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PROSPECTS OF NUCLEAR ENERGY IN INDIA

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The lines between fact and fiction have become blurred in the shrill debate on the Indo-US nuclear deal. Sadly no one has contributed more to obscuring that line than our leaders who profess to be most concerned about India's security needs. Blending missionary zeal with undaunted resolve to gain an upper hand by playing to the gallery, our leaders have left the real issues on the back burner. It is these issues that I have tried to raise in this paper. I have weighed the Prospects and consequences of nuclear energy, one of the most important factors articulated by our honourable Prime-minister for signing the deal. To quote him, "Today there is a talk of world nuclear renaissance and we cannot afford to miss the bus or lag behind these global developments."[1]

Now the question arises what is this nuclear renaissance? To understand it we need to first know what nuclear energy is. What is the economics of nuclear power in India? What are the views of experts on the feasibility of nuclear power in India as a viable alternative to fossil fuel?

Nuclear energy or atomic energy is the type of energy that comes from the nuclei of atoms. Both protons (positive electric charge) and neutrons (neutral) are found in the nucleus of an atom. The nucleus contains most of the mass of an atom. Energy is released any time there is a change in an atom's nucleus.

There are two types of nuclear reaction, nuclear fission and nuclear fusion. In nuclear fission, atoms having a large mass, like uranium, are split into two and energy is released. New elements are formed as a result of nuclear fission. As a reminder, mass refers to the amount of matter found within an object. During nuclear fission, the splitting of the nucleus results in a loss of mass. The two new nuclei, which have formed as a result of the division, together have less mass than the original nucleus. The missing matter has been converted into energy. Uranium 235 is an isotope that is used in starting nuclear fission chain reactions. An isotope is a form of an element with a different number of neutrons in its nucleus.

Uranium 235 is split in two by a neutron that releases energy and neutrons. These neutrons that are released will then split other atoms, enough uranium, a chain reaction will begin. Each uranium 235 atom will be split and send off neutrons that will split other uranium 235 atoms. If this chain reaction is controlled, like in a reactor, nuclear energy can be produced. This is also the type of chain reaction that resulted in the atomic bomb.

Uranium 235 is not the only isotope used in starting nuclear fission chain reactions, but is a widely used form. Plutonium-239 is also used, but many opponents of nuclear energy fear that plutonium is too dangerous. Plutonium is poisonous as it remains in fuel pellets until it's carefully removed from the plant. There has been no reported public damage from plutonium. Other materials are found in a reactor, like uranium-238. U-238 can change into a fuel that can start a fission reaction by absorbing neutrons from a U-235 fission reaction.

Atoms having a small mass, like hydrogen, are involved in nuclear fusion. Nuclear fusion occurs when and new elements are formed. Nuclear fusion has the capability of releasing greater amounts of energy than nuclear fission. These fusion reactions are also referred to as thermonuclear reactions. An example of thermonuclear reactions is found on the sun where hydrogen atoms unite and form a new element, helium. This type of reaction releases heat, radiation, and light. Another example of a thermonuclear reaction is the hydrogen bomb.

Nuclear fusion appears to be a better energy source and consumer-wise. The main problem is the control of a nuclear fusion reaction. Once that is achieved, there then would be the time needed to set up an energy plant to supply a large number of the population. The research behind nuclear fusion power and the possible fusion plant construction would take many years.

"It may well be 2020, then, before we arc a fusion society. It would be wise to conserve oil supplies and to substitute other energy sources hot springs, and so on: to keep us going until fusion can take over."[2]

This last statement reflects some of the present problems with nuclear energy production. Also this statement presents the various energy alternatives that are offered to us. It is important to stress here, that nuclear energy is part of our future, along with the other energy alternatives and collectively we can combat and possibly deplete our emphasis on foreign oil.

B. Nuclear Power Plants

Electricity in power plants is produced when a turbine is forced to turn. The turbine then spins a generator which produces the electricity. Water, gas, or steam can cause the blades of the turbine to spin. Steam can be produced in oil, coal, and nuclear power plants.

The main difference between coal or oil power plants and nuclear plants is that coal and oil are burned in a furnace producing enough heat to change water into steam. A reactor replaces a furnace in a nuclear power plant. The reactor contains the 'fuel', usually uranium. The splitting (fission) of uranium produces the heat needed to change the water to steam.

There are different types of nuclear power plants, but the major parts of a plant are generally the same. Within the reactor, fission occurs and energy, in the form of heat is released. This heat boils the water and steam is produced. The steam moves to the turbine that spins the generator which produces electricity. The 'used' steam then moves to the condenser where it changes back to water and returns through a pump to the reactor.

In Connecticut, we have two types of nuclear power plants: pressurized water reactor and boiling water reactor. The chief difference is that the pressurized water reactor has a separate steam generator and pressurizer. The pressurizer keeps heated water then moves it to the steam generator where the water is converted to steam. Also in a pressurized water reactor, the pump returns the water to the steam generator for reuse.

The main parts of a nuclear reactor where the chain reactions are controlled are:

(a) The fuel, like uranium 235, that undergoes fission

(b) Neutrons produced by the nuclear fission reaction are slowed down by a moderator.

(c) Control rods—have the ability to absorb neutrons that are released by nuclear fission. The control rods are placed in the reactor to stop nuclear fission and are removed when the fission chain reaction is needed.

(d) A coolant is used to move the heat away from the fission reaction.

(e) The inner containment structure or shielding to help prevent any radiation leakage. This is reinforced by a concrete building that houses the reactor.

There are different types of reactors. Two, the pressurized water reactor and boiling water reactor, have been described briefly above. Another type of reactor that is in use in parts of Europe and in Russia is the breeder reactor. A breeder reactor was used in this country in 1951 to produce electricity from the first nuclear reactor plant. But, America has no breeder reactors in operation today. One is presently under development: the Clinch River Breeder Reactor Plant in Oak Ridge, Tennessee.

A breeder reactor produces both electric power and fuel. Every reaction releases two or three neutrons, and only one is needed to continue the fission chain reaction. The other neutron(s) strike other atoms that are converted to fuel. Breeders are necessary for a nuclear future because the fuel supply for non-breeders is limited, but the breeder produces more fuel than it needs. A breeder reactor plant has an estimated fuel supply of thousands of years.

The opponents of breeder reactors argue many of the same ideals of the following statement: "But breeders convert uranium to plutonium reactor fuel, only a few pounds of which are needed to make a powerful bomb. Many fear nuclear weapons proliferation, and breeder development is stalled in the U.S..”[3]

ECONOMICS OF NUCLEAR POWER

It is the most debatable, controversial and yet most important part of energy security. It is on the economics that the future of nuclear power depends. Experts have varied in their views about the economy of Nuclear power plants. The secrecy that shrouds a nuclear plant has not helped the case either. It is difficult to reach at the exact costing of nuclear power plants till it is not known that what quantity of uranium is required and from where it has been shipped, the cost of heavy water, cost of disposal of nuclear waste, environmental pollution, radiation etc. The complex nature of the issue helps anti-nuclear absolutists as well as supporters of nuclear power to conveniently pick data that supports their point of view to nail down their detractors. The problem is further aggravated by the inability of the government to come out with transparent data.

Following reservations have been expressed by the anti-nuclear absolutists on the vital question of feasibility of nuclear power in India. In this group we find eminent scientists and experts such as MV.Raman, Antonelte D’Sa , Amulya K.N.Reddy and Brahama Chellaney etc.

1- Nuclear power is highly capital intensive and it takes 20-25 years to complete a nuclear power plant which always results in cost overruns and delays. These practical problems have impeded the growth of this industry and that is why not a single new power reactor in the U.S. has been built after the last one ordered in 1970.[4]

2- The baseline cost of new nuclear power is 6.2 to 6.7 cents Kwh, as compared to 3.3 to 4.2cents for pulverized ‘clean’ coal and 3.5 to 5.6 cents for natural gas. [5]

3- Cost of heavy water calculated by these experts is Rs 24880/ Kg. as against the government notified rate of Rs. 12,525/kg. [6]

4- While nuclear power generation itself is clean, the nuclear fuel cycle is carbon intensive, with greenhouse gases emitted in mining and enriching uranium with fossil fuels. Nuclear Reactor construction also carries large carbon footprints. [7]

5- Lastly waste disposal is an area of utmost concern. Besides being an environmental issue, this issue is also social and political in nature. There are methods available for the disposal of the waste but the best method is still being researched. Possibilities for disposal of high-level waste include burial beneath the surface of earth, other options like ocean burial are being practiced but there is still no fool-proof and economical method of waste disposal. [8]

6- Critics argue that nuclear energy is not sustainable; uranium the source of energy for nuclear power is available on earth only in limited quantities. Excessive mining of uranium will deplete the resources and will also push its prices. Moreover in India we do not have enough uranium to feed our reactors for this we will be always have to be dependent on outside source.

The above line of thought has been countered in India by stream of intellectuals and academicians like Sudhinder Thakur, B.P. Chaurasia, M. R. Srinivasan etc. The main arguments put forward by these intellectuals are as follows.

1- Nuclear power plants provide us clean power. Coal and oil burning power plants pollute air with the emission of greenhouse gases. Moreover one tone of uranium produces more energy than is produced by several million tons of coal and gas. If we take into account the social, health and environmental costs of fossil fuels, nuclear energy is most cost effective. [9]

2- Initial cost of building and operating a nuclear power plant is capital intensive but ultimate cost of running a power plant is quite low and electricity produced is quite competitive. Moreover the construction period of nuclear power plant is now 5 to 5.5 years. Sudhinder Thakur in his article Economics of nuclear power in India: The real picture has compared the cost of electricity in Kaiga nuclear power plant to that of Raichur thermal power plant and has found it cost effective. [10]

3- Heavy water used in reactors as coolant is produced in sufficient quantities indigenously and is also cost effective. [11]

4- Technological development has allowed countries to safely dispose of the waste. Countries like France have masterminded the technology of reprocessing the highly radioactive spent fuel, which again is used as fuel in atomic reactors.

5- As far as sustainability is concerned research are in advanced stage for building cost effective and economically viable breeder reactors which while producing energy also produces fuel.

To put aside this controversy among the nuclear nay Sayers and nuclear enthusiasts, Nuclear Energy agency and International Energy agency released their joint report titled, projected cost of Generating Electricity: 2005 update, with the objective to provide reliable information on key factors affecting the economics of electricity generation using range of technologies [NEA2005]. The report gives cost ratios of electricity generation from nuclear and coal and also from nuclear and gas. Experts from 19 countries participated in the study. The results indicate the following.[12]

At 5 percent discount rate, nuclear is cheaper as compared to gas in all the 19 countries. At 10 percent discount rate, except Japan and the US, nuclear is cheaper compared to gas. US have offered two gas-based plant designs for this study and gas is cheaper in the case of only one. At 5percent discount rate, except South Korea and the US, nuclear is cheaper as compared to coal. In South Korea, out of the four comparative evaluations given in the study, coal is cheaper for only one case. At 10 percent discount rate, in South Korea, the US and Germany, nuclear is cheaper as compared to coal. In South Korea, out of the four comparative evaluations given in the study coal is cheaper for only one case. At 10 percent discount rate in South Korea, the US and Germany, nuclear is cheaper compared to coal. In South Korea, for all the four comparative evaluations reported and in the US for the two cases given, coal is cheaper. For Germany, the four cases analyzed, coal is cheaper in case of two.

There have been several national studies, including by India as mentioned above, on comparative economics of various methods of electricity generation. In a recent paper, Proust (2005) has done a comparative analysis of all these studies. The studies examined by him include the DIDEME report from France, MIT and University of Chicago studies from the US, TARAJANNE study from Finland and other Studies. He concludes, "All recent European cost studies show that third generation nuclear is competitive with coal fired plants, and may be up to 20 per cent cheaper than CCGTs for base load electricity generation, even when CO_2 emissions costs are disregarded." He continues, "This EU picture should also apply to the US once the first new nuclear plants will have been successfully built and operated in the country." [13]

A study done by NPCIL [Nema et al 2000] indicates that nuclear power from PHWRs is competitive as compared to coal fired thermal power, when the nuclear plant is located about 1000 km from the coal pit-head. There are several regions in the country where such haulage is involved. [14]

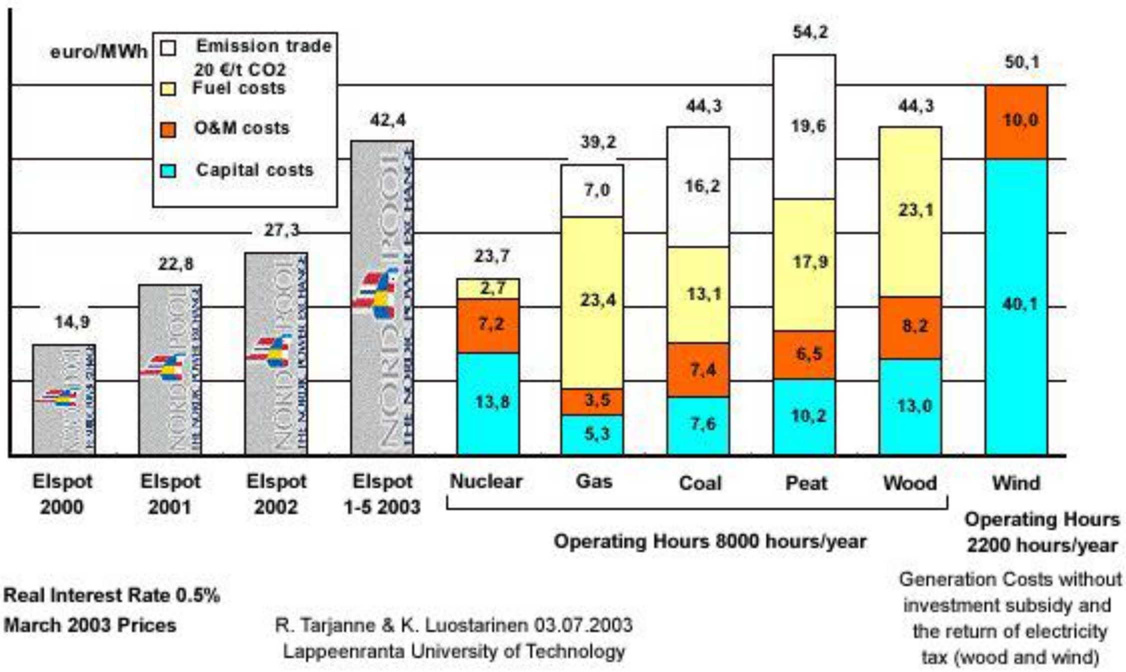
The figure compares the average tariff charged by the NPCIL with the average rate of purchase of power by the state electricity boards (SEBs). Average rate of purchase of power by the SEBs includes purchase from coal fired power plants located at or near the pit heads. One may note that when electricity is transmitted from plants near pit heads to load centres, one needs infrastructure for transmission and there are some transmission losses. The tariffs also depend on the age of the plant. Inspite of the fact that several new plants have been added by NPCIl, the average tariff charged by NPCIL is competitive considering the fact that NPCIL plants are located away from pit heads. Studies by IGCAR [Bhoje 2003] indicate that the cost of electricity from the fast reacter will also be competitive. [15]

In **1999 Siemens** (now Framatome ANP) published an economic analysis comparing combined-cycle gas plants with new designs, including the European Pressurised Water Reactor (EPR) and the SWR-1000 boiling water reactor. Both the 1550 MWe EPR if built as a series in France /Germany and the SWR-1000 (with an 8% discount rate) would be competitive with gas combined cycle, at EUR 2.6 cents/kWh. The current-generation Konvoi plants operating in Germany produce power at 3.0 cents/kWh including full capital costs, falling to 1.5 c/kWh after complete depreciation. [16]

A detailed study of energy economics in **Finland** published in mid-2000 showed that nuclear energy would be the least-cost option for new generating capacity. The study compared nuclear, coal, gas turbine combined cycle and peat. Nuclear has very much higher capital costs than the others --EUR

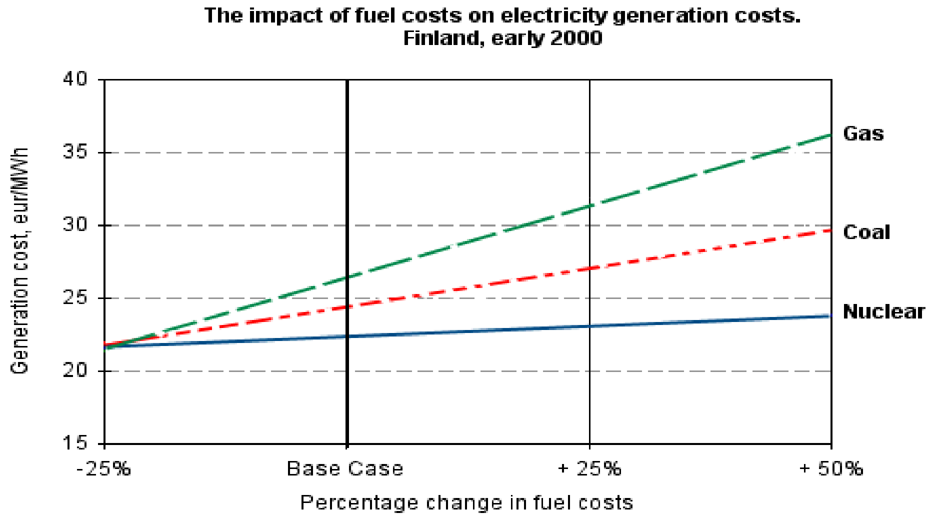
1749/kW including initial fuel load, which is about three times the cost of the gas plant. But its fuel costs are much lower, and so at capacity factors above 64% it is the cheapest option. [17]

August 2003 figures put nuclear costs at EUR 2.37 c/kWh, coal 2.81 c/kWh and natural gas at 3.23 c/kWh (on the basis of 91% capacity factor, 5% interest rate, 40 year plant life). With emission trading @ EUR 20/t CO2, the electricity prices for coal and gas increase to 4.43 and 3.92 c/kWh respectively:[18]



In the middle three bars of this graph the relative effects of capital and fuel costs can be clearly seen. The relatively high capital cost of nuclear power means that financing cost and time taken in construction are critical, relative to gas and even coal. But the fuel cost is very much lower, and so once a plant is built its cost of production is very much more predictable than for gas or even coal. The impact of adding a cost on carbon emissions can also be seen.

The Finnish study in 2000 also quantified fuel price sensitivity to electricity costs:



These show that a doubling of fuel prices would result in the electricity cost for nuclear rising about 9%, for coal rising 31% and for gas 66%. These are similar figures to those from the 1992 OECD report (bar chart below). Gas prices have already risen significantly since the study, partly reflected in the 2003 figures above.[19]

CONCLUSION

Myths about India's energy market happily muddy clear thinking about topic. This partly reflects a socialist legacy that has ensured India has only a rudimentary ability to analyse the energy sector, especially at the international level. Again India needs every energy source it can find. It can't afford to give up options. The infrastructure investments needed for natural gas may not materialize. Those of nuclear power could take off. Or vice versa don't keep all your energy eggs in one fuel basket.

Energy security for a country as large as India can only be provided by a diversified portfolio. An examination of data (IEA2005) indicates that India is the fifth largest producer of electricity in the world. However, while India is amongst the top 10 countries of the world for production of electricity by hydro, coal, and gas, it is nowhere near the top 10 with respect to nuclear power generation. For a large country like India this is an anomaly which needs correction.

Having said this we need to remember that experts have pointed out that even if we go all out for building nuclear power plants we will not be able to increase its share in domestic energy pool by more than 6 percent. Moreover it remains to be seen what pace nuclear energy gathers in India, what arrangements we have for uninterrupted supply of Uranium. What progress we are making in building fast breeder reactors and using fusion technology for production of nuclear energy. Till then we should keep our fingers crossed on the vital question of nuclear energy as an important alternative to fossil fuels or to the nuclear renaissance in India.

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