Ethics of adopting Nuclear Power Technology in India

Dr. Baldev Raj*

Abstract

India is a unique country, largest democracy with diverse cultures, heritage & languages and has large population of over a billion and still growing. Rapid economic development will depend upon optimal and efficient utilization of various resources such as human, infrastructure, food, water and energy with emphasis on sustainability issues such as technologies, climate mitigation, clean environment and bio-diversity. Important issues related to electrical energy production vis-a-vis energy options are discussed here, with emphasis on the role of nuclear energy.

Preamble

India is the largest and vibrant democracy of billion plus citizens. The country has a wide imaginable spectrum of languages, religions, cultures, income groups and political ideologies. The country has demonstrated high economic growth (6 to 9% of GDP) in the last few years and is confident of not only sustaining high growth rates but even enhancing these rates. India and the world believe in the vision of India as being one among the five largest economies by 2025. This vision necessitates synergy among the actions and effective implementation strategies in an expeditious manner. Energy is the key driver, which along with education, healthcare, water, food and other related infrastructure would enable achievement of the goals. In a diverse democracy, achieving this vision is full of challenges and opportunities. The ingredients for success in this demanding endeavour are conviction, determination, capacity, capability and commitment with ethics, selectivity and sensitivity of government with private participation.

India needs to combine the strengths of her heritage with modern outlook and experience of the west in a judicious manner. She needs enhancing the capacity and commitments of all the stake-holders. We need to face the challenges and opportunities of meeting the energy demands of the country in a sustainable and holistic manner. Holistic implies not only judicious mix of fossil, nuclear and

* *Dr. Baldev Raj, BE, Ph.D; Member, German National Academy of Sciences, Fellow, Third World Academy of Sciences, Fellow of all Engineering and Science Academies in India and Distinguished Nuclear Scientist, Padmasri awardee, Director, Indira Gandhi Centre for Atomic Research, Kalpakkam 603102, Department of Atomic Energy. E-mail: dirsec@igcar.gov.in*

renewable energy resources but also finding the sustainability models of energy, food, water, education, healthcare and equity in an interlinked manner. The remarkable achievements of India in education, industry, nuclear energy, space, and defence are the foundation bedrocks on which we are building to deliver future successes, which would earn India a distinction of one of the most developed countries with robust economy. This must be achieved in less than two decades to provide equity and quality of life to even the last citizen in India.

Energy Options and Nuclear Power

Let us analyze the difference between developed and developing countries in terms of energy consumption. The current per capita energy and electricity consumption in India is 23 GJ/annum and 660 kWh/annum, which are significantly low compared to USA and European countries. Presently, fossil based resources especially coal, lignite and hydro-electric meet the major portion of India's electricity generation. India is aiming to reach at least the per capita energy consumption of the present world average (2200 kWh/annum) by 2030 from the current position. This calls for the electricity generation capacity of about 600 GWe by 2030 assuming a population of about 1.4 billion. It is clear that coal based generation capacity would considerably increase in the next 20 years or so. However, the focus is on clean coal technologies with emphasis on super critical power systems. At a suitable juncture after next two decades, fossil energy contribution would come down as a percentage of total installed energy in India. Further, the total power generation by the year 2052 is projected to increase to 1344 GWe corresponding to an average per capita consumption of about 5000 kWh/annum with a suitable energy mix options. Policy planners are imparting attention to each and every possible resource of power generation. Fossil, nuclear and renewable energy resources are treated in complimentary and not in competitive manner in India. Out of the projected capacity by 2052, nuclear share is expected to be 25%. This calls for a monumental nuclear power growth rate. A few of the issues requiring careful consideration and planning are the optimal exploitation of available energy resources, diversity of energy supply resources, energy technologies, power generation and distribution policies, robust infrastructure, local, regional and global environments and a multi-disciplined human resources at all levels.

Figure 1 indicates the current Indian energy resources. The units used are in terms of effective electricity generation potential. It is obvious that the total energy content in the currently known Indian nuclear resources is at least twenty times higher than that in other non-renewable resources.

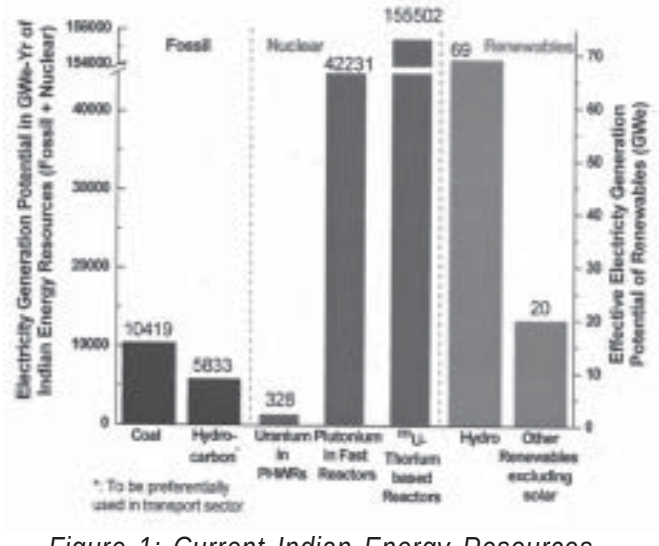

Figure 1: Current Indian Energy Resources

This data has been converted to indicate years of depletion for electricity generation, if only a single source is to be used. This information is shown in Table 1. The target electricity generation capacity in 2052 is indicated as 7957 TWh. This figure is based on a projection of need for our growing economy. Similar estimates have also been made by Planning Commission with different GDP growth rates. According to Department of Automic Energy (DAE) projections, India needs to reach a per capita electricity consumption of nearly 5000 kWh/y by the year 2050.

Table 1 : Years of depletion for electricity generation by a single source

	Coal	Uranium in PHWR	Plutonium in Fast Reactors	^{233}U-Thorium based reactors
Current rate (697 TWh)	130	4.12	211	>1950
2050 rate (7957 TWh)	11.5	0.36	18.5	>170

Approach of India to meet the nuclear energy demands in the last fifty years and the next fifty years is based on a well accepted vision of founder father of nuclear energy Dr. Homi J. Bhabha, whose birth centenary is being celebrated by the Department of Atomic Energy (DAE) and the country during October 2008 to 2009 to perpetuate his ideologies, policies and strong faith in indigenous science and technology. The Indian nuclear energy programme is implemented in three stages, which has been so devised to suit its domestic nuclear resources of moderate uranium to meet the needs with minimal dependence on external imports. It is pertinent to note that India has approximately 2% of the total uranium reserves on the world. The first stage of the nuclear power programme comprises a series of Pressurized Heavy Water Reactors (PHWR) aimed at the utilization of the natural uranium resources of the country and at the same time, generation of plutonium, the essential ingredient of proceeding to the second stage of fast breeder reactors (FBR). The FBRs enable effective utilization of the uranium resources and also enable mega energy delivering with generation of U-233 from thorium. The third stage of the power programme would be based on thermal/fast breeder reactors utilizing U-233 and thorium. The first stage programme is already operating in commercial domain.

India has planned for a robust FBR programme in the second stage of the nuclear programme. Fast reactor programme in large capacity has to work at least for about 30 years, for making reasonably large contribution to thorium programme. In the 90s, when there were uncertainties with respect to the viability, especially with reference to cost effectiveness of fast breeder reactors, India pursued its fast breeder programme with closed nuclear fuel cycle in an unrelented and steadfast manner. The approach has been vindicated by the recent initiatives at the global level in terms of INPRO programme of IAEA and GEN-IV programme in which fast reactor technologies have been identified as the key energy option from sustainability considerations. India has a rich operating experience of 23 years from its test reactor, Fast Breeder Test Reactor (FBTR) of 40 MWt (13 MWe) capacity, which combined with rigorous and comprehensive R&D has helped in launching the 500 MWe Prototype Fast Breeder Reactor (PFBR). The construction of PFBR is in progress and is proceeding in planned fashion to be commissioned in 2010. Having developed the technology, India is now embarking upon the development of FBR technology with advanced features towards economy and enhanced safety. In the fuel cycle front also, the successful experience from reprocessing of high burn-up carbide fuel (155 GWd/ton) has given confidence for taking up the fuel cycle facilities in industrial scale. The key ingredients for the successful pursuit of FBR programme are well planned science-based technologies undertaken by India covering the domains of structural mechanics, thermal hydraulics, fluid dynamics testing & evaluation, precision manufacturing, material science and engineering, chemistry of fuels and sodium, instrumentation and control, sophisticated sensors, safety research, separation chemistry, simulation and computer modeling, etc.

With respect to infrastructure; key components, viz. human resources, R&D, industrial capability and regulatory expertise are important. India has a well developed industrial infrastructure, which has been demonstrated through the indigenous manufacture and construction of several PHWRs and the ongoing construction of PFBR. Similarly, regulatory authorities possess a strong expertise matured over the years and has the necessary capacity and

independent decision structure to meet the expansion plans. It has been realized that success in the R&D efforts would heavily depend upon the availability of quality manpower to achieve short term goals and meet long term programmes. Thus, human resource development has been one of the areas of emphasis in the management philosophy of the DAE. In order to meet the urgent and growing need of human resources, a dedicated Training School for graduate engineers and science post-graduates has been established in respective DAE Units. To achieve breakthroughs, to provide for an adequate resilience in frontline technology and to provide momentum to the R&D activities, about hundred young research scholars have been inducted into programme under the aegis of Homi Bhabha National Institute. Another hundred research scholars are working in various Universities and Research Centres of eminence on programmes of relevance to fast reactor and associated fuel cycle science and technology. By virtue of the multidisciplinary expertise, Indira Gandhi Centre for Atomic Research (IGCAR) has established itself as a nationally and internationally reputed research Centre not only in the primary areas of fast reactor technology but also in many associated science pursuits. For achieving the mission objectives of the Centre, IGCAR has entered into collaborations with a number of educational and research institutions. The key highlight is the synergy between research, academic and industrial establishments for ensuring the realization of robust fast reactor and recycle technologies in India. R&D strengths of IGCAR are combined with Project Management capabilities of BHAVINI (Public Sector Undertaking of Govt. of India under the auspices of DAE to deliver electricity to the grid through Fast Breeder Reactors.

Future Nuclear Power Sources

Looking forward to the future, the DAE is also working on Accelerator Driven System (ADS) and the fusion power. In the ADS, high-energy proton beam generates neutrons directly through spallation reaction in a non-fertile/non-fissile element like lead. A sub-critical blanket with lesser fissile requirement will further amplify this external neutron source as well as energy. Development of such a system, which is already in progress in the DAE, offers the promise of shorter doubling time with Thorium–Uranium systems, incineration of long lived actinides and fission products and robustness to the approach towards realization of the objective of large scale thorium utilisation. Looking beyond fission, we have a mega energy potential in harnessing thermonuclear energy i.e. fusion energy. The International Thermonuclear Experimental Reactor (ITER) project has been launched by advanced countries to explore the possibility of harnessing fusion power. Recently, India has joined as a full partner in this mega initiative. Based on present indications, successful and practical fusion power systems may become available only around 2070.

Judicious Mix and Priority of Energy Resources and Technologies

There is global interest in harnessing solar energy, wind energy, energy from biomass, bio-diesel, energy from waves and from ocean thermal gradients. All these need to be explored and utilized wherever practical and economic.

The short paper does not allow me to discuss salient features of harnessing coal, hydro and renewable energy sources. I request the readers to visit IGCAR Web Site (www.igcar.gov.in) under the category Special Articles titled “Energy Options to Mitigate Climate Change” and see the power point presentation and manuscript for more clear understanding of the options. It is clear that for the short term coal, oil, natural gas and hydel would be the main choices of energy options for India. The energy deficiency needs to be mitigated by intelligent grids, minimizing transmission loss, adopting energy saving strategies, better highways, public transport system, energy efficient lights and appliances,

energy efficient buildings, energy efficient processes in producing materials such as steels, cement, non-ferrous metals, plastics, paper, etc. In the long term, nuclear, clean coal technologies, solar & wind with various hybrids, bio-wastes and bio-fuels would have a major contribution towards meeting the energy demands and mitigating environment degradation. One can appreciate the import of technologies for meeting immediate energy demands. However, the choice of technologies must be carefully done as these technologies are improving at a fast pace and many a technologies are in the evolution stage with high risk quotials. Also there is a need to spend focused efforts and finances for enhancing R&D in all the energy options to meet the current and future demands.

Epilogue

Various important issues related to economic development in the context of energy generation and utilization are discussed with due emphasis on nuclear power. It is clear that cost-effective energy sustainable over centuries for various parts of the world with strong base in science & technology along with addressing the issues of global warming and sustaining and enhancing bio-diversity are the key issues. There is an urgent need that energy, water, health, land and food are considered in a comprehensive and interlinked fashion for sustainable options to provide better quality of life to all the citizens of the planet.

That objective can be described as ethics of adopting nuclear power Technology in India

Reading Materials

[1] "Energy Options to Mitigate Climate Change", Baldev Raj, et.al, see www.igcar.gov.in under the category "Special Articles"

[2} "Evolution of Nuclear Programme: Rationale and Persdpective", Anil Kakodkar, Public Lecture delivered at Indian Academy of Sciences, Bangalore, July 4, 2008, see www.igcar.gov.in under the category "Special Articles"

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The Boss and the Leader

The Boss drive his men	The Leader inspires them
The Boss depends on authority	The Leader depends on goodwill
The Boss evokes fear	The Leader radiates love
The Boss says 'I'	The Leader says 'We'
The Boss shows who is wrong	The Leader shows what is wrong
The Boss knows how it is done	The Leader knows how to do it
The Boss demands respect	The Leader commands respect