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Economics of Nuclear Power

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India uses slightly non-standard reactors. These reactors have the advantage that they can work with naturally occurring uranium, without the need for enrichment. While this saves some expense, these Reactors use heavy-water, which is expensive. The Department of Atomic Energy (DAE)plans to construct more such pressurized heavy-water reactors in the future.

The economics of nuclear power in India is particularly complicated by two factors. First, it is hard to obtain an accurate estimate of the subsidies that go into various aspects of nuclear power, including heavy-water production. Second, the DAE uses a so-called "closed cycle," where the spent fuel is reprocessed. This reprocessing is very expensive, but is not included in the official estimation of the cost of power. The reasoning behind this is that the repro-cessed fuel will eventually be useful in the second stage of the nuclear programme; since this second stage has not yet become operational, this is rather specious.

It is sometimes argued that nuclear power is cost-competitive with coal. However, this argument completely ignores these subsidies and expenses. Under reasonable assumptions for the subsidy that goes into heavy-water production, nuclear power is not cost-competitive with coal even for (real) discount rates as low as 3 percent. This conclusion holds even if the costs involved in reprocessing are completely neglected.

This is consistent with the international pattern.

The large MIT study of 2003, referred to above, concluded, by studying a range of discount rates, that "in deregulated markets, nuclear power is not now cost competitive with coal and natural gas." An extensive study performed at the University of Chicago came to the same conclusion. It noted that, except for France, "for most other countries, the high capital costs of nuclear power prohibit it from being cost-competitive with coal and natural gas-fired technologies." Moreover, the study pointed out that even in the "most favorable case," the cost of the first new nuclear plants in the US would be above the highest coal and gas costs.

As the *Economist* summarized : "Since the 1970s, far from being ‘too cheap to meter’—as its proponents once blithely claimed—nuclear power has proved too expensive to meter". It is as a result of this that no new applications for plant-construction were made in the US for almost three decades.

The other question is whether putting a price on carbon emissions would change these calculations. Here, the *Economist* points out : "The price of carbon under Europe's emissions-trading scheme is currently around 14 per tonne, far short of the 50 that power-industry bosses think would make nuclear plants attractive."

So, there is a wide consensus, internationally, that nuclear power is more expensive than coal. India conforms to this pattern. While this has dampened the growth of the nuclear industry, it has not stopped new nuclear plants from being constructed. To the contrary, at times, the fact that nuclear power is more expensive has been seen as a rationale for further policy assistance and subsidies!

Concerns about climate change have partly driven the revival in the nuclear industry in recent times. Atomic energy does have the advantage of not producing

greenhouse gases. As a result of this (and other pecuniary reasons), some environmentalists like Patrick Moore, an influential former member of Greenpeace, have become advocates of nuclear energy. However, Greenpeace itself and most other environmental groups still disavow nuclear energy. One of their primary objections is to the waste that is generated.

Nuclear reactors produce radioactive waste, some of which remains hazardous for a very long time. For example, Pu (which is produced in nuclear reactors) has a half-life of 24,000 years (which means that the radioactivity from a lump of this material decreases by half every 24,000 years).

Unfortunately, there is no established technique of disposing this waste. In the long run, there is some agreement, among nuclear planners, that the waste should be put into a stable geological repository. Only one such repository - the Waste Isolation Pilot Plant in the US - exists, but operates only with military waste. The US plans to dispose of some of its radioactive civil waste in the Yucca mountain repository, but this has not yet been constructed. A discussion of the logistics of these programmes can be found in the *Nuclear Engineering Handbook*.

In India, the spent fuel from reactors is reprocessed. However, this process still produces dangerous radioactive waste. This volume is currently small. In 2001, it was estimated that about 5000 m of "high-level-waste" had been generated in India (this is about two Olympic size swimming pools). However, this is likely to go up sharply. In 2004, the DAE estimated that, by 2011, it would produce about 700 m of high-level waste every year. Although the DAE claims that it will finally dispose of this waste in a deep geological repository, it is forced to admit that "demonstration of feasibility and safety of deep geological disposal is a major challenge.

Another concern regarding nuclear energy is the safety of nuclear plants. The 1986 accident at Chernobyl (in the Ukraine, then part of the Soviet Union) sent up a huge amount of radioactive material into the atmosphere. This radioactive material carried across the Soviet border into other countries and as far north as Sweden. In 2006, the WHO estimated that there would be "about 4000 [excess] deaths ... over the lifetimes of the some 600,000 persons most affected by the accident" due to cancer caused by exposure to radiation. Beyond this, over the lifetime of the population of the more than 6 million people in "other contaminated areas," it estimated that there would be about 5000 excess deaths.

However, as Greenpeace pointed out, with a disaster of this magnitude, "any description which attempts to present the consequences as a single, 'easy to understand' estimation of excess cancer deaths ... will... inevitably provide a gross oversimplification of the breadth of human suffering experienced".

The accident at Chernobyl probably happened because of poor design and operator error. In particular, the reactor was not enclosed within proper containment. Also, at the time of the accident, it seems to have had a *positive void coefficient* which meant that the escaping coolant increased the intensity of the reaction which in turn caused more of the coolant to escape, thus leading to catastrophic positive feedback. Newer reactors seem to be better contained and designed. One can only hope that the nuclear industry has learned its engineering lessons well.

Nuclear power is inherently hazardous. However, in any discussion about the safety of nuclear plants, there is a point made by proponents of nuclear energy that cannot be overlooked. Nuclear energy is most commonly compared to coal. However, coal is also hazardous.

This is because thousands of people lose their lives in coal-mines every year. China is the most egregious example. According to official statistics, there were 4,746 fatalities in China in 2006 and 3,786 fatalities in 2007 .

Coal mining affects hundreds of people in India also. Statistics on coal mining in India are somewhat problematic. According to the Ministry of Coal, coal-mining in India is so safe that fatalities per man-shift are considerably lower than in the US and about as low as they are in Australia. This is not entirely believable. However, even taking the ministry's figures at face value, there were 128 fatalities and 966 serious injuries in coal-mining in 2006. In 2007, there were 69 fatalities and 904 serious injuries.

This is partly a result of the tremendous inequality that exists in the society today. A nuclear meltdown would be catastrophic and would affect everyone. So, a great amount of attention is paid to safety in nuclear installations. However, hundreds of people lose their lives in coal-mining around the world each year. Since these people are overwhelmingly poor and dispossessed, this does not attract anywhere near the same level of protest or attention.

There are two factors that modify the debate regarding the desirability of nuclear power in India.

The first factor has to do with the poor uranium resources of the country. Uranium deposits in India are not only rare, they are of very poor quality. The report of the Kirit Parikh-led expert committee on energy policy, appointed by the Planning Commission, pointed out that "India is poorly endowed with Uranium. Available Uranium supply can fuel only 10,000 MW of the Pressurised Heavy-Water Reactors (PHWR). Further, India is extracting Uranium from extremely low grade ores (as low as 0.1% Uranium) compared to ores with up to 12-14% Uranium in certain resources abroad. This makes Indian nuclear fuel 2-3 times costlier than international supplies." It is evident then that a large nuclear programme can only be sustained on the basis of imported fuel. Of course, this makes nuclear energy more expensive.

However, more seriously, importing fuel will make India dependent on America and its western allies for fuel supplies. After the nuclear tests in 1974, the US stopped fuel supplies to the Tarapur plant. Last year, India was given a waiver by the Nuclear Suppliers Group, allowing it to engage in nuclear trade, only because it was strategically allied with the US. A large scale nuclear programme, relying on imported fuel, would make it difficult for any future government to extricate itself from this relationship.

The second important issue in India is the lack of a strong regulatory framework. Once again, this poor institutional design can be traced to Bhabha and Nehru. In 1948, Bhabha wrote to Nehru stating that "the development of atomic energy should be entrusted to a very small and high-powered body, composed of say three people with executive power, and *answerable directly to the Prime Minister without any intervening link* ... this body may be referred to as the Atomic Energy Commission." (emphasis added) Evidently, Bhabha was no great believer in democracy. In this case, as in many others, he used his personal closeness to Nehru to free himself of even the minimal checks and balances that existed in other parts of the Government. The AEC was set up in 1954 and 55 years later, this small opaque clique of bureaucrats continues to oversee all aspects of atomic energy in the country.

In fact, for decades, the atomic energy establishment did not even see the need to have an independent regulatory body. The DAE was in charge of both the

construction and regulation of nuclear power plants. It was only after the serious nuclear accident at Three Mile Island (Pennsylvania, US) in 1979 that the DAE started the process of setting up a separate Atomic Energy Regulatory Board (AERB). However, the AERB, which was set up in 1983 with the mission of ensuring the safety of atomic energy, reports directly to the AEC, which is chaired by the head of the DAE! This makes its claim of being independent of the DAE somewhat specious.

In 1995, the AERB, under a proactive chairperson, A Gopala-krishnan, compiled a report citing 130 safety issues in Indian nuclear installations, with about 95 being top priority. It is unclear what, if any, action was taken on the AERB report.

Later, after leaving the AERB, Gopalakrishnan wrote that "the safety status in the DAE's facilities is far below international standards." Further, he said that "the lack of a truly independent nuclear regulatory mechanism and the unprecedented powers and influence of the DAE, coupled with the widespread use of the Official Secrets Act to cover up the realities, are the primary reasons for this grave situation." In its response, the Nuclear Power Corporation dismissed these concerns as "alarmist" and expressed its sorrow that Gopalakrishnan was "tilting at windmills." Moreover, it stated that "we do not consider the AERB ... as being adversaries. We are all part of a single scientific fraternity that has been mandated by the founding fathers of the nation to develop and deliver the numerous benefits of nuclear energy to the nation in an economical and safe manner."

While this evocation of fraternal cooperation is undoubtedly touching, it is somewhat problematic for the regulators and builders of a hazardous technology like atomic energy to be so cozy. In fact, as Gopalakrishnan points out, this is in violation of the international convention on nuclear safety that asks every contracting party (including India), to take "appropriate steps to ensure an effective separation between the ... regulatory body and ... any other body ... concerned with the ... utilization of nuclear energy."

Nuclear accidents are a low-probability event. So it is often possible to get away with violations of safety norms, as the DAE has been doing. However, the reason these low probabilities are taken so seriously is that the consequences of a single nuclear accident can be disastrous. The current regulatory framework is clearly broken, and this makes the planned expansion in the atomic energy programme particularly alarming. □□□

[courtesy : RUPE]