Nuclear Power – The Cons in the Debate

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EVER SINCE man learnt to harness fire for his own benefit, as civilization progressed, mankind's demand for energy as an instrument for economic and social development has increased by leaps and bounds. Primitive man had only the strength of his arms and the use of fire. Later he tamed animals as new sources of energy; they were used to pull plows and wagons and to move from one place to another. He discovered how to use the wind energy to move boats and ships. He used the water energy to move mills. A new stage in the development of the use of energy came at the end of the feudal period with the invention of steam engine, which ushered in the Industrial Revolution. Then introduction of power driven machinery led to explosive increase in production which transformed the basically rural and agricultural society into urban and industrial society in the capitalist world. Coal was then the principal source of energy. Subsequently petroleum and natural gas were discovered and these two together soon outstripped coal as a source of energy. Discovery of nuclear fission in the first half of the 20th century has given mankind access to a new, abundant and powerful source of energy. And if scientists can control the process of nuclear fusion it might solve mankind's energy problems for ever. Hence many people believe that nuclear energy is the energy option for the future.

Our civilization and our standard of living depend on an adequate supply of energy. In today's world the per capita energy consumption is often regarded as an index of a nation's development. Any country that aspires to improve the standard of living of the people must have a sound policy on power generation. In modern civilization the most important form of power generation is generation of electricity. We recall that after the October revolution one of the primary steps that the Soviet Government under the leadership of Lenin took was electrification of the country. Its importance is reflected in the slogan that Lenin coined, "Electricity plus Soviets equals Socialism". India, if it is to be developed as a modern industrialized state, must have a well thought out energy policy that would bring power cheaply to the people and meet the present and future demands of economic and social development.

The different sources of energy used for power generation are: (i) fossil fuels, coal, oil and gas, (ii) water power, (iii) nuclear energy, (iv) renewable sources like solar energy, wind power, tidal energy, geothermal energy etc. Hundred years ago coal and "traditional" sources like wood, crop residue, animal dung supplied most of the energy the world needed. They are still a major source of energy particularly in the less industrialized countries. In the second half of the last century the world's energy consumption has almost quadrupled. In 1950 the world's total primary-energy consumption was 2530 million tons of oil equivalent energy, and in 1999 it was ca. 9700 million tons. In 2000

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*Dr. Mukhopadhyay, FNA, is a retired Professor of Geology, Calcutta University, and the Editor of Breakthrough coal supplied about 22.9% of this total energy, oil about 35.1%, natural gas about 20.8%, hydropower about 2.4%, other renewable sources about 2.1%, wood etc. about 10.3%, and nuclear power about 6.5% (Source : *Statistical Review of World Energy(1999), BP Amoco)*. About one-fifth of this is for electricity generation, the rest is for transport, manufacture, heating etc. For electricity generation coal is still the major source, and nuclear power's share is still very little. In the coming decades, even allowing for the increase in energy efficiency, the total world's consumption would rise more than threefold, and in the developing nations the ratio would be even more. According to an assessment carried out by the UN Development Programme and the World Energy Council the global primary-energy demands will rise from about 400×10^{18} J today to $800\text{-}1600\times10^{18}$ J by the end of the 21st century, depending on assumptions about energy efficiency. How are we to meet this huge demand? The concern is that the fossil fuel resource of the world is limited and is going to be exhausted soon. Secondly, the burning of them causes the emission of green house gases which is leading to global warming and will ultimately result in an environmental catastrophe. In addition, they cause air pollution damaging our health and the ash from burning pollutes the environment with various toxic substances.

Hydroelectricity generation poses other problems like submergence of vast tracts of land, massive displacement of people, disturbances in the hydrological cycle, etc. Can nuclear power be the answer to our future energy demand? The proponents of nuclear power say that it can. They aver that opposing nuclear power generation is infantile and in a sense, refusal to reap benefit from latest scientific inventions. The arguments given are: the nuclear fuels have vast, or even unlimited, reserve; nuclear power generation does not cause global warming; and the running cost is cheap. According to one estimate while coal emits 850 tonnes of carbon dioxide per gigawatt (GW)-hour, the corresponding figures for oil are 750, gas 500, nuclear 8, wind 7 and hydro 4. Hence nowadays the question of setting up of nuclear power plants has taken the centre stage. It is also argued that the nuclear fuels produce thousands of times more energy per kilogram of material than coal, petroleum or natural gas. Typically 1 tonne of natural uranium would produce 44 gigawatt-hours of electricity. The production of the same amount of electrical power from fossil fuels would require the burning of over 20,000 tonnes of black coal or 8.5 million cubic metres of gas. But we have to also remember that the amount of fissionable material like uranium occurs in very small quantity in natural rocks and a very large quantity of ore will have to be mined and processed. Mining such huge quantities poses environmental problems. Hence, the pro-nuclear lobby, particularly of the establishment, is vociferous that nuclear energy is the only option for the future to provide cheap, safe power and arrest or even reverse the global warming and climate change. But as we shall discuss below there are serious problems related to nuclear power generation which are often unaddressed or pooh-poohed. It is, therefore, imperative that we rationally and scientifically judge the issue.

1. Hazards of Nuclear Power Generation

1.1 Hazards of Uranium Mining

The problem of hazard starts with the mining of uranium ore. In addition to the harmful effects of any mining, like degradation of land from quarrying and waste dumping and contamination of ground water by mine effluents, uranium mining poses special hazards to the miners and the communities living nearby because of the radioactive nature of rocks and minerals. The mine workers are exposed to the ionizing radiation from radioactive uranium, accompanying radium and radon gas emitted from the rocks and ores. The high energy particles in the radiation damage cells and DNA structure, produce genetic mutations, impair the immune system and cause cancers. According to the International Physicians for the Prevention of Nuclear War, uranium mining has been responsible for the largest collective exposure of workers to radiation.

Average concentration of radon and all of its decay products (daughters) in underground mines range from 100 to 1000 times normal natural background levels. In open-pit mines of moderate to high grade ore bodies the high density of radon (7.8 times heavier than air) and atmospheric inversion conditions can cause radon daughter levels which are 200-1000 times of normal background levels. Workers in open pits with low to moderate grade ore receive 2 to 4 times the normal lifetime dose of radon daughter radiation during their employment life, under conditions where there are no inversions. In a uranium mill, with low to moderate grade ore, the millers receive from 5 to 14 times the normal background lifetime dose of radon daughter radiation during their 30-year working lives. Uranium millers may receive doses of gamma radiation of 1000 times background from high grade ores. In reports by the International Commission for Radiological Protection (ICRP), work-related deaths in uranium mines are estimated at 5,500 to 37, 500 deaths per million workers in a year. The magnitude of the risk becomes apparent when we compare that the deaths due to accidents in the general manufacturing industry are estimated at 110 deaths per year per million workers and for the construction industry at 164 deaths per million workers per year.

The authorities generally fix a “safe” level of radiation, but often this fixing is based on arbitrary administrative decisions. However, it is widely agreed in the scientific community that there is no safe level of radiation exposure. Each time the ICRP and other experts/organizations conduct a review on “safe” levels of radiation exposure, they conclude that low levels of ionizing radiation are more dangerous than was previously decided. On average, these organizations have concluded that the actual danger is twice as bad as they thought twelve years before.

In “in situ leaching” (ISL) or solution mining, millions of litres of strong acid or alkaline solution are injected directly into the groundwater, which dissolves uranium, thorium, radium and radon, and also other toxic metals such as lead, arsenic, vanadium, molybdenum, cadmium, nickel etc.. These solutions can pollute the groundwater system over a wide region and can contaminate the surrounding environment irreversibly.

At the mine site, after the uranium is chemically removed the leftover piles of materials or uranium tailings still contain radioactive products. If this radioactive waste is left on the surface and is allowed to dry out, it can blow in the wind and be deposited on vegetation far away, entering the food chain. Or it can wash into rivers and lakes and contaminate them. There is no executable technological method to store millions of tonnes of this radioactive tailings safely forever, and keep it out of the environment. The tailings, most of which are in the form of a slurry, are dumped in large surface impoundments ("tailings dams"). The embankments forming these impoundments are earth-fill dams. Dam failure would pose a great danger of radioactive contamination of the environment. There have been many uranium tailings disasters in Australia, Canada and the US. In Jadugoda also, in 2006, a pipe burst, discharging radioactive waste into a nearby rivulet. The pipe was being used to move the waste from a UCIL plant to a storage dam.

In India, environmental scientists fear that within 5 km of the Jadugoda uranium mine in Jharkhand, 30,000 people are being exposed to radiation. Not much documentation is available on the radiation levels in the Jadugoda mines, the tailings pond or in the neighbouring villages. Hence it is almost impossible to gauge how much radioactive material is circulating within the environment and how it is entering into the food chain. The limited data available indicate that though the people of Jadugoda may not be exposed to 'high' levels of radiation, they have lived here for more than 30 years with low-level radiation, which acts in subtle and not fully understood ways. The mine authorities display a most irresponsible and careless attitude towards handling or storing the radioactive materials. The uranium ores are transported in open trucks. The mine tailings lie unprotected at several places and the villagers live close to the tailings ponds. Roads and buildings are being built with tailings, thereby spreading contamination. Water from the main tailings pond travels in open channels through the town, ultimately flowing into the river and contaminating it.

Mr. H. Koide, a Japanese researcher from the Research Reactor Institute, Kyoto University found high radioactive contamination around the tailings pond. At some places the strength of pollution is 10 to 100 times higher compared to a place without contamination. The permissible limit for radiation exposure is 1 mSv (microsievert; sievert is the SI unit of equivalent radiation dose on tissue) per year. At the tailings pond the air-gamma dose exceeds 10 mSv/year, and in the villages it exceeds 1 mSv/year. The soil surrounding the tailings ponds is contaminated by uranium. The radon value in tailings ponds is 12 times the value in the normal environment, and it seems that the contamination of radon has spread from the tailing pond into villages. An environment committee of Bihar Legislative Council, headed by Gautam Sagar Rana, had pointed out in its report the health hazards to which miners working in the uranium mines and the tribals residing close to the tailings ponds are exposed. Children in the 15 villages surrounding the uranium mines show congenital deformities and over 60 per cent of the workers in the mines and manning the tailings ponds are afflicted with serious ailments like chronic skin disease, cancers, TB, bone and brain damage, kidney damage, nervous system disorders, congenital deformities, nausea, blood disorders and other chronic diseases.

The Jharkhand Organization Against Radiation (JOAR) conducted a health survey in 1998 which revealed that the women folk in that locality have been suffering from certain reproductive health problems which may be caused by radiation effect. In 2000, nuclear scientist Dr. Surendra Gadekar and others from Sampoorna Kranti Vidyalaya and local grassroots groups conducted a health survey in Jaduguda. The aim was to record the actual public and occupational health status of the uranium mining and milling operations. The survey was conducted in the villages near the tailings ponds, as well as in 'control' villages further away. The survey team found a discernible rise in congenital deformities among people born after the start of mining operations in 1967. In the villages near the UCIL facility, of the nine children who died within a year of birth, eight had congenital deformities. In the control areas, on the other hand, of the six recorded premature deaths, all were due to reasons such as diarrhoea, fever and premature birth. In the nearby villages, 52 men and 34 women had deformities, in contrast to just seven of each in the control areas. the number of infants born with genetic disorders was six times higher than normal, due to the harmful radiation emitted by UCIL's operations for more than two decades. Of the 70 such cases reported, 60 were born with congenital deformities in villages close to the uranium plant, whereas 10 were born in non-affected areas. Moreover, 16 out of the 60 were mentally retarded, compared to one in other areas. Cases of infants born with Polydactyl (extra fingers or toes) and syndactyl (fused or missing fingers and toes) are also common in the affected areas. The team also recorded extremely high levels of chronic lung disease in UCIL's miners and millers. The Indian Doctors for Peace and development (IDPD), an affiliate of International Physicians for Prevention of Nuclear War (IPPNW), recipient of 1985 Nobel Peace Prize concluded from a controlled and rigorous study carried out in 2996 in five villages surrounding the uranium mines, tailings pond and ore processing plant that, (a) primary sterility is more common in the uranium mining operation area; (b) more children with congenital deformities are being born, and congenital defect as a cause of death of a child is also higher close to the mining area; (c) cancer as a cause of death is more common in villages surrounding mining area; (d) the life expectancy of people in mining areas is less.

The Atomic Energy Regulatory Board admitted that the radon concentration at the tailings pond is "slightly" above the background level, but the Uranium Corporation of India limited (UCIL) authority maintained that the health check-ups of mine workers and people living near the tailing pond show no radioactivity beyond permissible level. The UCIL management insists that there is no radiation here and refuses to commission independent studies on the overall impact on the environment. They went on to insinuate that the deaths and health conditions of the victims of Jadugoda are not due to radiation but are a result of poor nutrition, malaria, alcoholism and genetic abnormalities. But the study of Sonowal and Jojo disproves this.

1.2 Problems of Radioactive Waste Disposal

Starting from the stage of mining, nuclear power generation generates a lot of nuclear waste, and there is no secure, risk-free way to store nuclear waste. A large nuclear reactor produces 3 cubic metres (25-30 tonnes) of spent fuel (high level waste) each year. The global volume of spent fuel was 220,000 tonnes in the year 2000, and is growing by approximately 10,000 tonnes annually. The waste contains materials which show both short-term radioactivity and long-term radioactivity lasting for hundreds of thousands of years. So far no country has been able to provide a satisfactory solution of the problem of long-term storing this high level radioactive waste. The current practice is to first store the hot waste coming out of the reactor under water. The water can absorb and dissipate the heat, and confine the radioactive material. After five or more years in "swimming pool" storage, it can be moved for reprocessing or for long term storage. Most of the current proposals for dealing with highly radioactive nuclear waste involve burying it in deep underground sites. It is impossible to predict whether the storage containers, the store itself, or the surrounding rocks will offer enough protection to stop radioactivity from escaping in the long term. The proposed American solution was to store the waste in the Nevada Test Site which has already a lot of fission products from earlier bomb tests. However, this solution has been stalled by environmentalist policies in successive administrations and by objections from the State of Nevada. Storage in Yucca Mountain is also proposed but is not yet implemented.

The French solution is to make a glass out of the products and store the waste in caverns cut in granite. However, since the beginning of the French nuclear industry some 50 years ago, the management of nuclear waste has been largely neglected. Even today, large quantities of waste remain in unconditioned and unstable form; inventories of historical dump sites are lacking or were lost, and one of the largest dump sites in the world near the La Hague reprocessing plant is leaking into the underground water. Now evidence is emerging that a new nuclear dumpsite in the Champagne region of France is leaking radioactivity into the ground water threatening contamination by tritium and at a later stage by other radionuclides. In a very recent incident on May 24, 2006, the wall of a storage cell fissured, posing a great threat. In USA also in Washington State highly radioactive nuclear waste from an old nuclear reactor site at Hanford had seeped into the ground over several decades and polluted the Columbia River at a point which is more than 30 miles away.

In addition to the above there is a volume of low-level radioactive waste in the form of contaminated items like clothing, hand tools, water purifier resins etc. In the United States, the Nuclear Regulatory Commission (NRC) has repeatedly attempted to allow low-level materials to be handled as normal waste: landfilled, recycled into consumer items, etc., because it has low levels of radioactivity. But it is still harmful, and there are numerous examples of low level waste leaking radiation into the environment. Drigg in the UK and CSM in Le Hague, France are just two examples.

It has been suggested that in future 4th generation reactors the radioactive waste would be burnt in the reactor itself, and this would minimize the problem of waste disposal. But this has still to see the light of the day.

In India the storage of high level waste is a particularly worrying problem, because of a soft attitude of the administration to enforcing statutory norms and regulations paying scanty heed to the harmful effects on the people. The recent incident of radioactive contamination in Delhi through a scrap dealer shows how lax our regulatory system is to check the release of radioactive waste into the environment. That is why radioactive waste disposal at nuclear power plants is a matter of such serious concern.

Decommissioning nuclear facilities will also create large amounts of radioactive wastes. This is an additional worry. Many of the world's nuclear sites will require monitoring and protection for centuries after they are closed down.But no serious thought is given to it.

1.3 Safety and Security Concerns

The nuclear power generation process produces radioactive radiation. Two principal hazards of such radiation are cancers of all kinds and genetic mutation. Contrary to the vocabulary of the proponents of nuclear power, there is no "safe" dose of radiation. Even the lowest level of radiation exposure may cause biological damage and genetic mutation. It is true that the reactors are so designed that radiation is not leaked out. But like all machines nuclear reactors are and will always be vulnerable to accidents resulting in meltdown of the core or other large radiation releases. Accidents in nuclear power plants may and do happen due to malfunctioning of machine components, worn out or defective parts, accidents in transporting of radioactive materials, human error etc. Some reactors have design defects which make them prone to malfunctioning of components. Because the nuclear power generating process is complex with many interconnected components, all possible accident modes cannot be predicted, and there is no way to ensure that reactors and other nuclear facilities will not ever have major accidents. A study carried out at Massachusetts Institute of Technology (MIT), USA concluded that with the global growth scenario (1000 GW nuclear power generation by 2050), during the period 2005-2055 both the historical and the Probability Risk Assessment (PRA) data show that the expected number of core damage accidents with current technology is 4. B. Smith in a study sponsored by non-profit Institute of Energy and Environmental Research (IEER), USA found that the probability of at least one major accident occurring somewhere in the world by 2030 would be roughly 45 percent under the global growth scenario and more than 50 percent under the steady-state growth (same CO_2 emission as today) scenario. By 2050, the probability of at least one such accident having occurred would be greater than 75 percent for the global growth scenario and over 90 percent for the steady-state growth scenario.

A reactor accident may lead to catastrophic release of radioactivity which will have lethal effects on the population. The 1979 accident at Three Mile Island, USA, and the Chernobyl accident in Soviet Russia are well known. The Chernobyl nuclear accident demonstrated that the radioactive material released can be carried long distances in the atmosphere and affect human health far from the site of an accident. Apart from the millions of Soviet adults and young children exposed to high radiation doses, this accident raised the Earth's background levels of caesium137 by an average of 3% (caesium137, a man-made radioactive element, is toxic for over three hundred years). Near disaster situations happened several times in reactors in Japan and other countries. In March, 2006, safety reviews found that several nuclear plants in the United States have been leaking water contaminated with tritium into the ground, which would eventually drain into rivers and contaminate them. Even without an accident or attack, safety regulations are often violated in the nuclear power plants throughout the world, threatening public health by routinely releasing radiation into the air, soil and water.

The safety situation in Indian reactors is shocking. India is the only country in the world where nuclear research and plutonium production facilities are located inside or close to heavily populated areas. Serious accidents and shortcomings have been reported starting from 1969 at all the atomic power stations. There have been allegations that unscrupulous manufacturers with strong political connections sell defective parts for building or repairing reactors (*Asia Times online, Dec. 2, 2003, http://www.atimes.com/atimes/South_Asia/EL02Df01.html*). The Kaiga containment dome collapsed during construction stage. The safety violations in the Indian nuclear program range from hazardous mining practices, near meltdowns, heavy water leaks, turbine-blade failures, moderator system malfunctions, inoperable emergency core cooling systems, coolant pumps catching fires, structure failures, to flooding incidents. The Atomic Energy Regulatory Board (AERB) under the chairmanship of Dr. Gopalakrishnan had compiled more than 130 nuclear issues affecting the safety of the nuclear establishments in the country.

At Kalpakkam, in 1999 an accident resulting in spillage of radioactive heavy water exposed seven workers to high radiation. Again in January, 2003 a serious incident took place there, when a valve separating a high-level radioactive liquid waste tank and a low-level liquid waste tank malfunctioned and started leaking. This resulted in high-level radioactive waste mixing with low-level waste. The incident was serious enough to close down the main plant for six months. The plant at Narora experienced a devastating fire in 1993. But for the presence of mind and bravery of some workers the accident might have given rise to another Chernobyl. The AERB Report on the accident has not been made public. The Kakrapar Atomic Power Station was inundated by flooding in 1994. The floodwaters entered the turbine building, solid waste management facility and other parts of the complex, and nuclear waste canisters were floating out into the open. Fortunately the plant was shut down when the flooding happened otherwise the effect could have been devastating. Cracks, tube leakages always plagued the Rawatbhata plants, which developed such serious defects that one unit or another had to be shut down for years.

Nuclear scientist Dr.Surendra Ghadekar and Dr.Sanghamitra Ghadekar of Sampoorna Kranti Vidyalaya of Gujarat carried out a detailed study of the health situation in five villages around Rawatbhata plant and compared it with the health condition in four distant villages. All the villages were similar in social structure, educational status, age and sex ratio. In the nearby villages they reported higher incidences of solid tumour, congenital deformities, miscarriages, still births and deaths amongst new born babies, and some chronic ailments like recurring skin problems, cataracts, digestive tract problems, pain in joints, body ache, persistent feeling of lethargy and general debility. All this despite the fact that there has never been a major accident at Rawatbhata. These effects are the product of routine emissions of radiochemicals into the air and water over a period of 17 years.

At the Nuclear Fuel Complex (NFC) at Hyderabad the effluents and wastes containing radioactive materials and toxic chemicals are discharged into a waste storage pond. 50,000 tonnes of waste water accumulates every day and slowly the contamination is seeping into the underground water making it highly radioactive. There are reports of workers at Tarapur being exposed to excessive doses of radiation. Highly radioactive iodine has been detected in seaweed gathered around Tarapur plant. Radioactivity in the form of caesium137 has been reported to be present in the soil, water and vegetation near the discharge lines of CIRUS and DHRUVA research reactors at Trombay. The Indian government is secretive about leaks and accidents from the reactors. Dr. A. Gopalakrishnan, Chairman of the AERB said, "The DAE wants the government and the people to believe that all is well with our nuclear installations. I have documentary evidence to prove that this is not so. A national debate is needed." In 2001, S P Sukhatme, another former Chairman of the Atomic Energy Regulatory Board had warned after an accident in which tritium-contaminated coolant leaked from a reactor, that unless the very design of some of the nuclear reactors is drastically modified, India must be ready for the worst to come. His warning has been ignored.

Our country is the only one in the world where even though public funds are utilized in a faulty civil engineering design that resulted in the consequent collapse at the building stage of the structure of an atomic power plant meant for civilian use (at Kaiga), the entire matter can be kept away from the public gaze, all in the name of official secrecy and national security. The Indian Atomic Energy Act of 1962 prescribes that the nuclear program should be shrouded in secrecy. The Act gives the DAE enormous powers and the right to withhold any information from public. The DAE is an 'unaccountable organization'. This prohibits private and public probe into the workings of the Indian nuclear plants.

Another point of concern is that nuclear reactors are highly vulnerable to deliberate acts of sabotage, terrorist attack or attacks by missiles or bombs. An incident of tritium contamination alleged to be sabotage has recently happened in Kaiga in Karnataka. Even if for arguments' sake it is conceded that adequate safeguards can be instituted to prevent any catastrophic outcome from accident, negligence, mismanagement or natural disaster, vulnerability to hostile action still has to be taken into account. A successful attack on a nuclear plant can be incalculably catastrophic. Plutonium is a highly hazardous radioactive material, and if we go for breeder reactors in a big way, it would be transported in increasing quantities around the country. The potential diversion of even a small fraction of this material would significantly increase the threat of nuclear terrorism.

2. Economics of Nuclear Power Generation

It was once said that nuclear power would be “too cheap to meter”. Even now the proponents claim that nuclear power is the cheapest. But the reality is otherwise. Nuclear power plants are cheap to run but very expensive to build. Today, if nuclear power is to compete commercially with a natural-gas-fired power station, it would need a subsidy (overt or hidden) of more than $ 2 billion per GW. In France, where nuclear energy is the dominant power source, the amount of direct and indirect government subsidies for the nuclear industry was not disclosed very openly until 1992. It has now been shown that once the subsidies are included, the cost of nuclear power in France was 30 to 90 per cent more than official claims.

In 2003 and 2004 MIT and University of Chicago respectively sponsored projects to evaluate the real cost of electricity from nuclear power versus pulverized coal plants and natural gas combined cycle plants. The figures for 40-year economic life of the plants and 85% capacity factor are given in Table 1.

These costs do not include the very substantial waste disposal and decommissioning costs for the nuclear power plants. A later study in 2007 fixes a higher cost for nuclear power generation. The figures in the above table would be different in other countries depending upon the prices of coal, construction cost etc.

In India at 1997-98 price level a nuclear plant would cost Rs. 52.32 million/MW, compared to Rs. 37.5 million/MW for a thermal plant. A 1999 Nuclear Power Corporation (NPC) internal study remarked that the cost of nuclear electricity generation in India remains competitive with thermal [electricity] plants located about 1,200

Table 1: Peak levellised cost of electricity

	MIT (2003):	University of Chicago (2004):
Nuclear	6.7 US cents/KW-hr *	6.2 US cents/KW-hr *
Pulverised coal	4.2 ”	4.1 ”
Combined Cycle Gas Turbine		
Low Gas price	3.8 ”	3.5 ”
High Gas price	5.6 ”	4.5 ”

* Overnight capital cost $ 2000/KW in MIT study and $ 1500/KW in Chicago study.

km away from coal pit head, when full credit is given to long term operating cost especially in respect of fuel prices”. This is contradicted by M. V. Ramana, senior fellow at the Centre for Interdisciplinary Studies in Environment and Development in Bangalore, and currently Visiting Research Scholar at Princeton University, USA and his associates who compared the actual costs of generating electricity at the Kaiga atomic power station and the Raichur Thermal Power Station (RTPS) VII – both plants having similar size and vintage – using the standard discounted cash flow methodology. They showed that for a wide range of realistic parameters, nuclear power is significantly more expensive than thermal power. The atomic energy establishment claims that the Prototype Fast Breeder Reactor (PFBR) requires Rs. 35 billion investment, and will supply electricity at Rs. 3.22 per unit (KW-hr) to the power grid. Even then thermal power would be cheaper. The NTPC renovated a 20-year old thermal plant of the Orissa State Electricity Board near Talcher to give power to the grid at Rs. 1.30 per unit.

A further disadvantage of a nuclear power plant is that its lead time for construction is at least 7-10 years as against 4 years for coal, 2 years for natural gas, and 8-12 months for a wind farm. In addition, nuclear plants have a history of high cost overruns. Not only that, nuclear power plants in India have an infamous history of construction delay, cost overruns, frequent breakdowns and stoppages. As an example, the Kaiga I and II plants were to start production in 1994 with an investment of Rs. 7.31 billion. Production actually started in 1999, with the cost having overrun to Rs. 29 billion. A report from 1998 states that the Indian nuclear plants are operating at less than 40 per cent of their combined designed capacity. That means, with an installed capacity of 2180 MW in 1998, less than 872 MW of power was actually produced (B. K. Subbarao, *Manushi, Issue 109*). The situation in other countries is no better. In Finland, which renewed its nuclear programme, the flagship project of Olkiluoto-3 reactor is at least 24 months behind schedule after 28 months’ construction, and at least 50% over budget.

3. Rational Energy Planning

We have to recognize that in our present state of technology no energy system is totally free of negative impacts. The challenge is to choose the least bad mix of options that would develop a sustainable and equitable energy system to meet our increasing demand of energy, and at the same time reduces CO_2 emission as much as possible. It is true that running a nuclear reactor does not cause much greenhouse gas

(GHG) emission, in nuclear power generation CO_2 emissions arise from energy usage for the construction of the plant, the mining and milling of the uranium, the enrichment of the uranium, its conversion into nuclear fuel, the disposal of the spent fuel, and the final decommissioning of the plant. In a study sponsored by non-profit IEER (USA), B. Smith has shown that if we want to keep the CO_2 emission at the same level as the year 2000 (steady state growth scenario) and keep pace with the rising demand, 1900-3300 GW nuclear capacity will have to be installed by 2050, that is at least one reactor must be commissioned per week. This appears to be an unrealistic and we think even an undesirable target. Hence the claim that nuclear power generation would stop GHG emission and prevent global warming is merely a hype. The problem of global warming needs to be tackled with all seriousness. But just setting up nuclear plants is not a solution. As an example we cite that from 1965 to 1995 Japan's nuclear plant capacity went from zero to over 40,000 MW. But during the same period, carbon dioxide emissions went up from about 400 million tonnes to about 1200 million tonnes. In other words, increased use of nuclear power did nothing to reduce Japan's emission levels.

To tackle the problem of GHG emission, a host of other measures may be adopted that are better and far more economically viable. These include boosting energy efficiency, running coal fired plants in a more efficient way, going for combined cycle gas turbine (CCGT) electricity generation and utilizing renewable energy sources like wind energy and solar energy. Compared to pulverized coal power plants, CCGT emits about 55 percent less CO_2 for the same amount of generation. With respect to coal, the use clean coal technology, and of gasification technologies (Integrated Gasification Combined Cycle (IGCC) plants) would greatly reduce emissions. India is well endowed with renewable sources of energy. A 2006 estimate gives the potential for wind power at 46,000 MW; small hydro-power at 15,000 MW; biomass power/co-generation at 19,500 MW and waste-to-energy at 4,200 MW, making a total of 83,700 MW (Figures from the non-profit Global Energy Network Institute of USA). Of these, only 13 per cent has been exploited so far.

India has unlimited solar power and ocean energy, but is unable to exploit these due to lack of sufficient Research and Development. Increased investment on nuclear power diverts attention and squanders the resources necessary to dvelop other energy options; on the contrary it costs trillions of dollars, creates tens of thousands of tons of lethal high-level radioactive waste, contributes to proliferation of nuclear weapons materials, and carries a dangerous risk of another Chernobyl-scale accident.

The actual global situation about opting for nuclear power generation is that the setting up of nuclear plants has lagged far behind the claims and expectations of the nuclear lobby. In 1974 the International Atomic Energy Agency (IAEA) predicted that by 2000 the electricity generation by nuclear plants would be 4.45 million megawatt (MW). In 1986 after the Chernobyl accident the target was scaled down to 0.505 million MW, but the actual production was 0.367 million MW, 1/15th of the 1974 prediction. The production has remained more or less at the same level since 1998. In 1986 there were 394 nuclear power plants and construction work was in progress on 160 more, but in 2007 the numbers of operational plants was only 434 and work was in progress on 28 only. Construction of many plants was stopped, some old plants were closed down; some new plants did come up, but the net increase was insignificant. In France, Belgium and Sweden the major part of electricity (78%, 54% and 50% respectively) is now being generated by nuclear plants, but they are not expanding it. Germany has decided to close down its nuclear facilities by 2023. This past history we should keep in mind about realistically projecting the role of nuclear power in meeting India's future energy demands.

Bhaba had announced fifty years back that there would be 8000 MW of nuclear power in the country by 1980. In 1969 the Department of Atomic Energy (DAE) predicted that by 2000 there would be 43,500 MW of nuclear generating capacity. But the reality is quite different. Installed capacity in 2000 was 2720 MW, and the current capacity is 4120 MW.

India adopted a grand three stage program, first announced in 1954, for the development of nuclear energy in the country. The first stage involved the use of uranium fuel in heavy water reactors, followed by reprocessing the irradiated spent fuel to extract plutonium. In the second stage, the plutonium from reprocessed spent fuel from pressurized heavy water reactors (PHWR) would be used in the nuclear cores of fast breeder reactors (FBR). These nuclear cores could be surrounded by a "blanket" of either depleted uranium or thorium to produce more plutonium or uranium-233 respectively. To ensure that there is adequate plutonium to fuel these second stage breeder reactors, a sufficiently large fleet of such breeder reactors with uranium blankets would have to be commissioned before thorium blankets are introduced. The third stage would involve breeder reactors using uranium-233 in their cores and thorium in their blankets. One key element in the DAE's plans for the future of nuclear power in India is a large number of breeder reactors. While country after country has abandoned breeder reactors as unsafe and uneconomical, the DAE has been stubbornly sticking to its plan. Given that even the second stage of the three stage nuclear program is yet to start, more than fifty years after the initial announcement, it appears unlikely that the third stage – breeders involving thorium and uranium-233 – will materialize soon.

DAE's current projections for nuclear power generation are for 20,000 MW by the year 2020 and for 207,000 to 275,000 MW by the year 2052. The likelihood of these goals being met is slim at best. But even if they are met, nuclear power would still contribute only about 8-10% of the projected electricity capacity in 2020, and about 20% in 2052. There is thus little chance of nuclear electricity becoming a significant source of power for India anytime over the next several decades. The present hype about going for nuclear power to solve the country's energy problems hides the real issues in the energy scenario and the nuclear industry.

All governments (Congress, Janata, BJP, at the Centre and even the CPI (M) which professes to be a friend of the people and which rules in three states) have favoured nuclear energy and the DAE's budgets have always been high. At present, 25 percent of our energy budget goes to the Department of Atomic Energy (DAE), which accounts for far less than 3 per cent of total power output. After the 1998 nuclear weapons tests the DAE's budget has increased from Rs. 18.4 billions in 1997-98 to Rs. 55 billions in 2006-07, i.e., more than doubled even in real terms. The high allocations for the DAE have come at the cost of promoting other, more sustainable, sources of power. In 2002-03, for example, the DAE was allocated Rs. 33.5 billions, in comparison to a mere Rs. 4.7 billions allocated to the Ministry of Non-conventional Energy Sources (MNES). There has been no step towards, evolving an integrated composite plan of energy production. If the Government was really serious about meeting the country's energy requirements it should have effectively pursued the policy of employing clean technology in thermal plants to significantly reduce pollution, and aggressively promoted research on developing and improving the technologies for utilizing renewable sources, like wind power, solar energy etc. In Denmark wind turbines generate more than 20% of the total electricity production. In Germany the installed capacity of wind power generation is more than 22000 MW in 2007, and wind power is about 6% of Germany's total power production. The successive governments in India, on the contrary spend mind-boggling sums on nuclear reactors, but do not make even remotely comparable investment in developing and promoting other sources of power.

4. Nuclear Power Generation or Nuclear Weaponization?

Every state that has a nuclear power capability has the wherewithal to obtain nuclear material usable in a nuclear weapon. Almost all countries that produce nuclear power use the reactors for nuclear weapons production. In fact many developed countries began the nuclear research with the objective of developing nuclear weapons. India's nuclear programme has also long been linked with nuclear weaponization. In fact, no less a person than Dr. Gopalakrishnan, former Chairman of Atomic Energy Research Board (AERB), maintains that the main motive of the programme is not to generate nuclear energy, but to obtain the by-product of the nuclear reactions – plutonium – which according to him is siphoned off for use in India's nuclear weapons. The plutonium for Pokhran I and Pokhran II came from Bhaba Atomic Research Centre (BARC) reactors, and the U-233 was produced in India's fast breeder reactor. India has indigenously developed a cost effective advanced technology to produce tritium which is used in the construction of fusion bombs and to boost the fission yields of thermonuclear weapons. But the nuclear establishment in India is thwarted in its grandiose plans for expansion because of the scarcity of nuclear fuels. The domestic uranium production is not enough to meet the needs of even the existing reactors.

So, on the one hand the Government is desperately trying to open up new mines, set up new reactors, riding roughshod over the public protests, and on the other it is negotiating for an assured fuel supply through the recently concluded infamous Indo-US nuclear deal. The corporate interests in USA favour this deal because they see in it a possibility of huge and lucrative nuclear trade. As the construction of nuclear power plants is declining in the developed countries, that industry is turning its attention to markets like India for selling its technology. On the other hand, through this deal the Indian ruling class is aiming to gain access to the international nuclear market to develop its nuclear industry. The deal would permit India to retain a substantial capacity to produce fissile materials for use in nuclear weapons. The Indian rulers have sought strenuously to keep as large a part of the nuclear complex as possible outside the safeguards. Their intention is to ensure the international supply of nuclear fuels to run the existing and planned reactors for power generation, which would free the domestic uranium to be used in the reactors devoid of required safeguards for production of weapons grade fissile material, and allow a significant and rapid expansion in India's nuclear arsenal. This is clear from Prime Minister Manmohan Singh's statement in the Lok Sabha that the supply of nuclear fuel, technology, and reactors would serve to "enhance nuclear power production rapidly", but "there is nothing in the joint statement that amounts to limiting or inhibiting our strategic nuclear weapons program."

The question therefore arises – is the Government's insistence of going for nuclear power generation aimed at mitigating the country's energy problems and meeting the people's need for cheap supply of energy, or is it for the purpose of developing nuclear weapons? There is an urgent need for an informed debate in the country involving the common people, the scientists and the planners on this issue, – should we go about setting up a large number of nuclear reactors at a great cost, exposing the people to the grave hazard of radioactive contamination at all stages of production from mining to generation and waste disposal, and possibly triggering an arms race and heightening war tensions in this part of the world, or should we prudently use our valuable material and financial resources in developing environment friendly methods of power generation and formulating a sustainable and equitable energy policy?

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