Nuclear Power: An Indian Perspective

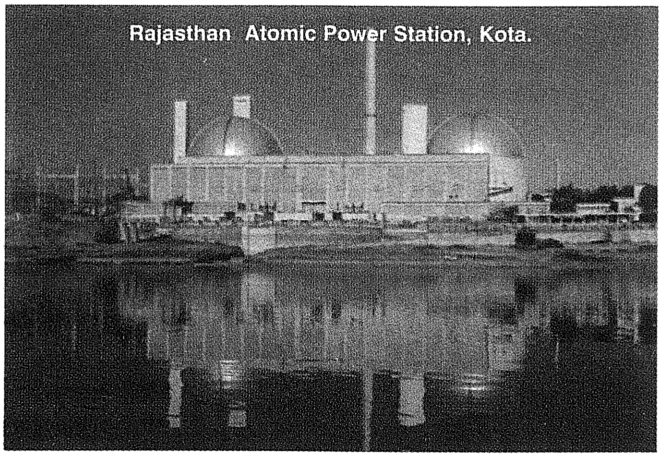
As the developing world tries to meet the energy needs of its growing population and support its development aspirations, the global energy consumption would double over the next three decades and will rise further subsequently. Only power of the atom can, in principle, realize this. Without a central role for nuclear power this could lead to a catastrophe both in terms of sustainability of energy resources with enhanced level of conflicts to grab the residual resources and, even more importantly, in terms of global climate...

- Dr. Anil Kakodkar

The world's population crossed the 6 billion mark in the year 1999. Most current estimates suggest that around 2 billion people will be added over the next 30 years with another billion in the following 20 years. Virtually all this increase will be in the developing countries with the bulk in the urban areas. The core challenge for development is to ensure availability of productive work opportunities and a better quality of life for all these people. The quality of life should be above a minimum threshold with equitable opportunities for all. At present, however, inequality is widening. The average income in the richest 20 countries is now 37 times that in the poorest 20 and this ratio has doubled in the past 40 years. Inequalities can give rise to conflicts and, therefore, it is necessary to address development concerns of all nations.

Energy is the engine for growth. It multiplies human labour and increases productivity in agriculture, industry and services. Thus, easier access to energy in the developing world holds the key to bridging the widening inequality. Rapid developments in nuclear power technology in the sixties and seventies have demonstrated practical feasibility of large-scale role that nuclear power can play in meeting the energy challenge. However, this deployment has largely been restricted to the industrialized world which is by and large in a stable mode so far as energy demand is concerned. The desperate need for growth in energy availability exists in the developing world because the per capita energy consumption needs to be taken to a much higher level and also because of the growth in population which would stabilize only when survival no longer remains an issue and there is a general feeling about an assured, reasonable quality of life.

As the developing world tries to meet the energy needs of its growing population and support its development aspirations, the global energy consumption would double over the next three decades and will rise further subsequently. Only power of the atom can, in principle, realize this. Without a central role for nuclear power this could lead to a catastrophe both in terms of sustainability of energy resources with enhanced level of conflicts to grab the residual resources and, even more importantly, in terms of global climate. As we move forward in time, the crucial importance of nuclear power would be increasingly felt not only for supporting economic growth but also for some basic human needs such as availability of clean air and water. In fact, the day is not far off when we would need to view nuclear energy as not just a source of electricity but a primary energy source which could assure our sustainable future.


Rajasthan Atomic Power Station, Kota.

Developments in science and technology have led to the improvement in quality of human life. Although new problems have arisen in the process, these have in fact been solved by further developments in science and technology. For example, today we can justifiably be proud of increased longevity realized through emphasis on health and nutrition programmes. The increased demand for food as a result has been met through advances in agriculture. Looking back to the 1950s and 1960s, it was then feared that the developing countries - particularly China, India and Indonesia - would not be able to feed their rapidly growing populations. Thanks to the green revolution in agriculture, the doomsday scenarios of famine and starvation in these, the most populous, developing countries were proved wrong. Given the inevitable role the nuclear power is required to play in the years to come, there is a strong need to examine further technological solutions that need to be brought about to overcome barriers that exist in its large- scale deployment in the developing world.

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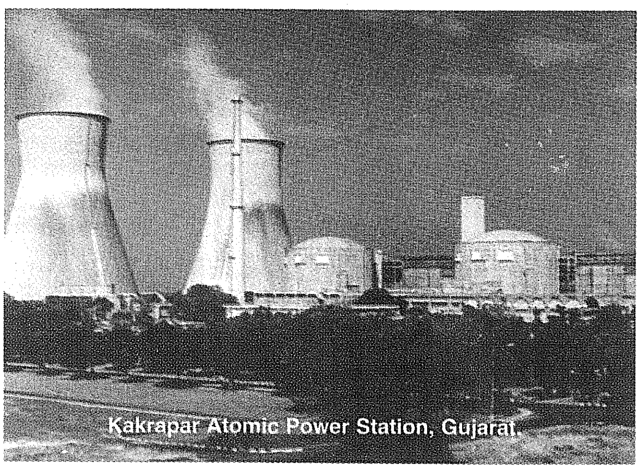
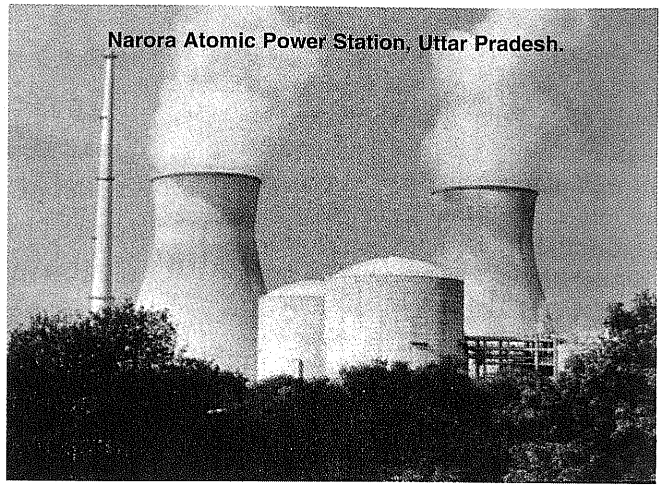
Scenario

Looking from India's perspective, development of nuclear energy based on a closed cycle approach enabling fuller use of uranium and thorium is inevitable for development aspirations of over a billion people. The electricity generation in the fiscal year 2002-03 was about 531 billion kWhr from electric utilities and an additional about 127 billion kWhr was generated by the captive power plants. On per capita basis, this works out to 620 kWhr per year. India's GDP in recent years has been increasing at 6 per cent per year. The development aspirations of its people demand that growth at this or even at a higher rate be sustained for a long enough time. The Centre has taken several steps to realize the aspirations. These include policy initiatives as well as planning and launching of projects aimed at improving the energy, transport and water infrastructure in the country. The examples include the ongoing project to build a network of national highways, setting up of a task force to prepare a blueprint for linking the major rivers in the country to solve the problem of recurring floods in some parts and drought elsewhere and ongoing reforms in the power sector with the Electricity Bill - 2003 having been passed by Parliament some time ago. Several other initiatives have been taken such as the new Telecom Policy which has resulted in a rapid growth of telecom infrastructure in the country. All these are steps towards achieving an average annual growth of 8 per cent during the ongoing 10th FiveYear Plan (April 2002 to March 2007).


Kakrapar Atomic Power Station, Gujarat.

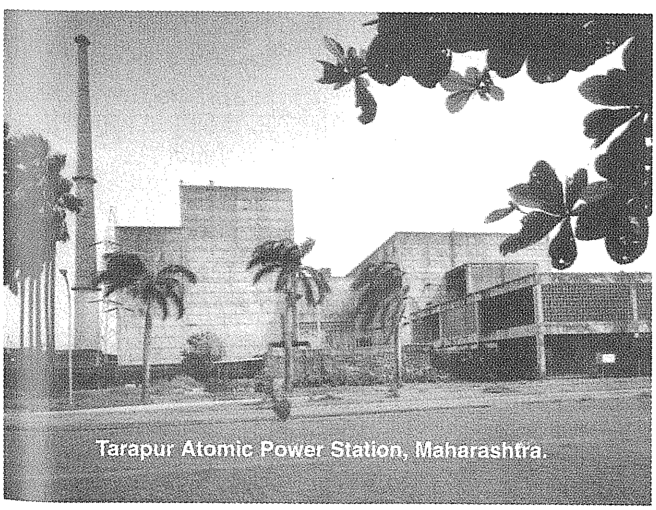
In terms of electricity generation, India would have to reach at least a modest target of generating 5000 kWhr per year per capita. India's population could rise to 1.5 billion by the year 2050. This would call for a total electricity generation of about 7500 billion kWhr per year. This is an order of magnitude higher than the generation in the fiscal year 2002-03 and calls for a careful examination of all issues related to sustainability including abundance of available energy resources, diversity of sources of energy supply and technologies, security of supplies, self-sufficiency, security of energy infrastructure, effect on local, regional and global environment, health externalities and demand side management. This situation is true for several other countries on a growth path. At the present stage of development no single energy resource or technology constitutes a panacea to address all issues. Therefore, it is necessary that all low-carbon and non-carbon emitting resources become an integral part of an energy mix - as diversified as possible - to ensure energy security to the world during the present century. The available sources are low carbon fossil fuels, renewables and nuclear energy. All these will have to be subject to increased levels of research, development, demonstration and deployment.

Let us examine the fuel resource situation in India. Estimates by us in the Department of Atomic Energy (DAE) and also by other agencies in the country indicate that we will have difficulties with regard to availability of coal by the middle of the present century. In addition, coal-based stations are likely to pose serious problems in the future arising out of transport of large quantities of coal across the country and environmental problems related to disposal of ash and emission of greenhouse and acid gases. Our oil and natural gas reserves are very modest and we are importing very substantial quantities of our requirements -a major part of our overall imports. Our hydro-potential is renewable and must be exploited to the maximum. But the exploitation of hydel resources is handicapped by issues like displacement of people. Non-conventional sources like solar, biomass and wind will no doubt play their useful roles. But at the present level of technology development they can only complement electricity generation by base load stations dependent on fossil, hydro or nuclear plants.


Narora Atomic Power Station, Uttar Pradesh.

Technology

Our uranium deposits are limited, while the thorium deposits are large. To maximize the energy potential of our available nuclear resources, a closed fuel cycle involving reprocessing of spent fuel to recycle plutonium and uranium-238 has to be pursued. Besides recovering valuable fissile and fertile materials, reprocessing helps to sort out the wastes according to their activity levels and their decay period, thereby assisting waste disposal and minimizing environmental impact. The development and experience in closed uranium fuel cycle would soon need to be expanded to cover the thorium fuel cycle to ensure long-term energy security for the country. Closed cycle has the capability to virtually de-couple energy supply from resource-related constraints for generations to come.


Tarapur Atomic Power Station, Maharashtra.

Indigenously-developed

Pressurized Heavy Water Reactors (PHWRs) and associated fuel cycle facilities are being established to meet the current electricity needs and fuel requirements in the future. At present, we have 12 such reactors in operation and six under construction, which include larger indigenously-designed and developed 540 MW units under construction at Tarapur. The designs of these reactors have progressively evolved taking into account the needs for indigenisation, our own operating experience, operating experience in PHWRs outside the country and progressive evolution of enhanced safety features. We are self-sufficient in all aspects of PHWR technology. As we gain experience and master various aspects of the nuclear technology, the performance of our plants is also improving. The average capacity factor of our plants has steadily risen from 60 per cent in 1995-96, to 90 per cent in the year 2002-03. Our nuclear power plants have so far produced about 200 billion units. We have accumulated about 200 reactor-years of operational experience free of any serious incident involving release of radioactivity to the environment.

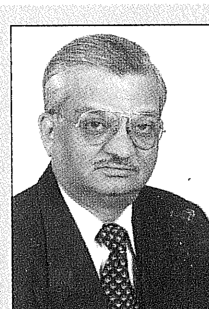
We started our fast breeder reactor (FBR) programme with the setting up of a Fast Breeder Test Reactor at Kalpakkam. This reactor, operating with indigenously developed mixed uranium-plutonium carbide fuel has achieved all its technology objectives. Based on the experience gained with this reactor and with the active cooperation of academia and industry, detailed design and technology development of the 500 MW Prototype Fast Breeder Reactor (PFBR) has been completed. Pre-project activities for this project have already begun at Kalpakkam. Overall, we plan to have an installed nuclear capacity of about 20,000 MW by the year 2020.

As a further step towards self-sustained thorium utilization with a potential for growth, a road map for the development of an accelerator-driven system (ADS) has been prepared. The development of such a system offers the promise of shorter doubling time with thorium-uranium-233 systems, incineration of long-lived actinides and fission products. ADS alongwith thorium-uranium 233 reactors and fuel cycle has the potential to provide a robust eco-friendly technology base to a large-scale thorium utilization. As a first step towards realization of ADS, we are launching the development of proton accelerator in the 10th five-year plan.

Nuclear fuel contains energy in a concentrated form requiring much less tonnage for fuel to be transported or stored. In the overall cost of electricity generated from nuclear fuel, the cost of fuel is a much smaller fraction as compared to the other components. If the capital cost of setting up atomic reactors can be brought down substantially, nuclear energy would become an abundant and inexpensive source of power...

It is worthwhile to recognize the importance of high calorific value of nuclear fuel. Nuclear fuel contains energy in a concentrated form requiring much less tonnage for fuel to be transported or stored. In the overall cost of electricity generated from nuclear fuel, the cost of fuel is a much smaller fraction as compared to the other components. If the capital cost of setting up atomic reactors can be brought down substantially, nuclear energy would become an abundant and inexpensive source of power. Today we are already building our nuclear power stations at an overnight cost of around $1100 per kWe. With the development of newer technologies we expect this to go down further.

Nuclear energy is based more on knowledge, less on materials, than most others, and therefore, requires expertise in several disciplines of science and technology. This expertise has to be acquired through painstaking efforts and for the spread of nuclear technology, conventional technology transfer models can work only if they are accompanied by strong human resource development component - a prerequisite for technology assimilation. ■



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