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Nuclear power: no route to energy security

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After decades of poor performance, atomic energy seems to have received a second wind, especially after the joint statement of 18 July 2005 by the Indian prime minister Manmohan Singh and the US president George W Bush. Many pro-nuclear advocates now aver that a large-scale expansion of nuclear power is the only way to meet our electricity needs and ensure energy security. An examination of the history of atomic energy in India shows, however, that this is not a new claim. Since its inception, the DAE (Department of Atomic Energy) has been promoting nuclear power as the answer to our energy needs. As per the DAE's predictions, by 2000, there should have been 43 500 MW of nuclear-generation capacity in the country. But only 3310 MW (megawatts) has been realized, which is less than three per cent of the installed electricity generation capacity. Even by the DAE's projections, it will not become a significant fraction of India's electricity for the next few decades. And, as we argue below, nuclear power does not enhance our energy security.

Energy security connotes the capacity to satisfy the energy needs of all sections of society without excessively compromising safety, the environment, or the well-being of future generations. This implies that electricity generation technologies should be economical, not run the risk of catastrophic accidents, be minimally polluting, and not leave long-lasting harmful legacies—nuclear power does not meet these criteria.

Economic and environmental costs

The DAE claims that nuclear power would be cheap and its costs compare very favourably with electricity from coal-fired thermal power plants. However, a comparison of the costs of the two using the standard discounted cash-flow methodology shows that nuclear power is competitive only for low discount rates (see Figure 1); for a wide range of realistic parameters, nuclear power is significantly more expensive (Ramana, D'Sa, and Reddy 2005). The discount rate is a measure of the value of capital, and given the multiple demands on capital for infrastructural projects, including for electricity generation, very low discount rates are not realistic. A larger proportion of nuclear

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capacity, therefore, implies that poorer sections of society cannot afford electricity, at least without greater subsidies, which would be detrimental to energy security.

Results shown in Figure 1 are based on costs of generating electricity at the Kaiga atomic power station and the RTPS (Raichur Thermal Power Station) VII: both base load plants of similar size and vintage in Karnataka. Coal for the RTPS VII is assumed to come from mines 1400 kilometres away. The largest component of the cost of producing electricity at nuclear reactors is the capital cost of the reactor, which includes construction cost (18 160 million rupees for Kaiga I and II, and 27 270 million rupees for Kaiga III and IV), and the costs of the initial loading of uranium fuel and heavy water used in reactor. The corresponding capital cost in case of the RTPS VII is 4910 million rupees (all of the capital costs mentioned do not include the interest during construction).

This economic comparison is largely based on assumptions favourable to nuclear power. In particular, cost of coal-generated electricity internalizes the cost of disposal of fly ash in an environmentally responsible fashion, but nuclear costs do not include cost of dealing with radioactive wastes. Despite more than half a century of intensive research, no one has found a way to render these wastes non-radioactive. This unsolved problem has caused many countries to reconsider the nuclear option. The DAE treats spent nuclear fuel by reprocessing it and segregating the waste into different categories on the basis of their radioactivity. Reprocessing also allows separation of plutonium, which, with further treatment, can be used as fuel in breeder reactors. Reprocessing, however, is expensive: as per our estimates, the cost of reprocessing each kilogram of spent fuel from the DAE's heavy water reactors is 20 000–30 000 rupees. The Nuclear Power Corporation does not include reprocessing costs in its tariff estimates; if included, it would increase the unit cost by 0.40 to 0.60 rupee.

Apart from the economic cost, because wastes stay radioactive for tens of thousands of years, they pose a potential health and environmental hazard to the future generations. This is clearly iniquitous as these generations would bear the consequences while we use the electricity generated by these reactors.

Finally, reactors are not the only source of pollution. Large quantities of radioactive and other toxic material are released into the biosphere at different stages of the nuclear fuel cycle. Thus, the nuclear fuel cycle is polluting, albeit in a way different from coal power.

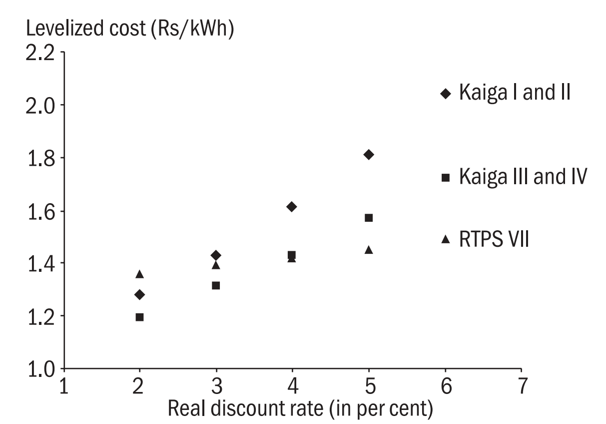

Figure 1 Levelized cost (the bare generation cost, which does not include other components of electricity tariff like interest payments and transmission and distribution charges) of Kaiga I & II (operating reactors), Kaiga III & IV (reactors under construction; projected costs), and Reichur Thermal Power Station VII (operating thermal plant) as a function of real discount rate[1]

Safety

Nuclear power also poses a risk to energy security because it is susceptible to catastrophic accidents. Chernobyl is the best-known instance of such a disaster. It resulted in several thousand deaths and contamination of tens of thousands of km^2 (square kilometres) of land with radioactive elements like cesium-137. Agriculture across large parts of Ukraine and Belarus had to be suspended, over a hundred thousand people were relocated, and the economy of Belarus was devastated. Such accidents can happen in other (non-reactor) facilities too. In 1957, a tank containing radioactive wastes from the Mayak reprocessing plant in the erstwhile Soviet Union exploded

[1]A measure of the value of capital after taking out the effects of inflation.

and contaminated 20 000 km^2 of land. India, still a largely agriculture-dependent economy, can simply not afford the risk of such disasters.

It is often stated that safety issues have been adequately addressed after the Chernobyl accident. However, basic features of nuclear reactors remain the same. It is a complex technology, involving large quantities of radioactive materials where events can spin out of control in a very short time. In studying the safety of nuclear reactors and other hazardous technologies, sociologists and organization theorists have come to the pessimistic conclusion that serious accidents are inevitable with such complex high-technology systems (Perrow 1984; Sagan 1993). The character of these systems makes accidents a 'normal' part of their operation, regardless of the intent of their operators and other authorities. In such technologies, many major accidents have seemingly insignificant origins. Because of the complexities involved, all possible accident modes cannot be predicted and operator errors are comprehensible only in the hindsight. Adding redundant safety mechanisms only increases the complexity of the system, allowing for unexpected interactions between subsystems and increasing new accident modes. All this means that it is not possible to ensure that reactors and other nuclear facilities will not have major accidents.

There is an experiential basis for concern about such accidents within India. Practically, all nuclear reactors and other facilities associated with the nuclear fuel cycle operated by the DAE have had accidents of varying severity (Chanda 1999; Rethinaraj 1999). A few examples are the unexplained power surge at the Kakrapar reactor in 2004, the 1993 fire at Narora, and the collapse of the containment at Kaiga in 1994. Because of the reasons mentioned in the earlier paragraph, many of these accidents could well have become the basis for a major radioactive release.

A further source of concern is that the AERB (Atomic Energy Regulatory Board), which is supposed to oversee safe operation of all civilian nuclear facilities, is not independent of the DAE. Further, as the former chairman of the AERB has observed, 'The AERB has very few qualified staff of its own, and 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 reviews of their own installations. The perception is that such dependency could be easily exploited by the DAE management to influence the AERB's evaluations and decisions' (Gopalakrishnan 2002).

Uranium shortage and dependence on imports

The growth of nuclear capacity is contingent on the availability of fuel for reactors. Most of the nuclear reactors of DAE are fuelled using uranium from the Jaduguda region of Jharkand. These require over 400 tonnes of uranium annually. The current uranium production from Jaduguda has been estimated at less than 300 tonnes a year. The DAE has been continuing operations by using stockpiled uranium, which is likely to be exhausted by 2007.

Given this domestic resource crunch, the DAE will soon have to depend on imported uranium to run its reactors. This is one of the primary motivations for the Indo–US agreement. As an official stated in an interview on 26 July 2005 to the BBC, 'The truth is we were desperate. We have nuclear fuel to last only till the end of 2006. If this agreement had not come through, we might have as well closed down our nuclear reactors and by extension, our nuclear programme.' Just as power generation from natural gas and oil is dependent on importing these fuels, electricity from nuclear reactors will become increasingly import-dependent. Imports of uranium and other nuclear materials like heavy water have been subject to political considerations. The US, for example, refused to supply enriched uranium fuel for the Tarapur I and II reactors, following the 1974 nuclear test and the Nuclear Non-Proliferation Act passed by the US Congress in 1978. Therefore, if nuclear power is to expand significantly, electricity production could be subject to disruption by external events.

The alternative to importing uranium is to rely on breeder reactors fuelled by plutonium or uranium-233 derived from thorium. However, despite 50 years of ambitious plans, the DAE is yet to build a single industrial-scale breeder reactor. If and when they are built, because of greater safety requirements, they will likely be more expensive to build and operate than reactors so far constructed by the DAE. They will thus be capital-intensive, fuelled by materials produced through expensive reprocessing, and have higher maintenance costs, making electricity from these reactors very costly.

Poor economics and safety concerns have caused many western countries to abandon their breeder programmes. Even countries like France and Japan, where governments have long supported breeder programmes, are reconsidering their strategy. In France, a high level official commission examined the future of reprocessing (necessary for construction of breeder reactors), and found it more expensive than other options (Charpin, Benjamin, and Pellat 2000). Japan has not restarted the Monju breeder reactor, which was shut down in 1995 after a major sodium leak and a resultant fire; no new ones are under construction.

Conclusion

Nuclear establishment in India has long promised much; however, in spite of unstinted government support, delivered little. The DAE budgets have historically been high, at the cost of promoting other, more sustainable sources of power. In 2002/03, for example, the DAE was allocated 33 516.9 million rupees, dwarfing in comparison the 4735.6 million rupees allocated to the MNES (Ministry of Non-conventional Energy Sources), in charge of developing solar, wind, small hydro, and biomass-based power. Nevertheless, installed capacity of these sources was 4800 MW (as compared to 3310 MW of nuclear energy). While their contribution to actual electricity generated would be smaller because these are intermittent sources of power, they have much lower maintenance costs. Further, exploitation of most of these sources started in earnest only recently and there is ample scope for improvement.

Increased investment in renewable sources of energy is clearly desirable. Owing to the increased research and development investments and cumulative operational capacity, capital costs of several RETs (renewable energy technologies) have been declining. This trend is likely to continue because unlike mature technologies like these pertaining to coal and nuclear power, RET can improve considerably. These technologies are also amenable to the decentralized, community-based production and cause much less environmental damage than fossil fuels and nuclear energy. An increased reliance on the RETs and improvements in energy efficiency offer a basis for a robust energy strategy.

In light of the modest performance of nuclear power, in addition to the associated high costs and environmental and safety hazards, India should reconsider the nuclear option as it does not ensure true energy security.

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