



NUCLEAR POWER IN DEVELOPING COUNTRIES PROSPECTS & PROBLEMS

BY

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Mr. Director General, Distinguished Delegates, Ladies & Gentlemen,

I thank the International Atomic Energy Agency for inviting me to deliver a lecture at this scientific afternoon. This general conference marks the thirtieth anniversary of the Agency, and it is appropriate that this afternoon is devoted to reviewing broad perspectives relating to nuclear power development. I propose to devote my lecture to examining issues relating to the prospects and problems of nuclear power in developing countries. Coming from a developing country which has successfully integrated a number of nuclear power units into its power system, the lessons we have learnt would be of relevance to other developing countries.

Energy availability a must for development

Usage of energy is characteristic of practically every human activity. Due to the intimate relationship of energy to development, its availability has always been of basic concern. The well being of a country's populace, which is reflected to a significant extent by its per capita Gross National Product (GNP), has always had a positive correlation with its per capita energy consumption. This dependancy was highlighted during the energy crisis of the mid 1970s, when the economic growth of energy importing developing countries was significantly retarded. The after effects of that phenomenon are still with us in another form — the huge foreign debts of several developing countries.

By and large, the people of DCs are primarily engaged in maintaining a minimum level of subsistence. Agriculture is the main component of their economy and they have limited resources for a transition to a more literate, industrial, urban and agriculturally advanced society. Historically, such transitions have been accompanied by an increasing usage of commercial energy and a larger share of electrical energy in the total energy consumption. At present, electric energy as a percentage of the total energy consumed averages from 32.2% for the developed countries to about 19% for the developing countries. In India this ratio has gone up from about 4% to about 20% during the past three decades. The mag-

nitude and desirability of this share has of course been a subject of much debate in recent times. While "Conservation of energy" or alternatives like "Bio-mass" or "Cogeneration" are of relevance, the basic necessity of increasing availability of electrical energy has sometimes been lost sight of. Under the conditions prevailing in most developing countries, electricity can contribute directly to the priority need of food production. In India about 25% of the electricity consumed is used for irrigation pumping and if one were to add the electricity consumed in the production of fertilizers, pesticides and production of plastics used for storage of grains etc., the share of electricity consumed for food production and related activities would be almost a third of the total power generated. Therefore, the future well being of all developing countries depends to a large extent on how their planners make efforts for the supply of electrical energy.

Demand scenario regarding electrical energy in developing countries

Energy demand grew exponentially in most of the developed countries all through the fifties and sixties. Earlier projections had expected this trend to continue, and this was also reflected in highly optimistic projections made during the 1960s for growth of nuclear power. The energy crisis of the 1970s, conservation schemes for energy, and the levelling of economic growth rates in developed countries have significantly brought down earlier projections. It is now accepted that demand for energy has generally reached saturation levels in most of the highly industrialised developed countries.

On the other hand, electricity consumption in developing countries grew at about 9% per year during the 1960s and 1970s, with some of the industrialised countries in the developing world exhibiting annual growth rates of 13 to 20%. Of significance is the fact that electricity consumption in these countries is not only growing faster than primary energy consumption, but also more rapidly than electrical energy consumption in the developed countries. Though the slowing down of the world's economy did reduce the growth of electricity demand in most develop-

ing countries, in some of them (like China, Indonesia, India and Turkey), the growth of consumption has been limited by supply constraints. Estimates of growth of electricity consumption in developing countries during the next decade range from 6% to 7%, and even at the lower rate, the demand for electricity in these countries would be enormous. It is estimated that this will involve a net addition of about 300,000 MWe of power generation capacity by the year 2000, requiring total investments of the order of US \$600 billion. On the other hand, even if the developing countries succeed in attaining such a growth rate, most of the households in the developing world will still not have access to electricity and the average per capita energy consumption will continue to be a fraction of that prevailing in the developed countries — primarily due to their large and increasing population.

Electric power generation — Options for developing countries

Considering a time frame of 20 to 40 years, technology available for bulk and economic generation of electricity will continue to depend primarily on three sources : fossil fuel, hydro potential and nuclear energy.

As is well known, nearly 95% of the world's coal reserves are confined to the USSR, USA, Peoples Republic of China, Western Europe, Canada and Australia. As regards oil and gas, most of the global reserves are located in a few Middle-East countries, the USSR, USA, Canada, People's Republic of China, Mexico, Nigeria, Libya and Algeria. The discovery of new oil and gas resources is tapering off and current estimates are that the known reserves would be depleted in the early decades of the next century. The bleak scenario regarding fossil fuel reserves of developing countries, which contain a large part of the global population, is compounded by their economic condition which severely limits their ability to import fossil fuels.

On the face of it, tapping hydroelectric potential is no doubt an attractive option. At present hydro electric power is estimated to supply about 23% of the world's electric power needs. However, one perceives a global

trend of increasing caution in pursuing this option. A few decades ago many large scale hydro projects were taken up in many parts of the world and the pace has slackened in recent years. Apart from the handicaps of being capital intensive and having long gestation periods, contemporary concerns about inundation of forest lands, rehabilitation of large populations, and upsetting the local ecological balance, have all combined to discourage initiation of new hydro-electric projects in recent times. This situation is also reflected in India, where only 20% of the hydro-electric potential has been tapped, and newer schemes are facing some of the problems mentioned earlier. While efforts are being made to tap the available hydro-electric potential consistent with ecological and rehabilitation concerns, one may foresee greater difficulties in the years to come.

This leads to the third option – electric power from nuclear energy. Its technical feasibility and economic viability is attested by the 400 power reactors operating worldwide that supply about 16% of the world's electricity. Most of the present nuclear power generation is confined to the developed countries and some developing countries like Republic of Korea, India, Argentina, Bulgaria and Taiwan. No doubt, concern has been expressed in recent times about its safety following the accidents at Three Mile Islands (TMI) and Chernobyl. Of relevance is the fact that the event at TMI did not result in any danger to the public or environment and the safety systems performed in accordance with the design objectives. The accident at Chernobyl, on the other hand, was due to gross human failure resulting primarily from unauthorised violations of several safety procedures. As a consequence of the lessons learned from these accidents, nuclear technologists are reviewing their safety practices relating both to men and machines to prevent their recurrence. Sharing of information about operations of nuclear stations on a global scale is getting institutionalised, and this should result in enhanced safety of nuclear power in general. The experience with nuclear power in many countries has shown that it is a safe,

clean and economic source of electricity, even if a country has to import fuel from another country located far away.

Against this background, classical electrical energy planning, which primarily focuses on the perceived alternatives of fossil and hydro electric resources, has the high probability of resulting in most developing countries being destined to live with a perpetual energy shortage and therefore with low levels of economic growth. Under these circumstances, it is time for these countries to seriously consider nuclear power as a viable and safe option for generating electric power. However, the nature of nuclear technology and the economics involved, indicate that for new entrants, it has to be a multi-country effort. The success of any such effort depends on the approach adopted, which will have to address the following major issues :

- 1) Reactor size and location
- 2) Choice of technology
- 3) Financing
- 4) Mechanism to construct and operate nuclear reactors
- 5) Absorbtion of technology by the user country/region

Size and location

As most developing countries are characterised by relatively small electrical grids, there is a severe limitation on the unit size of a power generation unit that a country can set up. Consequently, one way to exercise the option of using nuclear power is to consider forming inter-country or regional grids. This will enable them to incorporate reactors of about 200 to 500 MWe capacity. On the other hand, forming a regional grid will also require that the concerned group of countries agree to mechanisms for identification of an optimal site, sharing costs, power generated, and contingent risks.

Choice of technology

There are two clear options available today as regards choice of technology. These are the Light Water Reactor (LWR) technology, and the Pressurised Heavy Water Reactor (PHWR) technology. The first has the advantage in that there are a large number of reactors in operation using this technology, and therefore the manufacturing in-

frastructure and operating experience is available widely. On the other hand, it involves use of enriched uranium whose availability might impose a constraint. There is no shortage *per se* of enrichment capacity in the world at present, but satisfactory agreements including safeguards need to be entered into with the supplier countries. The PHWRs, though more complex in design, use natural uranium which is easily mined and can be converted to fuel without the complex technology of enrichment. These reactors although relatively small in number have also shown consistently good operating performance over the years.

Financing

Nuclear power stations are highly capital intensive and it is therefore obvious that most developing countries will find it difficult, if not impossible, to finance such projects on their own. Countries like India, Argentina, South Korea, Taiwan and Brazil which have to varying degrees tried this path, have taken several years to reach their present state of progress as regards nuclear power. But the luxury of waiting so long may not be available to most developing countries. This means that financing of nuclear projects in the developing world will have to be a multinational effort. Ultimately, it is this aspect of financing which will decide the success or failure of nuclear power in developing countries. Till date the World Bank has been the largest single international financier of electric power in these countries. Since 1948, about 16% of the Bank's total lending, estimated at about US \$25 billion, has gone for power projects in 90 countries. With the overall energy scenario leading to increased viability of nuclear power, it should be possible for this body to consider financing nuclear power schemes. But to a large extent this effort will have to be augmented by bilateral and commercial lending arrangements.

Mechanism to construct and operate nuclear reactors

Most developing countries do not have the resources, and more importantly the time, to develop the expertise for nuclear technology. It will therefore be necessary to build standard units on

a turnkey basis, with the builders even taking the responsibility of operating them for a period of say 5 to 10 years. During this period, it should be possible to train the locally available manpower in operating the reactors safely during subsequent years. A mechanism akin to the "Build-Operate-Transfer" (BOT) concept may be appropriate for sharing of revenue, responsibility and ownership of such reactors.

Absorption of technology and development of manpower

As nuclear technology is a complex and demanding one, availability of skilled manpower is very important to ensure success. No doubt, experience has shown that prior to embarking on an indigenous nuclear power programme, comprehensive experience and a large number of trained personnel have to be accumulated. IAEA has so far done considerable work in assisting in manpower training, but it will have to step up this activity further in future. This basic training will have to be supplemented by training programmes which involve utilities operating nuclear power plant in the developed countries. Some hold the view that nuclear technology is too complex to be absorbed by a developing country. On the other hand, one may look at the example of civil aviation, also a complex and demanding field. We see many developing countries operating national airlines, some of which are quite extensive, in a successful manner.

Need for a package approach

Within the framework of the major issues discussed above, it is possible to draw up an outline for a multi-national effort to promote nuclear power in developing countries. There is a fortuitous circumstance in that energy demand in developed countries is generally tapering off which could result in significant surplus capacities for the manufacture of nuclear power equipment. Nuclear power plant builders with excess capacities should be in a position to offer a standard reactor in the 200 to 500 MWe range to a developing country or a

group of them. In the past the IAEA has supported studies on the feasibility of small and medium power reactors (SMPRs). Nuclear power plant builders from the advanced countries have shown their readiness to offer appropriate designs. The developing countries should respond to this initiative and examine if either singly or as a group they could look at locations, reactor sizes, and mechanisms for sharing power if necessary. Arrangements worked out between the supplier and recipient country should cover construction, operation and ownership of such units, and making arrangements for financing on a bilateral or multi-lateral basis. The IAEA can play a catalytic role in this process. Efforts of this nature are required to bring the prospect of nuclear power in developing countries closer to reality

Present nuclear power programmes in developing countries

Some developing countries have realised the importance of nuclear power to electric power generation and have been pursuing their own national programmes over the years. It is a matter of significance that of the ten developing countries which account for about 65% of the total electricity production in the developing world, eight have nuclear power programmes. Some are facing problems arising primarily out of economic reasons, but it is important that they do not "drop out" from the nuclear power scene. These countries have to consolidate and efficiently manage their nuclear programmes and serve as models for encouraging other developing countries to consider using nuclear power in their national development programmes.

Indian experience to date

In India we have gradually built up and consolidated our nuclear power programme over the years. Efforts during the first three decades were concentrated on : mastering in technology through intensive in-house R&D; establishing design and manufacturing

capability of nuclear power station equipment; and gaining experience on operating nuclear power station on a commercial scale. We are now embarking on what can be termed the "industrialising phase", wherein the above potential will be used to step up the nuclear power programme in a significant manner. Several steps have been taken to reduce gestation periods for future projects. These include standardising on two sizes of reactors (235 MWe & 500 MWe), manufacturing of major reactor equipment in series, and mechanisation of site construction activities. Programmes for augmenting production of heavy water and nuclear fuel, are also being implemented in step with the reactor building programme. The organisation responsible for the design, construction and operation of nuclear power stations in India is in the process of being converted into a commercial corporation, which will enable it to tap public funds for supplementing the finances required for future nuclear power projects.

Indian power reactors have been putting up increasingly good performance during recent years. Six reactor units with an installed capacity of 1230 MWe, currently supply about 3% of the country's electric power. Within the next decade eight more units of 235 MWe each are expected to come on line. Work on six reactors of 500 MWe and four more 235 reactors has been initiated. The first generation thermal reactors will be followed by fast breeder reactors. Following the commissioning of a fast breeder test reactor, design work on a prototype fast breeder reactor of 500 MWe has been taken up and component development is now under way. As a country with the constraints of limited fossil resources and a large population, India expects nuclear power to play an increasingly important role in the decades to come. India will be happy to share its experience in the peaceful uses of nuclear energy with other developing countries.