Nuclear Energy — Facts and Fiction

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Early warnings

Two incidents in the recent past come dangerously close to disaster in India. Both involve nuclear power plants.

One occurred at the Narora nuclear reactor in UP on 31 March, 1993. Early that morning, two blades of the turbine of the first unit at Narora broke off. They sliced through other blades, destabilizing the turbine and making it vibrate excessively. The vibrations caused the pipes—which carried hydrogen gas that cools the turbine—to break, releasing hydrogen, which soon caught fire. Around the same time, lubricant oil too leaked. The fire spread to the oil and throughout the entire turbine building. Among the systems burnt by the fire were four cables that carried electricity. This led to a general blackout in the plant. One set of cables supplied power to the secondary cooling systems. When it got burnt, those cooling systems were rendered inoperable.

To make things worse, the control room was filled with smoke and the operators were forced to leave it about ten minutes after the blades broke. Prior to leaving, however, the operators *manually* actuated the primary shutdown system of the reactor. Fortunately, the reactor shutdown systems worked and control rods were inserted to stop the chain reaction. The problem then was similar to that happened at Fukushima: the reactor went on generating heat because the fuel rods in a reactor accumulate fission products which continue to undergo radioactive decay.

The situation was saved by some workers who climbed on to the top of the reactor building, with the aid of battery-operated torches, and manually opened valves to release liquid boron into the core, further absorbing neutrons. Had these workers not acted as they did there could have been a local core-melt and *explosive* fuel-coolant interaction. The names of those heroic workers have never been made public! [1]

Another major disaster would have occurred at Kakrapar in Gujarat but for a stroke of luck. On 15 and 16 June 1994, there was heavy rain in South Gujarat and the water level of the lake began to rise. That resulted in the ducts that were meant to let out water becoming conduits for water to come in. Water began entering the turbine building on the night of 15 June. There was no arrangement for sealing either the cable trenches or the valve pits, both of which also allowed water to enter the reactor building. By the morning of 16 June, there was water not only in the turbine building but also in other parts of the reactor complex.

The workers in the morning shift had to swim in chest-high water, and the control room was reportedly inaccessible for some time. A site emergency was declared and workers were evacuated. The gates of the Moticher Lake could not be opened, even after the management requested help from the district and state authorities.

Finally, *villagers* from the area, who were worried about the security of their own

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homes, made a breach in the embankment of the lake which allowed the water to drain out. Fortunately, the reactor had been shut down for over four months at the time of the flooding and there was no great danger of an accident. Had it been functioning and there had been reason to issue an off-site emergency, the situation would have been disastrous. [1]

It is important to note that common people and workers, who remain unnamed, have come to the rescue of the plants in both incidents—one caused by fire and the other, by water.

No wonder, then, that people elsewhere are deeply worried. The ongoing agitation against the proposed Rs.17,000 crore nuclear power plant in Koodankulam, Tamil Nadu is the latest manifestation of a long series of protests against nuclear technology. Despite this struggle going on for about 500 days, the government is bent upon going ahead with the commissioning of the plant. But the agitation has brought to focus the important questions: Is nuclear technology really safe? Is nuclear energy really the only way to meet the power shortage in India? Most importantly, why is the government so bent upon going ahead at any cost?

A bit of history

Before we delve into these questions, let us look back to get a historical perspective of the issue. A most interesting chapter in the history of nuclear energy in India is the titanic clash between two foremost physicists, Dr. Homi Bhabha and Prof. Meghnad Saha on the future of Indian Nuclear Programme. Saha and Bhabha differed in their notions about the goals of science and technology, and the means for achieving these goals. Saha emphasized large-scale industrialisation, development of competent manpower, judicious and equitable distribution before embarking on a nuclear programme. He advocated participatory democracy even in such highly technical engineering projects. On the contrary, Bhabha argued that nuclear energy is an immediate need for India and he preferred an elitist approach—even if it means secretiveness—over Saha's open and democratically disposed approach. [18,1]

A memorandum sent by Dr. Bhabha to Nehru argued that "In order to keep activities secret, a small, high-powered centralised body controlling atomic energy research has to be set up rapidly reporting only to the Prime Minister." [18] In contrast, Saha wanted to see universities do research on nuclear physics and engineering, and be supported (by the government) in their efforts to do so. [19]

Saha's argument did not find favour with the ruling establishment under Nehru and Bhabha's argument prevailed. Thus, the Atomic Energy Commission (AEC) founded in 1948 just one year after independence is—as historian Ramachandra Guha puts it—the *most secretive* institution in India! The power plants run by AEC do not have to report to the Parliamentary Committee on Public Undertakings. In fact, they have been made exempt from the scrutiny of Parliament itself by an Act of Parliament: the Atomic Energy Act of 1948. [3] This Act clamped secrecy on the entire atomic energy programme of the country. [20]

During the early 1950s, as an elected Member of the Parliament, Saha repeatedly raised this issue on the floor of the Lok Sabha. In the debate in the Lok Sabha on Peaceful Uses of Atomic Energy on 10 May 1954, Saha made an impassioned appeal: "If you read out Atomic Energy Act, you find that it does not tell us what to do but it simply tells us what is not be done. (But) the Atomic Energy Acts of England and America ··· deal with how the efforts of the scientific talents of the country have to be harnessed in one scientific effort.” [20] He continued to oppose the secrecy and the exclusivity of the Atomic Energy Commission. [19] But, the nuclear energy programme went ahead on the chosen path of secrecy.

The compulsions behind this secrecy and exclusivity are dealt with later in this article.

The claims on nuclear energy in the Indian context

Let us look at the most important claims of the nuclear programme in India:

a) Nuclear energy is a must to meet India’s expanding energy needs

b) In comparison with other sources, nuclear energy is cheap and plentiful

c) Nuclear energy is relatively safe

d) Nuclear energy is more environment friendly than energy based on fossil fuels.

Let us examine each of these claims in the light of experiences of nuclear programmes in India and around the globe.

Claim 1: Nuclear energy is a must to meet India’s energy needs

In 1954, Bhabha predicted India would produce 8,000 MW by 1980. In 1969, DAE extravagantly predicted that 43,500 MW of nuclear energy would pulsate the country by 2000. These grand words have failed to materialise. By 2000, India was only able to produce 2,720 MW. [1]

An empirical analysis shows that the nuclear establishment has consistently overstated the amount of electricity it can feasibly generate in the near future. Here, the term ‘nuclear establishment’ refers to the pro-nuclear bigwigs in politics (including the PM), bureaucracy, media, Department of Science & Technology, the Department of Atomic Energy and various bodies under it namely AEC, AERB, NPCIL, UCIL and others, and most importantly, the domestic and international corporate houses who pull the invisible strings.

In 1984, the Department of Atomic Energy (DAE) drew up a new atomic energy plan that envisioned setting up 10,000 MW of nuclear power by the year 2000. But an audit in 1998 found that the actual additional generation of power under the plan as of March 1998 after having incurred an expenditure of Rs. 5292 crore was NIL. [1]

As of today, India has 19 nuclear reactors with a total electricity production capacity of 4,680 MW. Now, the total installed capacity in India including coal, hydro and other energy sources is 2,07,900 MW. This means, nuclear capacity accounts for a mere 2.3% of the total installed capacity. While thermal and hydroelectric plants together constitute 85% of this capacity, wind-based capacity is more than 3 times the nuclear capacity. [7]

If all the 7 planned nuclear plants including Koodankulam begin operations, nuclear capacity would go up to about 10,100 MW. Add to this, the proposed 9900 MW Jaitapur plant—claimed to be the largest nuclear plant in the world—the total nuclear capacity would reach about 20,000 MW. However, the required capacity to meet the projected electricity demand in 2016-17 i.e., end of 12th five year plan, would be about 2,50,000 MW. [18] So, how can nuclear technology that creates such a pittance in relation to total electricity demand really cater to it?

Claim 2: In comparison, nuclear energy is cheap and plentiful

On the economic side, distinguished energy scientist Prof. Amulya Reddy and others have shown that nuclear power in India is more costly per unit than coal.[2] Based on this work, a study at IIT Kanpur shows that realistically, the cost of one Unit (KWh) of electricity in 2007 was Rs. 2.68 for Kaiga nuclear plant and Rs. 1.90 for Raichur coal plant.[21] A separate study has found that the Unit cost of hydro power in India is 35% lesser than coal (and hence, nuclear).[23]

The United States is a close ally of India in her nuclear quest. But, even in the US, Energy Information Administration (EIA) in Dec, 2010 suggested that Coal, Natural Gas, Hydro and Wind options are cheaper than Nuclear option as shown in Table 1 ($1 = Rs. 55).

Table 1:

Plant type	Average Cost per Unit (Rs./KWh)
Natural Gas	Rs. 3.60
Hydro	Rs. 4.75
Wind	Rs. 4.95
Coal	Rs. 5.20
Nuclear	Rs. 6.25

A prestigious publication like 'The Tech' (MIT's oldest and largest technology newspaper) agreed in Nov, 2011 that the cost of nuclear power is likely to be about twice the cost of natural gas power in the US.? [13]

Indian Nuclear sector has garnered more than 60% of the total budget on energy research despite contributing a mere 2.3% of the country's total capacity. If these priorities are reversed, with clean technologies like solar and wind power getting the kind of support nuclear energy currently enjoys, the energy demands will be better served. [3]

'One of the big problems with nuclear power is the enormous upfront cost. These reactors are extremely expensive to build' says Daniel Indiviglio, Washington-based columnist with Reuters. The work of Dr. M.V. Ramana, nuclear physicist with Princeton University and Senior Fellow at CISED, Bangalore demonstrates that a nuclear plant two times the size of a coal plant costs about four times to build [22] as shown in Table 2. For example, the nuclear plants Kaiga I & II with capacity 2×200MW commissioned in the year 2000 costed Rs.1,816 crore to build while the coal-based plant Raichur VII with capacity 210 MW commissioned in the year 2002 costed Rs.491 crore to build.

Dr. M.V. Ramana goes a step further: 'This illusion (that nuclear energy is cheap) is conjured up by hugely underestimating costs, by hiding subsidies, and most significantly, by limiting liabilities in the event of catastrophic accidents. The nuclear establishment tries to substantiate it through calculations based on estimated costs of future facilities rather than actual costs of existing facilities. Given the huge cost overruns at most facilities when compared to initial estimates, the distortion is significant'. For instance, the actual capital cost of Kaiga plant (reactors I & II) including the construction cost mentioned above was 4 times the initial estimated cost.[2]

Dr. Surendra Gadekar, physicist with a focus on nuclear affairs, adds: 'The huge subsidies paid to the nuclear power plants are in the form of heavy water subsidy, the fuel fabrication subsidy, the insurance and liability subsidy, the security subsidy, the research subsidy, the waste management subsidy, and other hidden and unknown subsidies'.[16]

There is no clear idea of how much it costs to decommission a reactor i.e., make a reactor inoperative, dismantle and decontaminate it keeping the environment safe. The few examples in other countries show that the decommissioning of the reactors has invariably cost much more than expected. Similarly, the cost of radioactive waste management is completely arbitrary (typically, 5 paise per unit of power generated). [1]

India relies on costly uranium imports for its nuclear power industry, with only half of its operating reactors (Kaiga, Narora, Kalpakkam, Tarapur) running on domestic uranium. Last year, NPCIL claimed to have found natural uranium deposits of about 49,000 tons in Andhra Pradesh but mining and milling it would be an expensive and hazardous process if we are to go by the experiences of Jaduguda Uranium mines (discussed later) apart from the well-known issues of impact to the environment and rehabilitation of poorest of the poor.

But, Thorium is plenty in India!

India has the largest reserves of Thorium—touted as a nuclear fuel—in the world. Dr. Bhabha formulated the 3-stage nuclear programme to use Thorium as the fuel, more than 5 decades ago. In this plan, fast breeder reactors running on uranium fuel would bombard thorium with neutrons, converting it into fissile Uranium-233. This will be processed into fuel rods to be used in the next stage as reactor fuel. But it is a dream yet to come true, if at all. There is no reactor existing today which is equipped with Thorium-based power generation technology as there are several serious technical problems.

Consider this. Dr. V.S. Arunachalam, former Scientific Adviser to Defence Minister of India and his colleague at Carnegie Mellon University, Dr. Rahul Tongia, said way back in 1997 that the Thorium-Uranium 233 cycle does not appear attractive and the three stages of the plan appear to be non-realisable even in a timeframe spanning five decades.[62] Other experts point out that Thorium based power generation will be both expensive and unsafe.[12][14]

Even though India has indigenously built nuclear reactors (Pressurised Heavy Water Reactors or PHWRs) based on Canada's CANDU Reactor in Rajasthan and has made some further innovations, almost all the nuclear reactors currently under commissioning are imported. The noted economist I.M.D Little made this farsighted remark way back in 1958: 'As Dr.Bhabha says, electricity is in short supply in India. It is likely to go on being in short supply if one uses twice as much capital as is needed to get more (electricity)'. This remarkable prediction—that an expensive nuclear energy cannot meet the electricity shortage in India—is as true today as it was 5 decades ago.

So, cheap nuclear power is as true as flat earth!

Claim 3: Nuclear technology is relatively safe

The safety concerns primarily arise from human and environmental damage caused due to and expected from nuclear accidents and radiation emission in the nuclear life cycle (from mining till decommissioning) most notably, from nuclear waste. Let us deal with both of them starting with nuclear accidents.

World Nuclear Association (WNA) is an international lobby group that promotes nuclear power with support from global nuclear industry. WNA claims that 'the risks from (western) nuclear power plants, in terms of the consequences of an accident or terrorist attack, are minimal compared with other commonly accepted risks'.[9]

Let us look at the top three incidents considered by WNA to be world's worst civilian nuclear disasters to verify this claim.

Chernobyl disaster, Ukraine – 1986

Chernobyl disaster was a catastrophic nuclear accident that occurred on 26 April, 1986, in the Chernobyl Nuclear Power Plant, Ukraine. An explosion caused by a sudden power surge and consequent fire released large quantities of radioactive materials that even spread to Russia, Belarus and the rest of Europe.

World Health Organisation (WHO) in its April, 2006 report on Chernobyl noted that the clean-up operation undertaken after the accident involved an estimated 350,000 clean-up workers from the army, power plant staff, local police and fire services.

In 2006, the Chernobyl forum—a group consisting of UN agencies and interestingly, governments of Russia, Ukraine and Belarus—estimated the eventual death toll to be 9,000 from among the worst affected workers, residents, evacuees as well as neighbouring nations due to leukemia, thyroid cancer and other radiation-induced cancer as well as acute radiation sickness (ARS). The United Nations considers this report to be most comprehensive report on Chernobyl. The accident resulted in a massive relocation of the population as radiation made human life impossible over 5000 sq. km area.[31] More than 3.3 lakh people had to be relocated.[10]

Three Mile Island Disaster, USA – 1979

The Three Mile Island (TMI) accident—the worst civilian nuclear disaster in the US—occurred on March 28, 1979. Radiation and Public Health Project suggests that infant mortality in the local area increased by 47% in the two years after the accident. It also says that, 25 years on, cancer-related deaths among children under 10 are 30% higher than the national average.

Joseph Mangano, in his study 'Three Mile Island: Health Study Meltdown' revealed that the number of cancers within 10 miles of TMI rose by 64% in the 5-year period after the accident when compared to 5-year period before the accident. In 1997, the National Cancer Institute of the US calculated that radioactive iodine may have caused thyroid cancer in more than 2 lakh Americans.

Fukushima disaster, Japan – 2011

It is now well known that the Fukushima nuclear disaster in Japan occurred due to an earthquake and consequent tsunami in March 2011. The plant had 6 reactors with 3 of them active when the earthquake struck. Immediately after the earthquake, these reactors shut down automatically but the tsunami flooded the emergency generator room cutting power to the critical pumps that circulate coolant water through a nuclear reactor. So, the reactors overheated due to the high radioactive decay heat and the 3 reactors started to melt down. In the intense heat and pressure of the melting reactors, several hydrogen-air chemical explosions occurred even as the workers struggled to cool the reactors.[24]

Significant amounts of radioactive substances were released into air, soil as well as ground and ocean waters. The government had to ban the sale of food grown in the area 30-50 km around the plant. Radioactive material was detected in a range of produce, including spinach, tea leaves, milk, fish and beef, up to 320 km from the nuclear plant. Residents were advised not to use tap water to prepare food for infants. Even a millionth gram of some of these substances, if ingested or breathed in, could seriously raise the cancer risk for individuals, especially in children and infants.

Within a few days, radiation was observed by monitoring stations around the world including the US, Canada, Austria, Russia, Australia and Malaysia. Large amounts of radioactive materials have also been released into the Pacific Ocean and the long-term effect on marine life is not fully understood. A total of 573 deaths have been certified as 'disaster-related' by 13 municipalities affected by the crisis. 300 workers were confirmed to have received high radiation doses. Predicted future cancer deaths go up to 1000.

New evidences are unfolding and the final impact is yet to be fully understood. The 40-year-old plant was built on the assumption that the biggest tsunami that could be expected on the Fukushima coast would be 5.7 metres high. The tsunami that crippled backup power supplies at the plant, leading to the meltdown of three reactors, was more than 14 metres high.[17]

Benjamin K. Sovacool has reported that worldwide there have been 99 accidents at nuclear power plants.[105] An interdisciplinary team from MIT estimated in 2003 that given the expected growth scenario for nuclear power from 2005 to 2055, at least four serious nuclear accidents will occur in that period.[93] And, Fukushima has already happened.

In these circumstances, is it tenable to argue that nuclear energy is 100% safe?

Lack of 'safety culture'

The Japanese government panel that investigated the Fukushima accident pointed to a lack of a 'safety culture' at both the levels of central government and the Tokyo Electric Power Co. (TEPCO) which operates the plant. Astoundingly, in Oct 2012, TEPCO admitted for the first time that it had failed to take stronger measures to prevent disasters for fear of inviting lawsuits or protests against its nuclear plants.[7] TEPCO reportedly has a dubious history of falsifying safety records and changing piping layouts without approval.[4]

South Korea derives 32% of its electricity from nuclear energy. In Nov, 2012, it was found that in two of its reactors, components with fake quality certificates had been used for replacement. They were forced to shut down following public protests.

Let us now ask the question: Can anybody claim this type of malpractice will not happen in India especially when their work is so shrouded in secrecy?

Take for example, the proposed Rs. 1,12,000 crore 9900 MW nuclear plant at Jaitapur in Maharashtra. In April, 2011, the Department of Atomic Energy (DAE) and the NPCIL claimed that Jaitapur plant site is not earthquake prone since the nearest tectonic fault—an area where one underground earth plate meets another—is at least 30 km away.[82] But how was this claim made? The Atomic Energy Regulatory Board (AERB) which reports to the Department of Atomic Energy (DAE) oversees nuclear safety management in India. It is relevant to recall that AERB was severely criticised by the Comptroller and Auditor General (CAG) in August, 2012 on numerous grounds: not preparing a nuclear safety policy despite having had a mandate to do so since 1983, failing to prepare the complete list of safety documents, not having a detailed inventory of all radiation sources and failure to adopt international practices.

Now, let us hear from Dr. A. Gopalakrishnan, himself a former chairman of AERB: 'Disaster preparedness oversight of AERB is mostly on paper and the drills they once in a while conduct are half-hearted efforts which amount more to a sham. NPCIL strategy is to have their favourite consultants cook up the kind of seismic data which suits them, and there is practically no independent verification of their data or design methodologies. AERB has become a lap dog of DAE and PMO. A captive AERB makes the overall nuclear safety management worthless'.[8]

It is ironic that AERB was set up by DAE to review safety measures at its own plants. Dr. Gopalakrishnan lays bare the ridiculous situation: 'About 95% of the technical personnel in AERB safety committees are officials of the DAE, whose services are made available on a case-to-case basis for conducting the reviews of their own installations'![22]

An impact assessment report by Tata Institute of Social Sciences (TISS) came down heavily on the proposed plant stating that the project will have a huge negative impact on social and environment development as it is sitting on a high to moderate severity earthquake zone.[6]

An independent study by the team of Prof. Roger Bilham of the University of Colarado and Prof. Vinod K. Gaur of CSIR suggests that the site may be vulnerable to an earthquake with a magnitude of 6 or more on the Richter scale in close vicinity. They lament that reliable geological studies are unavailable to characterize seismic activity of the region and data is insufficient to conclude that the site is not earthquake prone. Prof. Bilham has even said 'the absence of such data's availability raises suspicion'.[5]

The reason for this suspicion is not difficult to see. The Latur earthquake in 1993 which killed at least 9000 people had its epicenter in Killari which was considered to be seismically inactive!

Dr. A. Gopalakrishnan further points out that the Evolutionary Pressurized Reactors (EPRs) to be built in Jaitapur, are not commissioned anywhere in the world so far. Its potential problems are totally unknown even to Areva, its French developer, let alone India's NPCIL.

While NPCIL boasts of zero nuclear accidents in India, Dr. Gopalakrishnan had said that AERB had prepared a list of 130 incidents in Indian installations and has charged that the DAE had uniquely failed in meeting its responsibilities. In 1999, the 'Outlook' magazine listed 9 major accidents some of which had the potential to lead to a partial or total meltdown.[104] But the real causes behind these 'incidents'—the soft word used by DAE for accidents—may never be known. For example, in Nov 2009, more than 55 workers fell sick after consuming water contaminated with radioactive Tritium in Kaiga power plant in Karnataka and the NPCIL attributed it to an insider's mischief. Dr. M.R. Srinivasan, former Atomic Energy Commission chairman, promised an investigation but nobody knows the outcome till date. Interestingly, the same man headed the expert panel which declared in Feb, 2012 Koodankulam plant to be safe!

As the Department of Atomic Energy is not obliged to reveal details of ongoings at these nuclear plants to the public and reports directly to the Prime Minister, there is possibly many other accidents that we do not know about.

Finally, out of the world's three worst nuclear disasters, two were caused by human error and third, though caused by a natural calamity, was aggravated by human error. The French Atomic Energy Commission (CEA) has concluded that technical innovation cannot eliminate the risk of human errors in nuclear plant operation.[92] How is this factored in, when Dr. Kalam gave an 'all is well' certificate to Koodankulam?

Dr. Gadekar summarises the 3-stage process of misinformation of the nuclear establishment to handle public concerns on nuclear safety. First, say nothing. Next, if forced to say something, give out a very low figure which can be termed a 'mistake' if caught. Finally, if the lies are detected, apologise and keep repeating a variation of the lie such as? increase? ¿safe?'? radiation limits twenty times. The whole plan is to keep the people in ignorance? ?through misinformation.?

So, can we safely rest assured on the official claims that nuclear energy is safe?

Nuclear waste and radiation – perpetual threat

The nuclear disasters and accidents constitute a sudden spurt in the damage to life and environment that are unexpected, unguarded and largely uncontrolled. However, radiation emitted during various stages of the nuclear fuel cycle namely mining, milling, enrichment, transportation, processing, reprocessing, waste disposal, and decommissioning constitute perhaps, a bigger threat to health and environment. Exposure to radiation leads to ailments, deformities, birth defects, life threatening diseases and in some cases, deaths, and the effects extend across generations. Hence, this is no less a concern than nuclear accidents.

Let us look at the impact of radiation on the health of the people as well as the dangers posed by nuclear waste.

In France, around 30,000 workers dubbed as 'nuclear nomads' are subcontracted annually in the 58 nuclear reactors operated by Electricity of France (EDF) group, the largest energy company in France. EDF subcontracts over 1,000 companies, who employ the 'nuclear nomads', sometimes of foreign origin, to do the dangerous maintenance, repair and clean-up work in these plants.[26]

French Sociologist Annie Thébaud-Mony is the author of 'Nuclear Servitude: Subcontracting and Health in the French Civil Nuclear Industry' that investigates the effects of the radiation on these workers, and how the practices of the Nuclear industry exposes them to large amounts of radiation further endangering their health. It is worth noting that she refused to accept her country's most renowned civil award, the Legion of Honour, to protest against the failure of French courts to condemn those responsible for industrial crimes to the true degree of their responsibility. She found that subcontracting has 3 clear benefits: it is cheaper; it makes it hard for the nomads to get organised; and, most importantly, these nomads are temporary staff who are made to work in high radiation zones for brief periods only to be discarded after they reach their radiation limit. So, these nomads move around from plant to plant, often staying at campsites, with the constant threat of job loss hanging on their head like Damocles' sword. [25]

Since the 1970s, Japan has had a dubious track record of subcontracting maintenance work of reactors to outside companies which hire workers on a short-term basis who remain employed till they reach their radiation exposure limit. In that sense, they become the part of nuclear waste![11]

88% of the workers in Japan's nuclear power plants are contract workers who handle the bulk of the dangerous maintenance work for less pay, less job security and fewer benefits. These temporary workers were exposed to levels of radiation about 16 times higher than the levels faced by TEPCO permanent employees. But they work under the constant fear of getting fired, trying to hide injuries to avoid trouble for their employers, carrying skin-colored adhesive bandages to cover up cuts and bruises.[27]

Prof. Gabrielle Hecht from the University of Michigan brings up a very important point while dealing about nuclear waste. Uranium-producing African countries—which supplied between 25-50% of the West's uranium—remain contaminated from uranium mine debris. Today, regional poverty is so extreme that in Niger—the largest producer of uranium—people modify radioactive trash barrels into basins for collecting water. Such instances—though large in number—never make into any of the official statistics on the risks of nuclear waste.[11]

Dr. Surendra Gadekar and Dr. Sanghamitra Gadekar extensively studied the adverse health impact of Jaduguda Uranium mines in Jharkhand, Rawatbhata Nuclear Plant in Rajasthan, Kakrapar Nuclear Plant in Gujarat among others. Here is what they have to say: 'Contract workers do the dangerous and most dirty jobs but are not entitled to any benefits. They do not (even) get admission to plant hospital. Tarapur Annual Performance Report in 1985 says the radiation levels in various parts of the reactor were 10 to 500 times higher than what was expected during design. Emergency evacuation plan is to transport 15,000 residents of Mandvi into a primary school in Mangrol that cannot take more than 200 people. In Jaduguda Uranium mines area, the cases of congenital deformities have increased by over 7 times when compared to nearby villages. There are also high incidence of TB and chronic lung disease leading to 78 deaths'.

They also conclude that Rawatbhata atomic plant neighbourhood is no different with increased number of cases of congenital deformities, tumours, miscarriages, stillbirths and life expectancy falling by a staggering 11 years. They show workers carrying nuclear waste on bare hands and feet into lorries.

'U.S. reactors have generated about 65,000 metric tons of spent fuel, of which 75 percent is stored in pools, according to Nuclear Energy Institute. The spent fuel rods give off about 10,000 sieverts of radiation per hour at a distance of one foot (sievert is the unit to measure biological effects of nuclear radiation)' says Robert Alvarez, who served as Senior Policy Advisor to the Secretary for US National Security and Environment. To get the point across, he adds that this is 'enough radiation to kill people in a matter of seconds'. There are more than 30 million such rods in U.S. spent fuel pools. No other nation has generated this much radioactivity from either nuclear power or nuclear weapons production.[15]

In France, Greenpeace says that since the origins of the French nuclear industry some 50 years ago, the management of nuclear waste has been largely neglected. In 2006, France's iconic sparkling wine, Champagne, was threatened by radioactive contamination leaking from a nuclear waste dumpsite in the region. Low levels of radioactivity have already been found in underground water less than 10 km from the famous Champagne vineyards. In another incident, French laboratory ACRO said that radioactive waste from a storage facility in Normandy, France was leaking into groundwater and was being used by local farmers for their dairy cattle.[35]

The French Nuclear establishment touted reprocessing as the way to reduce nuclear waste but the Union of Concerned Scientists (USC) busted the myth. In a study released in Mar, 2011, USC found that reprocessing of spent nuclear fuel would increase, not decrease, the total volume of nuclear waste. The study concluded that reprocessing is not a sensible answer to the nuclear waste problem.[36]

Advocates D.Nagasila and V.Suresh disclosed a chilling point in *The Hindu* on 5 Nov, 2012: As per the 1988 agreement between India and erstwhile Soviet Union on the Koodankulam plant, the highly dangerous and toxic 'Spent Nuclear Fuel' (SNF) would be shipped back to the Soviet Union. However, in 1997 India signed another agreement—this time with Russia—contrary to the original proposal to ship out the SNF to Russia, the highly radioactive SNF from the nuclear power plant was to be stored, transported and reprocessed within India. Right now, secrecy shrouds the fate of the radioactive spent fuel, its reprocessing and transportation in Koodankulam.

No safe way to dispose nuclear waste

The fundamental problem is that there is absolutely no known way to dispose nuclear waste in a manner that ensures permanent safety. A March 2006 report by the UK government's Sustainable Development Commission (SDC) identified that 'No safe long-term solution to the problem of radioactive waste from nuclear plants is available, let alone acceptable to the general public'.[28]

According to International Atomic Energy Agency (IAEA), a 1000 MW nuclear power station produces approximately 30 tons of high level solid waste per year. High level waste consists of spent fuel rods which can no longer be used for power production as well as waste materials after processing. High-level waste contains highly radioactive fission products, and so, must be handled and stored with extreme care. Since the only way radioactive waste finally becomes harmless is through decay, which can take lakhs of years for high-level wastes, the waste must be stored and finally disposed of in a way that provides adequate protection of the public for a very long time.[89] But, a group of physicists at the School of Physics, University of Melbourne have pointed out that currently, no country has a complete system for storing high level waste permanently though many have plans to do so in the next 10 years.[29]

Even the available technologies such as storing in deep rocks by vitrification (converting to glass) or destroying the spent fuel using high energy incinerators, are very costly affairs and hence, are very unlikely to be included as part of safety measures in the upcoming nuclear plants in India.

How should any sensible man, whether a poor fisherman or an educated urbanite, react when he is forced to live under the constant threat of an evidently unsafe technology?

Claim 4: Nuclear technology is environment friendly

This is indeed a hotly debated topic because most experts agree that the routine health risks and greenhouse gas emissions from nuclear power are small relative to those associated with coal. Pro-nuclear advocates have offered nuclear power as a solution to global warming. Let us examine this claim.

Firstly, it is true that nuclear power plant operation emits no or negligible amounts of carbon dioxide during fuel processing. However, all other stages of the nuclear fuel chain—mining, milling, transport, fuel fabrication, enrichment, reactor construction, decommissioning and waste management—use fossil fuels and hence emit greenhouse gases notably, carbon dioxide. Dr. Benjamin K. Sovacool, Director of Energy Security & Justice Program at the Vermont Law School says that the largest part of the greenhouse emission (nearly 40%) in the nuclear fuel cycle comes from mining, milling and enrichment. He concludes that the total carbon emission in the nuclear life cycle is twice as much as solar and six times as much as wind farms. So, nuclear energy, though cleaner than coal in terms of carbon dioxide emission, is not as clean as other clean energy sources.

Secondly, there are incidents of commercial nuclear power plants releasing gaseous and liquid radiological effluents into the environment. A leak of radioactive tritium at Vermont Yankee in 2010 which contaminated ground water, along with similar incidents at more than 20 other US nuclear plants in recent years, has kindled doubts about the reliability, durability, and maintenance of aging nuclear installations. In France too, in July 2008, 18,000 litres of Uranium solution containing natural uranium was accidentally released at the Tricastin plant forcing the authorities to ban drinking well-water, and swimming or fishing in two local rivers.[34]

So, seen in the context of the catastrophic risks involved with nuclear accidents, waste and radiation hazards in the nuclear fuel cycle, the overall risks to environment far exceed the marginal contribution in terms of limited green house emission in one specific stage—namely power generation—of the entire nuclear fuel cycle.

Cleanup and compensation - at what cost?

When the estimates are made, the accident costs are not factored in. While the Nuclear Safety Commission in Japan is grappling to come up with the enormous economic cost of the Fukushima disaster, Jan Haverkamp—a Greenpeace nuclear energy expert—puts the total cost of the Fukushima catastrophe, including compensation and clean up, at over Rs.5 lakh crores. Kazumasa Iwata, president of the Japan Center for Economic Research, thinks the estimate ranges from Rs.3.5 lakh crores to Rs.12.5 lakh crores (however, the cost of compensation to affected people is less than 10% of the total cost).

India appears to have learnt a 'clever' lesson from the big brother, the US, when it comes to indemnifying the nuclear reactor vendors against accidents. The US enacted a cap on the damages that could be passed on to the private operator as early as in 1957 through Price-Anderson Act. Thus, today in the US, while the cap is at $12 billion, the actual cost of a nuclear meltdown as shown by a Nuclear Regulatory Commission study (adjusted to current inflation level) would be about $720 billion—60 times more than the cap.[31]

On same lines, as part of the Indo-US Nuclear deal, followed by similar bilateral deals with the other nuclear equipment manufacturing countries, the Indian Central Government enacted a law on capping the liability that could be passed on to the reactor suppliers in the event of an accident. The cap so fixed is a mere Rs.1,500 crores! If you look at the massive liability incurred in a nuclear mishap as in Fukushima, this only means that if a disaster were to occur in India, an exceedingly large part of the cost would be borne by the ordinary Indian tax payers. This point has been conveniently covered up by the nuclear establishment.

The meager value of the cap raises another disturbing question. A Public Interest Litigation (PIL) filed in the Supreme Court in Mar, 2012, represented by advocate Prashant Bhushan, has argued that the low cap on liability would make nuclear plants more unsafe as operators would prefer to bear the burden of an accident rather than going for safety installations.[33]

Nuclear power phase-out

Austria was the first country to begin a nuclear phase-out in 1978 to close down all its nuclear plants in a phased manner. It is followed by Sweden (1980), Italy (1987), Belgium (1999), and Germany (2000). Switzerland and Spain have enacted laws not to build new nuclear power stations. The United States has not built any new nuclear plants since the TMI accident in 1979.

Japan has 55 reactors and following Fukushima disaster, all nuclear reactors have been shut down by May 2012. Interestingly, CNN Japan reported that 'the trains ran exactly on time, the elevators in thousands of Tokyo high-rises efficiently moved between floors, and the lights turned on across cities without a glitch even though none of the energy is derived from a nuclear reactor for the first time in 4 decades'. So, obviously, skys don't open up if there is no nuclear power!

Two reactors have restarted in Japan since July this year. Tens of thousands of people have protested the decision and recent polls showed that majority of people favoured abandoning nuclear power entirely. Thanks to the public pressure, Japan government has announced a plan to completely phase-out nuclear plants.[30]

Sweden and Denmark have already given

up nuclear power. Germany has already shut down eight reactors and plans to close the rest by 2022. Japan was forced to announce a planned phase-out by 2040 following a bigger-than-nuclear explosion of public anger.

(*To be concluded in the next issue.*)

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