NUCLEAR ENERGY SCENARIO OF INDIA

By

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1. Introduction:

India, the second most populous country of the world with its vibrant economy and impressive growth of GDP during last few years has been facing a formidable challenge in meeting its energy needs. Energy is an essential input for the sustained growth in development. With ascendant economy, a shift from the use of non-commercial energy sources to commercial energy sources, particularly electricity has resulted in surging demand outstripping the supply. In spite of being the sixth largest electricity producer in the world, India's per capita energy consumption rates remain low in comparison to many developing countries. As the economy grows, the energy sector of the country is also undergoing a massive revamp from policy changes to investment pattern and restructuring the preference for sources of power.

Some important steps in this regard include outlining the integrated energy plan, reform of the electricity sector beginning in 2001, restructuring the bankrupt state electricity boards, liberalizing the generation of power with private participations, stepping up efforts to secure oil and natural gas by investing in overseas oilfields, international agreements on nuclear co-operation which includes supply of nuclear fuels, greater emphasis of other renewable energy sources etc.

2. Sources of energy:

The inherent weakness of conventional sources of electricity generation like fossil fuels and hydro-power are now being aptly realized. Depletion of coal reserves, their poor quality and lack of infrastructure to upgrade, environmental issues related to use of coal, poor productivity of the operating plants are some of the major threats for over-dependence on coal-based power plants. Oil consumption, which accounts for roughly a third of India's energy use, has gone up by six times in the past twenty-five years. 65% of the country's oil demand is met from import and international price fluctuation greatly affects the economy of the electricity generation. Natural gas consumption has also risen faster than any other type of energy source and India's limited domestic gas reserves spell a need for foreign dependency in this sector as well. The generation of electricity from hydel projects faces stiff resistance owing to the need of land and associated issues like large scale displacement of the population. But tapping the potential of hydro-power is also limited to geographically located suitable sites and entirely depends on good rain-fall year after year. Wind power and solar power have also been found to have very limited scope to make any noticeable contribution to the energy security of the country.

In order to make sure that a secure and robust energy supply is maintained at a reasonable cost, it is essential that our supply is generated from a variety of sources through diversified technologies. In this regard, energy planners are looking forward to corrective measures of enhancing the share of other sources of power generation. The atomic minerals like uranium and thorium are the abundant sources of concentrated energy with enormous potential of generating electricity and hence, hold the promise for the future. In a nuclear reactor, a controlled splitting of uranium atoms releases enormous amount of heat to make steam to produce electricity. In this process, a very large amount of heat is produced from a relatively small amount of uranium. The comparative power of uranium atom to generate electricity is much higher than conventional coal. Accordingly, the nuclear energy sector of our country has also undergone massive revamp with an ambitious growth path already outlined and this sector is all set to become a major contributor towards the total electricity generation.

3. Nuclear energy:

Nuclear power is the cleanest form of mass energy generation, producing no greenhouse gases like CO_2, SO_2 and ash. Therefore the growth of nuclear energy in developing and populous countries is a matter of great benefit for mankind in view of its potential to protect the earth from irreversible environmental damage.

Uranium has the advantage of being a highly concentrated source of energy, which is therefore easily and cheaply transportable. In addition the fuel cost contribution to the overall cost of electricity produced is relatively small. Therefore, abundant, affordable and clean energy is just what nuclear power can provide towards the sustainable growth of the economy.

Today, about 17 % of the world's electricity is generated from over 441 nuclear reactors operating in 32 countries. Additional 32 reactors are under construction, and many more are on the drawing board. Life of quite a few reactors in some countries has also been increased.

Nuclear power today is a significant contributor to global supply of electricity. There are many countries in the world whose lion’s share of electricity is met by nuclear power reactors. In some countries, public pressure has demanded to call for a referendum on nuclear energy considering it as a safe, clean and efficient means of meeting the expanding energy needs. The Asian countries, specially are poised to witness a substantial growth of nuclear power in coming decades.

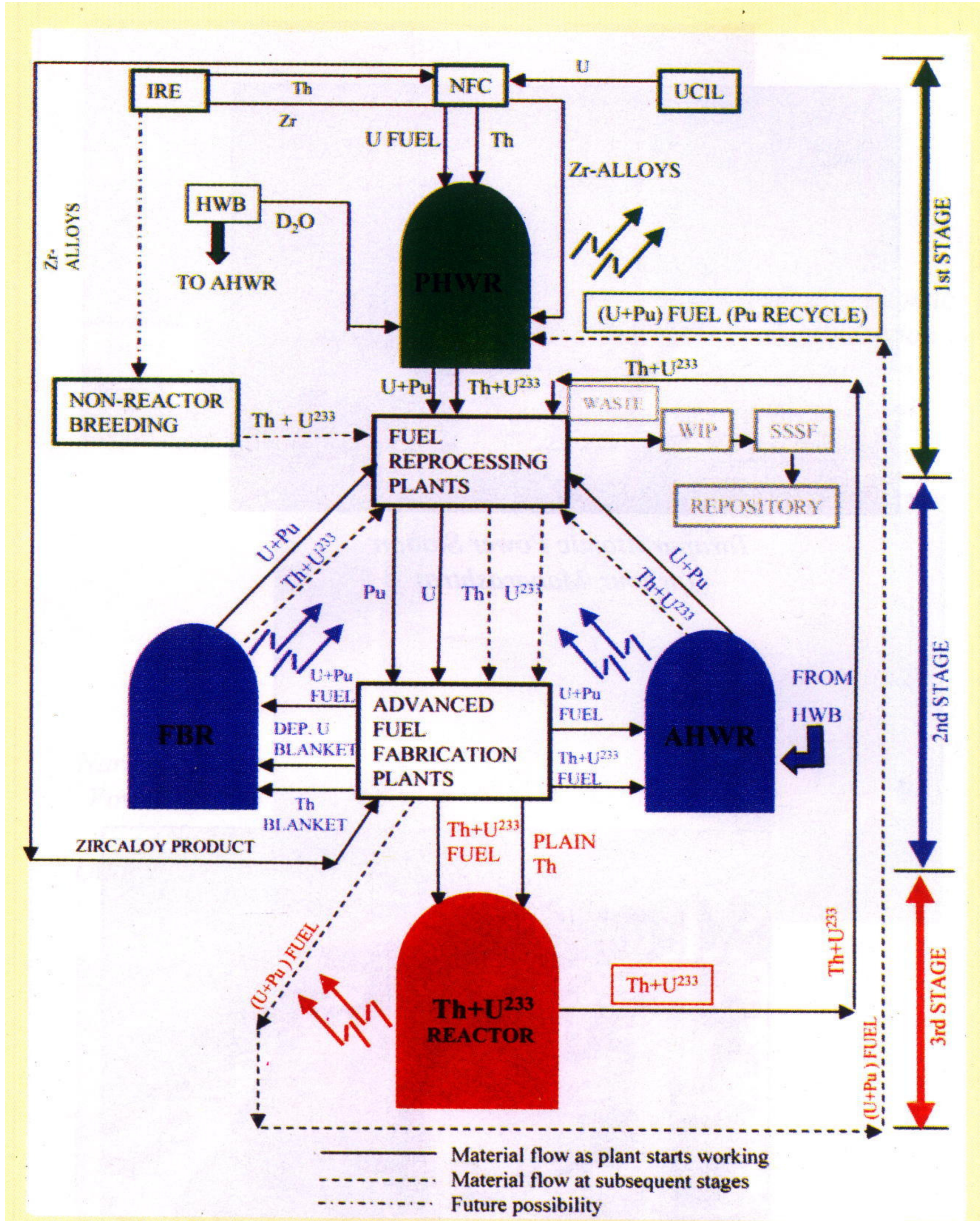
4. Indian Nuclear power programme:

In the field of nuclear power, our country has a very high standing in the world. The programme is being pursued by the Department of Atomic Energy since 1954 with the vision of Dr. Homi Bhabha who once had said "For the full industrialization of underdeveloped areas, for the continuation of our civilisation and its further development, atomic energy is not merely an aid, it is an absolute necessity". The DAE, pursuing the basic research and technological development within the country with the participation of Indian industries has established a strong base for producing safe and viable nuclear power using indigenous resources of atomic minerals. This indigenous, self-reliant technology has also found wide range of applications in agriculture, medicine, industry and basic research. Such level of world-class excellence has been achieved in spite of restrictive international regime.

While tapping the full potential of the nuclear power from atomic minerals, our country confronts a unique situation in respect of atomic minerals inventory. We have a modest reserve of uranium and abundant reserve of thorium.

In natural uranium, Uranium-238 is the dominant isotope, which is a fertile material and cannot make a reactor critical by itself. It has to be converted to fissile plutonium-239. This process of conversion takes place in a nuclear reactor and spent fuel from thermal reactors contains plutonium-239. On discharge from the reactor, spent fuel can be dealt in two ways. The first one termed **open cycle** consists of treating the entire spent fuel as waste and disposing it as such. With this approach, only a small fraction of the energy potential exploitable from uranium is utilised. To avoid this colossal waste, a **closed fuel cycle** involving reprocessing of spent fuel to separate plutonium and uranium-238 has to be pursued. Besides recovering valuable fissile material, reprocessing helps to sort out the wastes according to their activity levels and their decay period thereby assisting waste disposal and minimising environmental impact. Similarly, thorium is a fertile material and has to be converted to a fissile material viz. uranium-233. Pursuit of closed cycle approach calls for setting up of reprocessing plants and breeder reactors.

Considering the mineral resource pattern, technological development and long-term energy security, the Department of Atomic Energy has chosen to follow the closed cycle approach and accordingly, has formulated a **three-stage nuclear power programme**.



3 STAGES OF THE INDIAN NUCLEAR POWER PROGRAMME

In the first stage, the natural uranium of our country will be fully exploited to be used as fuel in the pressurised heavy water reactors (PHWRs) generating electricity. In these reactors, U^{235} (0.72%) in natural uranium will undergo fission and remaining 99.28% of U^{238} will get converted to Pu^{239}. The waste (spent fuel) generated from these reactors will be reprocessed to recover these Pu^{239}, which will be utilized as fuel in the second stage of reactors (Fast Breeder Reactors). These reactors besides using Pu^{239} as fuel, will also make use of thorium as blanket in the reactor core. The thorium (Th^{232}) will undergo nuclear mutation in the reactor core to produceU^{233}. This U^{233} along with thorium will be used as fuel in third stage of reactors, thus exploiting the vast potential of enormous thorium reserve of our country. It has been estimated that this mammoth programme of DAE has the potential to provide energy security to the country for about 400 years supplementing the potential of other resources.

The road to success for this programme starts with successful implementation of first stage of programme i.e. making use of entire natural uranium available in our country in PHWRs. In order to fulfil the immediate target of 20,000 MWe, about 10,000 MWe of power has to come from PHWRs, thereby making the fuel supply chain sustainable for all the three stages. Presently, 15 PHWRs totaling 3800 MWe capacity are in operation, which include unit sizes of 100 MWe, 200 MWe, 220 MWe and 540 MWe. Three PHWRs of 220 MWe unit size each in the advanced stage of construction. All future PHWRs are planned to be of 700 MWe unit size capacity.

In addition to PHWRs, two Boiling Water Reactors are in operation for last 40 years and two Pressurised Water Reactors of 1000 MWe capacities are being set up with Russian technical cooperation at Kudankulam in Tamilnadu.

Operation of the nuclear power reactors with overall capacity factor upto to 90% has been demonstrated with highest standards of safety. Latest projects have been completed in about five years gestation periods. The Indian industry has also evolved to manufacture all equipment and components to the required exacting standards. Infrastructure for R&D, Human Resource Development and training and other needs of the programme is also in place.

The PHWR potential based on the presently known indigenous extractable uranium is about 10,000 MWe. However, exploration of additional uranium has also indicated possibility of more resources, which will result in increase in the potential of PHWRs using indigenous uranium.

The DAE, entering into the second stage of operation, has already established three waste reprocessing plants to extract plutonium from spent fuel. The construction work of one prototype fast breeder reactor (PFBR) is in progress at Kalpakam. An Advanced Heavy Water Reactor (AHWR) is under development by BARC to expedite the transition to thorium based technology. A small beginning has also been made for the third stage of operation with the successful running of KAMINI research reactor at Kalpakam based on uranium-233 fuel, which is derived from thorium. This fuel was bred, reprocessed and fabricated indigenously.

The successful implementation of India's international civil nuclear co-operation agreements has opened up the opportunities for widening the nuclear power production capacity. PHWRs of about 10,000 MWe capacity are planned to be taken up using imported natural uranium. Setting up of Light Water Reactors (LWRs) through external co-operation and fuelled by imported enriched uranium has been introduced as additionalities to the indigenous nuclear power programme. These LWRs are planned to be under safeguards.

5. Uranium resources of India

The beginning of uranium exploration in India started immediately after the formation of the Atomic Energy Commission (AEC) in 1948. The exploration activities were intensified to locate good deposits of uranium, specially in geological provinces known for occurrences of multi-metallic minerals. The discovery of uranium mineralisation at Jaduguda in Singhbhum shear zone in Jharkhand (formerly in Bihar) during 1951 led to expansion of exploration activities. Early successes led to intensify search in this region with renewed vigour. As a result many new deposits in this region were brought to light of which some of them are now big operating mines, successfully catering to the need of uranium in the country. The exploration activities were later on shifted to other parts of the country in line with the concept based approaches and models increasingly being applied in many mineral exploration campaigns.

Well thought-out exploration strategy for uranium in India by AMD has led to the identification of a large number of uranium anomalies and a number of small to medium sized uranium deposits, of low to medium grade. The major deposits types in different areas, identified so far are as follows.

1. Shear-controlled vein type deposits:
2. Sandstone type deposits
3. Strata-bound uranium deposits
4. Unconformity related uranium deposits
5. Fracture controlled uranium mineralisation

The total U_3O_8 resource identified in the above areas is about 1,03,552 tonnes of which Jharkhand accounts for about 45%, Andhra Pradesh 27%, Meghalaya 17% , Rajasthan and Karnataka 4% each and remaining in other states. (Mar. '06).

6. Uranium production centers of India:

The uranium production in our country to cater to the indigenous need made an exciting beginning with the formation of Uranium Corporation of India Ltd (UCIL) in 1967 under Department of Atomic Energy. The operation was launched with the commissioning of an underground mine and ore processing plant at Jaduguda (1968) in Jharkhand (the then Bihar). Later, in line with the requirement of uranium new underground mines at Bhatin (1987), Narwapahar (1995) and Turamdih (2003), Bagjata (2008) and an opencast mine at Banduhurang (2009) were commissioned. All these operating uranium mines of the country are within 25 km from Jaduguda in the state of Jharkhand. The new underground mines have been developed with layout suitable for employing trackless equipment. Ore from all these deposits are being processed in two central plants located at Jaduguda and Turamdih. These plants adopt acid leaching route following indigenously developed flowsheet. The plant at Jaduguda has been expanded thrice with a capacity to process 2500 tonnes of ore per day.

Keeping in view the nation's endeavour to expand nuclear energy base, new uranium mines and processing plants are being constructed not only in Jharkhand but also in other parts of the country. One more underground mine at Mohuldih in Jharkhand is under construction to supply additional ore to the plant at Turamdih which is under expansion to process 4500 tonnes of ore per day. One large underground mine and a process plant (alkali leaching under pressure) have been taken up for development at Tummalapalle in the state of Andhra Pradesh.

The Government is committed to appreciable increase in contribution of nuclear power for meeting the long-term power requirement. The programme has been very strategically designed to make full use of atomic minerals (uranium and thorium) resources of our country. The uranium exploration activities have also been stepped up leading to the discovery and augmentation of uranium resource base and UCIL is in the process of developing these sites after necessary techno-feasibility study. After successful surface exploration, exploratory mining and ascertaining the viability of regular mining operations, an underground mine and a process plant adjacent to the mine have been planned at Gogi in the state of Karnataka. The plant at Gogi has been planned with alkali leaching route. Pre-project activities are in full swing and this project is expected to be in operation during XI plan period. Pre-mining activities are also in advance stage to develop uranium reserves at Lambapur-Peddagattu in Andhra Pradesh. Three underground mines and open cast mine have been planned for development. A large sandstone hosted uranium deposit at Kyelleng-Pyndengsohiong, Mawthabah (former name Domiasiat) in Meghalaya in N-E parts of the country has also been planned for development by opencast mining method. Ore from both these sites will be processed by acid leaching route in the plant to be constructed at respective mine sites.

Quite a few small to medium size low grade uranium deposits have also been recently located in different parts of the country notable amongst them are Chitrial and Kuppunur in northern part of Cuddapah basin and carbonate hosted small deposits around Tummalapalle in SW part of Cuddapah basin (Andhra Pradesh), Wahkyn in Mahadek basin (Meghalaya), Rohili-Ghateswar area in Aravalis (Rajasthan), Dishnur area in Karnataka etc. Developments of these deposits after due techno-economic evaluation are expected to be taken up at appropriate time.

7. Conclusion

Energy has been crucial to the survival of mankind and every major step in our evolution has seen a manifold increase in energy consumption. Nuclear energy, in this regard hold the key to survival and growth of mankind for this century and beyond.

The long term vision of DAE with mammoth power programme has been outlined with due emphasis on augmentation of resources, manpower needs, training etc in which educational institutions, manufacturing industry, consultants, civil and other package contractors have to play important role with manifold increase in their capacity. The necessity to introduce / strengthen institutional mechanisms has been emphasized to ensure that all parties gear up to meet the challenges in a coordinated manner.