to some water allocation

problems among provinces, actual construction has not yet started. If the development effort on various hydro projects other than Kalabagh proceeds according to the existing plans, the hydro capacity may be expected to become about 6,500 MW by the year 2000. Assuming that two large dams (the possibilities being Kalabagh, Basha and Dasu) are completed within the first decade of the next century, the available hydro capacity may possibly reach a level of 13,000-14,000 MW by the year 2010.

Thus the country's indigenous resources of hydro and fossil fuels may, at best, be stretched to support some 10,000 MW capacity by the year 2000 and, perhaps, 19,000 MW or so by the year 2010. Accordingly there will be large gap -- about 10,000 MW in the year 2000, increasing to some 26,000 MW by the year 2010--that will have to be filled in either by building thermal plants based on imported coal and oil or by making use of nuclear power or through a combination of both.

4. NUCLEAR POWER

Nuclear power is a well established and proven technology for power generation. This technology is being

used by a number of countries, in preference over oil and coal, to meet their electricity requirements. At present, there are 438 nuclear power reactors with a total capacity of 342,000 MW connected to the grid in 26 countries [3]. These reactors contributed about 17% to the total global electricity generation in 1989. The share of nuclear electricity generation now exceeds 25% in 12 countries, and 40% in 6 countries. As for the developing countries, operating reactors now exist in 10 developing countries and account for about 8% of the global nuclear installed capacity.

Economic aspects: Nuclear power plants are more capital intensive than oil and coal fired plants. However, the fuel cost of a nuclear plant is relatively much lower than that of a fossil fuel fired plant so that the overall cost economics of electricity generation is generally in favour of nuclear plants (see table 1). It is largely for this reason that over the past three decades a number of countries, both developed and developing, have resorted to large scale use of nuclear power for electricity generation. One other important feature of nuclear power is that its fuel cost hardly

amounts to 20% of the electricity generation cost as compared to some 50-70% for fossil fuel fired plants. This makes the cost of nuclear electricity generation relatively insensitive to possible future escalation in the price of fuel. Further, the higher initial investment on the nuclear plant is offset by savings in fuel costs in a few years time and thereafter the nuclear plant results in net savings. It is this favourable cost economics, coupled with the freedom from dependence on fossil fuels, which makes nuclear power particularly attractive for oil importing developing countries.

Environmental Aspects: Nuclear power plants are not only more economic compared to fossil fuel fired plants, they are also environmentally less polluting. In fact nuclear power is the only technology used for electricity generation which, from the very beginning of its development, has taken into account the possible environmental impacts. As a result, even the radioactivity released to the environment by a nuclear power plant is less than that from some of the existing coal fired power plants of comparable size. Further, unlike the fossil fuel fired plants, a nuclear power

plant does not produce any carbon dioxide or oxides of sulphur and nitrogen, which lead to adverse environmental degradation through the well known phenomena of acid rain and the greenhouse effect.

5. NUCLEAR POWER DEVELOPMENT IN PAKISTAN

In view of the limitations of its fossil fuel and hydropower resources, Pakistan is extremely keen to make large scale use of nuclear power to meet its future electricity requirements. A beginning to this effect was made when a 137 MW CANDU type reactor, called Karachi Nuclear Power Plant (KANUPP), built with Canadian assistance was commissioned in 1971. The plant has since been kept operational and has generated over 5 billion KWh of electricity. However, inspite of a pressing need for large scale use of nuclear power it has not been possible to build any additional nuclear power capacity due to unfavourable international environment coupled with lack of indigenous technological and industrial capability for independent design and construction of nuclear power plants. In fact since 1976, Pakistan has even been operating KANUPP under great odds. This has been because following the explosion of a nuclear device

by India, Canada in 1976 unilaterally abrogated the tripartite arrangement (between Pakistan, Canada and IAEA) and stopped all supplies of fuel, heavy water, spare parts and technical information [4]. This posed very serious supply and safety problems for Pakistan. It had no other option but to develop local capabilities for making fuel and spares by itself. Uranium mining, refining and fabrication of fuel were achieved within a short span of time to avoid forced shutdown of KANUPP. At the beginning, the plant was partially loaded with locally manufactured fuel, whose fraction was gradually increased with perfectly satisfactory performance, and August 7, 1990 marked the historic event of nuclear history of the country with an All-Pakistan KANUPP Fuel [5]. Besides mastering fuel technology, Pakistan has developed capabilities to design and manufacture necessary spare parts for the plant, to modify and update computer, control and instrumentation systems and to undertake routine maintenance.

In order to make large scale use of nuclear power in a manner that would gradually lead to a high degree of self-reliance, PAEC is now pursuing simultaneously two

plans encompassing short term and long term time horizons respectively. The short term plan envisages construction of a few nuclear power plants with assistance from some friendly countries, as quickly as possible with a view to alleviate power shortages. It is planned to purchase proven type of commercially available plants of standard design at reasonable financing terms, ensuring full participation of PAEC and local industry for maximising transfer of technology.

The long term plan aims at systematically developing local capability, leading progressively to increasing indigenous design, engineering and manufacture of nuclear power plants together with their components and fuel. Efforts have been initiated, particularly, i) to develop design and engineering know-how for a complete nuclear power plant including nuclear steam supply system, ii) to establish nuclear equipment design and fabrication facilities, iii) to develop design know-how and create fabrication facilities for instrumentation and control systems of a nuclear power plant, iv) to build facilities for production of all necessary nuclear materials in adequate quantities, v) to strengthen and

create necessary institutions to produce qualified and skilled manpower in various fields of nuclear technology, and vi) to constitute R & D projects related to various aspects of nuclear fuel cycle. In this way it is envisaged that, about 2000 MW nuclear capacity would become operational by the year 2000, increasing to some 6000-8000 MW by the year 2010.

6. CONCLUSIONS

In order to promote economic development, it is imperative to alleviate the electric power shortages in the country which are seriously affecting both industrial and agricultural production. Nuclear power presents a technologically proven option for the supply of electricity in a cost effective way. The electricity generation cost from a nuclear plant is considerably lower than that from fossil fuel fired plants and is also largely immune to future fluctuations in fuel prices. Although the initial investment is higher for a nuclear plant, its fuel cost is much lower resulting in considerable yearly savings in operation costs. As a result, the higher initial investment in the nuclear plant is offset by the higher fuelling cost of a fossil

fuel fired plant within a few years. Thereafter the nuclear plant results in net savings, which over the plant life may amount to several times the initial investment. For an oil importing country, like Pakistan, such savings will be in foreign exchange, resulting in improvement of the country's balance of payments. Further, the development of nuclear power in the country will also have profound positive impact on the local industrial capability. These advantages, together with increased energy independence, make nuclear power very attractive for sustained economic development of Pakistan.

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Table 1

ECONOMIC COMPARISON OF 900 MW (NOMINAL) NUCLEAR AND FOSSIL FUEL-FIRED PLANTS
(COSTS IN CONSTANT U.S. DOLLARS OF JANUARY 1990)

	NUCLEAR	OIL-FIRED	COAL-FIRED
SPECIFIC CAPITAL COST ($/KW)			
WITHOUT IDC	1,400	700	1,065
INCLUDING IDC	1,535	740	1,130
GENERATION COST (MILLS/KWH)			
FIXED CHARGES	16.6	7.8	12.2
O & M COST	2.0	1.2	2.4
FUEL COST	5.7	35.8-64.8	22.5
TOTAL	24.3	44.8-73.8	37.1

ASSUMPTIONS

1. PLANT CONSTRUCTION TIME: 6 YEARS FOR NUCLEAR, 3 YEARS FOR OIL-FIRED, 4 YEARS FOR COAL-FIRED PLANTS.
2. PLANT LIFE: 30 YEARS
3. PLANT FACTOR 68.5 %
4. INTEREST AND DISCOUNT RATE: 5.0 % P.A. (IN REAL TERMS)
5. NUCLEAR FUEL COSTS: $ 32/LB U_3O_8
6. FOSSIL FUEL COST:

	FUEL OIL	COAL
FUEL PRICE ON EMBARKATION	$ 130-260/TON	$ 40/TON
SEA TRANSPORTATION	$ 5/TON	$ 17/TON
PORT HANDLING/IN-LAND TRANSPORTATION	$ 25/TON	$ 3/TON
DELIVERED PRICE	$ 160-290/TON	$ 60/TON